



BAT32G127 Datasheet

Ultra-low power 32-bit microcontrollers based on ARM® Cortex®-M0+

128KB Flash, analog functions, timers and communication interfaces.

V1.0.0

Please note the following CMS IP policy

* China Micro Semicon Co., Ltd. (hereinafter referred to as the Company) has applied for patents and holds absolute legal rights and interests. The patent rights associated with the Company's MCUs or other products have not been authorized for use, and any company, organization, or individual who infringes the Company's patent rights through improper means will be subject to all possible legal actions taken by the Company to curb the infringement and to recover any damages suffered by the Company as a result of the infringement or any illegal benefits obtained by the infringer.

* The name and logo of Cmsemicon are registered trademarks of the Company.

* The Company reserves the right to further explain the reliability, functionality and design improvements of the products in the data sheet. However, the Company is not responsible for the use of the Specification Contents. The applications mentioned herein are for illustrative purposes only and the Company does not warrant and does not represent that these applications can be applied without further modification, nor does it recommend that its products be used in places that may cause harm to persons due to malfunction or other reasons. The Company's products are not authorized for use as critical components in lifesaving, life-sustaining devices or systems. The Company reserves the right to modify the products without prior notice. For the latest information, please visit the official website at www.mcu.com.cn.

Features

- **Ultra-low power operation environment:**
 - Supply voltage range: 1.8V to 5.5V
 - Temperature range: -40°C to 105°C
 - Low power consumption modes: sleep mode, deep sleep mode
 - Operating power consumption: 35uA/MHz@32MHz
 - Power consumption in deep sleep mode: 0.7uA
 - Operation in deep sleep mode +32.768K+RTC: 0.9uA
- **Core:**
 - ARM® 32-bit Cortex®-M0+ CPU
 - Operating frequency: 32KHz to 32MHz
- **Memory:**
 - 128KB Flash memory with shared program and data storage
 - 2.5KB dedicated data Flash memory
 - 8KB SRAM memory with parity check
- **Power and reset management:**
 - Built-in power-on reset (POR) circuit
 - Built-in voltage detection (LVD) circuit (settable threshold voltage)
- **Clock management:**
 - Built-in a high-speed oscillator with accuracy of $\pm 1\%$, supporting 1MHz to 32MHz system clocks and peripheral module operation clocks
 - Built-in a 32KHz low-speed oscillator
 - Support 1MHz to 20MHz external crystal oscillators
 - Support 32.768KHz external crystal oscillators
- **Multiplier module:**
 - Support 32-cycle 32-bit multiplication operations
- **Enhanced DMA controller:**
 - Interrupt trigger start.
 - Selectable transfer modes (normal transfer mode, repeat transfer mode, block transfer mode and chain transfer mode)
 - Transfer source/destination realm are
- **Rich analog peripherals:**
 - 12-bit ADC converter with a conversion rate of 0.71 Msps. It has 26 external analog channels and selectable internal OPA outputs as conversion channels. It includes a temperature sensor and supports single-channel conversion mode and multi-channel scan conversion mode. Conversion range: 0 to positive reference voltage.
 - Comparator (CMP) with two built-in channels. Input sources are selectable, and reference voltage options include external pin inputs (2), internal reference voltage (1.45V), or outputs from an 8-bit DAC.
 - Operational amplifier (OPA) with a one-channel OPA.
 - 8-bit resolution D/A converter for controlling analog outputs.
- **Input/output ports:**
 - I/O ports: 38 to 60
 - N-channel open drain, internal pull-up and pull-down switching
 - Built-in key interrupt checkout function
 - Control circuit for built-in clock output/buzzer outputs
- **Serial two-wire debugger (SWD)**
- **Rich timers:**
 - 16-bit timer: 8 channels
 - 15-bit interval timer: 1x
 - Real Time Clock (RTC): 1x (with perpetual calendar, alarm function, and support a wide range of clock correction)
 - Watchdog timer (WWDT): 1x
 - SysTick timer
 - Timer A
- **Rich and flexible interfaces:**
 - 3-channel serial communication unit: each channel can be freely configured as a 1-channel standard UART, 2-channel SPI or 2-channel simplified I²C
 - UART0 supporting LIN-bus receive function
 - Standard SPI: 1 channel (support 8bit and 16bit)
 - Standard I²C: 1 channel
 - IrDA: 1 channel

selectable from the full address space range

- **Linkage controller:**

- It can link event signals to realize the linkage of peripheral functions
- 16 input events and 6 trigger events

- **LCD controller/driver**

- LCD supports
4COM*42SEG/6COM*40SEG/8COM*38SEG

- **Safety function:**

- Comply with IEC/UL 60730 standards
- Report abnormal storage access errors
- Support RAM parity check
- Support hardware CRC
- Support SFR guard and avoid misoperation
- 128-bit unique ID
- Flash Level 2 protection in the debug mode (Level1: only perform flash full-scale erase, cannot be read or written. Level2: Emulator connection is invalid, cannot operate on flash.)

- **Package:**

- 64LQFP, 48LQFP, and 40QFN

1 Overview

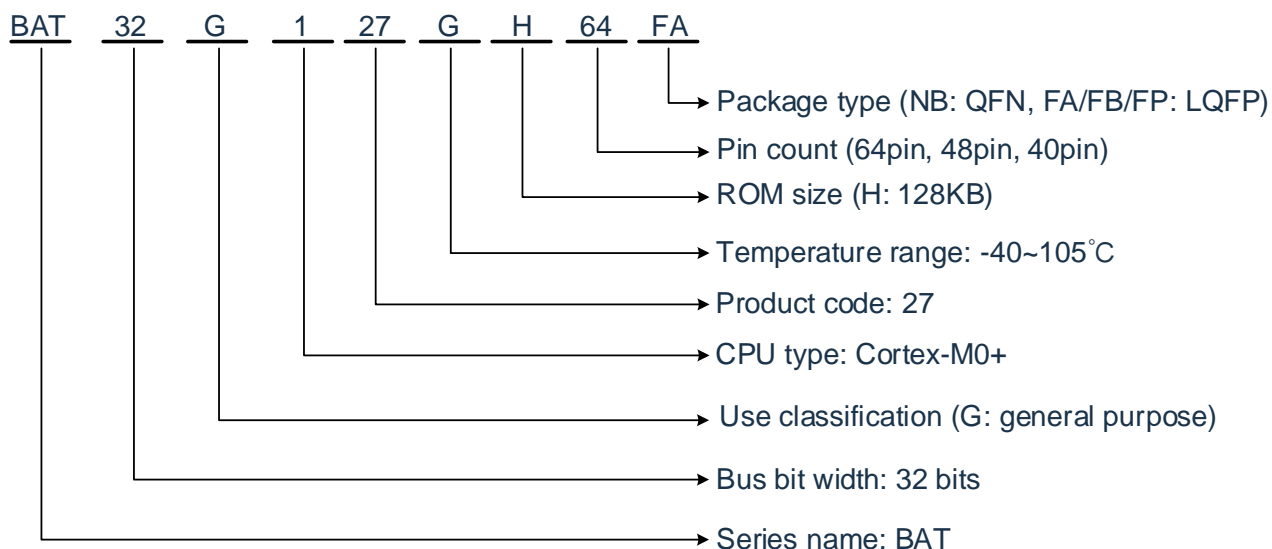
1.1 Brief introduction

The ultra-low-power BAT32G127 features a high-performance ARM®Cortex®-M0+ 32-bit RISC core, capable of operating up to 32 MHz. It includes high-speed embedded flash memory (up to 8KB SRAM and up to 128KB program/data flash). This product integrates multiple standard interfaces such as I2C, SPI, and UART, and supports C-Type/R-Type LCD drivers. It integrates a 12-bit A/D converter, temperature sensor, comparator, and operational amplifier. The 12-bit A/D converter can be used to capture external sensor signals, reducing system design costs. The integrated temperature sensor allows for real-time monitoring of external environmental temperature. The integrated comparator supports both high-speed and low-speed operating modes. In high-speed mode, it can support feedback control for high-speed motors, while in low-speed mode, it can be used for battery monitoring. The BAT32G127 also features an 8-channel 16-bit timer module, which, in conjunction with the timer, can control a DC motor or two stepper motors.

The BAT32G127 excels in low-power performance, supporting both sleep and deep sleep modes for energy efficiency. Its operating power consumption is 35μA/MHz at 32 MHz, and in deep sleep mode, the consumption is only 0.7μA, making it suitable for battery-powered low-power devices. Additionally, the integration of an event-driven controller allows for direct connections between hardware modules without CPU intervention, providing faster response times compared to interrupt-based systems and reducing CPU activity, thereby extending battery life.

These features make the BAT32G127 microcontroller series suitable for battery-powered LCD display products such as smart water meters, heat meters, gas meters, measurement instruments, and temperature controllers.

1.2 Product model list



BAT32G127 product list:

| Pin count | Package | Product model |
|-----------|--|-----------------|
| 40 pins | 40-pin plastic package QFN (5x5mm, 0.4mm pitch) | BAT32G127GH40NB |
| 48 pins | 48-pin plastic package LQFP (7x7mm, 0.5mm pitch) | BAT32G127GH48FA |
| 64 pins | 64-pin plastic package LQFP (7x7mm, 0.4mm pitch) | BAT32G127GH64FB |

Capacity of FLASH and SRAM:

| Flash memory | Dedicated data Flash memory | SRAM | 40-pin /48-pin /64-pin |
|--------------|-----------------------------|------|------------------------|
| 128KB | 2.5KB | 8KB | BAT32G127 |

BAT32G127 product list:

| Part No. | Core | Clock frequency (MHz) | Min. operating voltage (V) | Max. operating voltage (V) | Code Flash (KB) | SRAM (KB) | Data Flash (KB) | DMA | GPIO | 12bit ADC | 8bit DAC | CMP | PGA | Universal timer (16bit) | RTC | WDT | UART | SPI | IIC bus | IrDA bus | LIN bus | CAN bus | Hardware multiplier | Hardware divider | Package |
|---------------------|------|-----------------------|----------------------------|----------------------------|-----------------|-----------|-----------------|-----|------|-----------|----------|-----|-----|-------------------------|-----|-----|------|-----|---------|----------|---------|---------|---------------------|------------------|------------|
| BAT32G127 GH40NB | M0+ | 32 | 1.8 | 5.5 | 128 | 8 | 2.5 | 24 | 38 | 16 | 1 | 2 | 1 | 9 | 1 | 1 | 3 | 6+1 | 6+1 | 1 | 1 | - | Y | Y | QFN 40 |
| BAT32G127 GH48FA | M0+ | 32 | 1.8 | 5.5 | 128 | 8 | 2.5 | 24 | 44 | 17 | 1 | 2 | 1 | 9 | 1 | 1 | 3 | 6+1 | 6+1 | 1 | 1 | - | Y | Y | LQFP 48 |
| BAT32G127 GH64FB | M0+ | 32 | 1.8 | 5.5 | 128 | 8 | 2.5 | 24 | 60 | 26 | 1 | 2 | 1 | 9 | 1 | 1 | 3 | 6+1 | 6+1 | 1 | 1 | - | Y | Y | LQFP 64 |

1.3 Top view

1.3.1 BAT32G127GH40NB

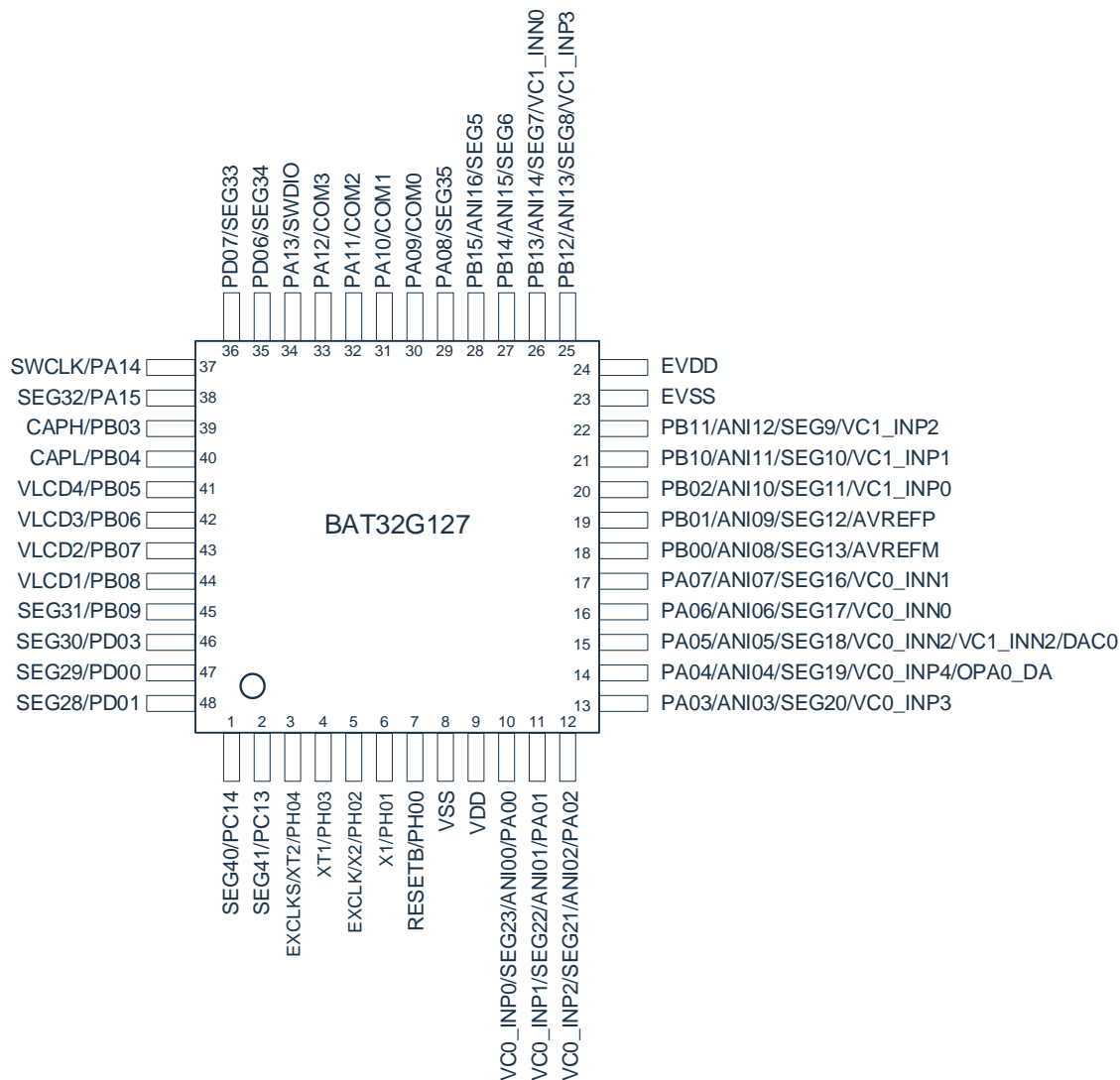
- 40-pin plastic package QFN (5x5mm, 0.4mm pitch)



Note: The functions not labeled in the figure are configurable via pins, see Section 4.1 for details.

1.3.2 BAT32G127GH48FA

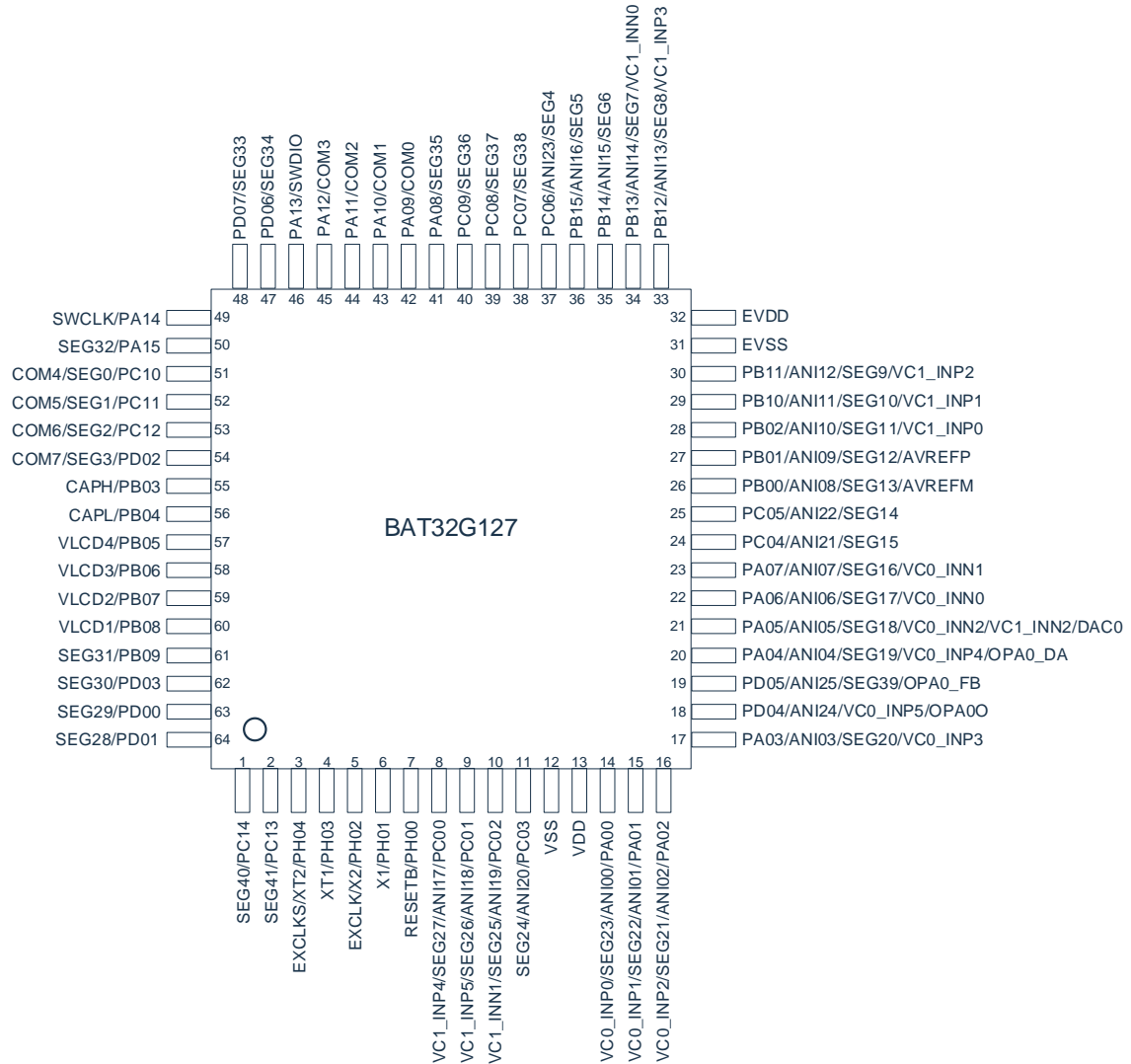
- 48-pin plastic package LQFP (7x7mm, 0.5mm pitch)



Note: The functions not labeled in the figure are configurable via pins, see Section 4.1 for details.

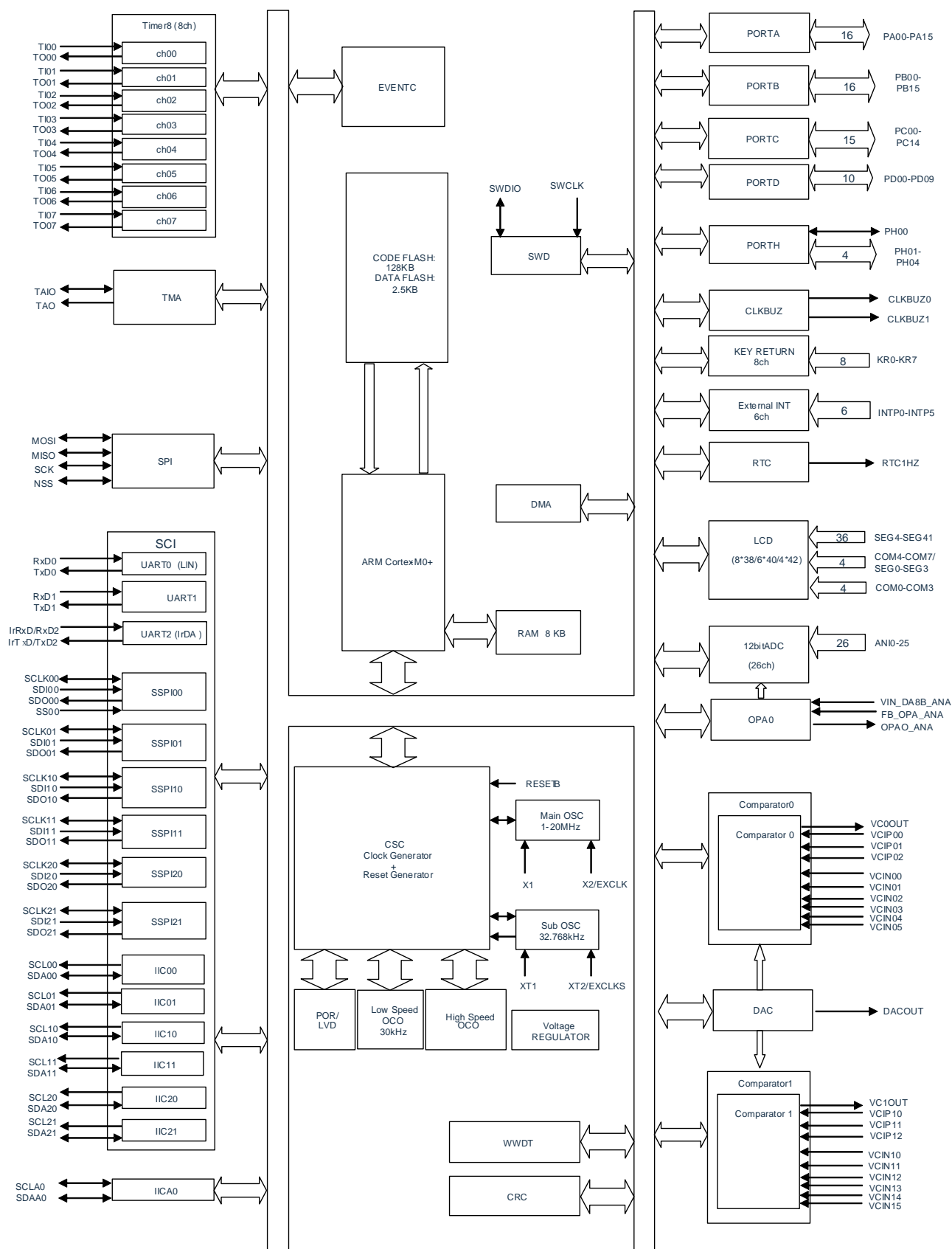
1.3.3 BAT32G127GH64FB

- 64-pin plastic package LQFP (7x7mm, 0.4mm pitch)



Note: The functions not labeled in the figure are configurable via pins, see Section 4.1 for details.

2 Product Structure Diagram



3 Memory Map

| | |
|-------------|---|
| FFFF_FFFFH | Reserved |
| E00F_FFFFH | Cortex-M0+ Dedicated Peripheral Resource Area |
| E000_0000H | Reserved |
| 4005_FFFFH | Peripheral Resource Area |
| 4000_0000H | Reserved |
| 2000_1FFFFH | SRAM (up to 8KB) |
| 2000_0000H | Reserved |
| 0050_0BFFFH | Data Flash 2.5KB |
| 0050_0200H | Reserved |
| 0001_FFFFH | Main Flash Memory Area (up to 128KB) |
| 0000_0000H | |

4 Pin Functions

4.1 Port function

Table 4.1.1 (1/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PH00 | RESETB | RSTM=0 (default function) | • | • | • |
| | GPIO | RSTM=1 | • | • | • |
| PA00 | TXD2/SDO20 | 3'h01 | • | • | - |
| | TI00 | 3'h02 | • | • | - |
| | TO00 | 3'h03 | • | • | - |
| | VC0OUT | 3'h06 | • | • | - |
| | GPIO | 3'h00 | • | • | - |
| PA01 | RXD2/SDI20/SDA20 | 3'h01 | • | • | • |
| | TI01/TO01 | 3'h03 | • | • | • |
| | SPI0_MOSI | 3'h05 | • | • | • |
| | PCLBUZ0 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA02 | TXD1/SDO10 | 3'h01 | • | • | • |
| | TI02/TO02 | 3'h03 | • | • | • |
| | SPI0_MISO | 3'h05 | • | • | • |
| | VC1OUT | 3'h06 | • | • | • |
| | PCLBUZ1 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA03 | RXD1/SDI10/SDA10 | 3'h01 | • | • | • |
| | TI03/TO03 | 3'h03 | • | • | • |
| | TI00_GATE | 3'h04 | • | • | • |
| | SPI0_NSS | 3'h05 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA04 | TXD1/SDO10 | 3'h01 | • | • | • |
| | TI04/TO04 | 3'h03 | • | • | • |
| | SPI0_NSS | 3'h05 | • | • | • |
| | GPIO | 3'h00 | • | • | • |

Table 4.1.1 (2/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PA05 | SS10 | 3'h01 | • | • | • |
| | TI05/TO05 | 3'h03 | • | • | • |
| | TI06_GATE | 3'h04 | • | • | • |
| | SPI0_SCK | 3'h05 | • | • | • |
| | PCLBUZ0 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA06 | SS20 | 3'h01 | • | • | • |
| | TI06/TO06 | 3'h03 | • | • | • |
| | TI07_GATE | 3'h04 | • | • | • |
| | SPI0_MISO | 3'h05 | • | • | • |
| | VC0OUT | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA07 | SCLK10/SCL10 | 3'h01 | • | • | • |
| | TI07/TO07 | 3'h03 | • | • | • |
| | SPI0_MOSI | 3'h05 | • | • | • |
| | VC1OUT | 3'h06 | • | • | • |
| | PCLBUZ1 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA08 | TXD0/SDO00 | 3'h01 | • | • | • |
| | TI00 | 3'h02 | • | • | • |
| | TO00 | 3'h03 | • | • | • |
| | TI01_GATE | 3'h04 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA09 | TXD0/SDO00 | 3'h01 | • | • | • |
| | SCLA0 | 3'h02 | • | • | • |
| | TI01/TO01 | 3'h03 | • | • | • |
| | TI02_GATE | 3'h04 | • | • | • |
| | PCLBUZ0 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA10 | RXD0/SDI00/SDA00 | 3'h01 | • | • | • |
| | SDAA0 | 3'h02 | • | • | • |
| | TI02/TO02 | 3'h03 | • | • | • |
| | TI03_GATE | 3'h04 | • | • | • |
| | PCLBUZ1 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |

Table 4.1.1 (3/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PA11 | SS00 | 3'h01 | • | • | • |
| | SCLA0 | 3'h02 | • | • | • |
| | TI03/TO03 | 3'h03 | • | • | • |
| | TI04_GATE | 3'h04 | • | • | • |
| | SPI0_MISO | 3'h05 | • | • | • |
| | VC0OUT | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA12 | SS11 | 3'h01 | • | • | • |
| | SDAA0 | 3'h02 | • | • | • |
| | TI04/TO04 | 3'h03 | • | • | • |
| | TI05_GATE | 3'h04 | • | • | • |
| | SPI0_MOSI | 3'h05 | • | • | • |
| | VC1OUT | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA13 | RXD0/SDI00/SDA00 | 3'h01 | • | • | • |
| | TI05/TO05 | 3'h03 | • | • | • |
| | RTC1HZ | 3'h04 | • | • | • |
| | KR4 | 3'h06 | • | • | • |
| | PCLBUZ0 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA14 | TXD0/SDO00 | 3'h01 | • | • | • |
| | TI06/TO06 | 3'h03 | • | • | • |
| | KR1 | 3'h06 | • | • | • |
| | PCLBUZ1 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PA15 | RXD0/SDI00/SDA00 | 3'h01 | • | • | • |
| | TI07/TO07 | 3'h03 | • | • | • |
| | SPI0_NSS | 3'h05 | • | • | • |
| | KR0 | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |

Table 4.1.1 (4/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PB00 | TXD1/SDO10 | 3'h01 | • | • | • |
| | TI00 | 3'h02 | • | • | • |
| | TO00 | 3'h03 | • | • | • |
| | PCLBUZ0 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB01 | SCLK20/SCL20 | 3'h01 | • | • | • |
| | TI01/TO01 | 3'h03 | • | • | • |
| | PCLBUZ1 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB02 | TXD2/SDO20 | 3'h01 | • | • | • |
| | TI02/TO02 | 3'h03 | • | • | • |
| | TA_TI/TA_TO | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB03 | SCLK11/SCL11 | 3'h01 | • | • | • |
| | TI03/TO03 | 3'h03 | • | • | • |
| | TI04_GATE | 3'h04 | • | • | • |
| | SPI0_SCK | 3'h05 | • | • | • |
| | PCLBUZ0 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB04 | SDI11/SDA11 | 3'h01 | • | • | • |
| | TI04/TO04 | 3'h03 | • | • | • |
| | TI05_GATE | 3'h04 | • | • | • |
| | SPI0_MISO | 3'h05 | • | • | • |
| | TA_TI/TA_TO | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB05 | SDO11 | 3'h01 | • | • | • |
| | TI05/TO05 | 3'h03 | • | • | • |
| | TI06_GATE | 3'h04 | • | • | • |
| | SPI0_MOSI | 3'h05 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB06 | TXD0/SDO00 | 3'h01 | • | • | • |
| | SCLA0 | 3'h02 | • | • | • |
| | TI06/TO06 | 3'h03 | • | • | • |
| | TA_TI/TA_TO | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |

Table 4.1.1 (5/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PB07 | RXD0/SDI00/SDA00 | 3'h01 | • | • | • |
| | SDAA0 | 3'h02 | • | • | • |
| | TI07/TO07 | 3'h03 | • | • | • |
| | TA_TON | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB08 | SCLK00/SCL00 | 3'h01 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB09 | TXD0/SDO00 | 3'h01 | • | • | - |
| | SCLA0 | 3'h02 | • | • | - |
| | TO00 | 3'h03 | • | • | - |
| | TI07_GATE | 3'h04 | • | • | - |
| | TI00 | 3'h05 | • | • | - |
| | GPIO | 3'h00 | • | • | - |
| PB10 | TXD1/SDO10 | 3'h01 | • | • | • |
| | SCLA0 | 3'h02 | • | • | • |
| | TI02/TO02 | 3'h03 | • | • | • |
| | SPI0_SCK | 3'h05 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB11 | RXD1/SDI10/SDA10 | 3'h01 | • | • | • |
| | SDAA0 | 3'h02 | • | • | • |
| | TI03/TO03 | 3'h03 | • | • | • |
| | TI00_GATE | 3'h04 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB12 | TXD1/SDO10 | 3'h01 | • | • | • |
| | TI04/TO04 | 3'h03 | • | • | • |
| | SPI0_NSS | 3'h05 | • | • | • |
| | VC0OUT | 3'h06 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB13 | SCLK10/SCL10 | 3'h01 | • | • | • |
| | SCLA0 | 3'h02 | • | • | • |
| | TI05/TO05 | 3'h03 | • | • | • |
| | TI01_GATE | 3'h04 | • | • | • |
| | SPI0_SCK | 3'h05 | • | • | • |
| | GPIO | 3'h00 | • | • | • |

Table 4.1.1 (6/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PB14 | SS01 | 3'h01 | • | • | • |
| | SDAA0 | 3'h02 | • | • | • |
| | TI06/TO06 | 3'h03 | • | • | • |
| | RTC1HZ | 3'h04 | • | • | • |
| | SPI0_MISO | 3'h05 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PB15 | RXD2/SDI20/SDA20 | 3'h01 | • | • | • |
| | TI07/TO07 | 3'h03 | • | • | • |
| | TI02_GATE | 3'h04 | • | • | • |
| | SPI0_MOSI | 3'h05 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PC00 | SS21 | 3'h01 | • | - | - |
| | TI00 | 3'h02 | • | - | - |
| | TO00 | 3'h03 | • | - | - |
| | TI03_GATE | 3'h04 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC01 | SCLK21/SCL21 | 3'h01 | • | - | - |
| | TI01/TO01 | 3'h03 | • | - | - |
| | TA_TI/TA_TO | 3'h06 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC02 | SDI21/SDA21 | 3'h01 | • | - | - |
| | TI02/TO02 | 3'h03 | • | - | - |
| | SPI0_MISO | 3'h05 | • | - | - |
| | TA_TON | 3'h06 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC03 | SDO21 | 3'h01 | • | - | - |
| | TI03/TO03 | 3'h03 | • | - | - |
| | SPI0_MOSI | 3'h05 | • | - | - |
| | TA_TI/TA_TO | 3'h06 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC04 | TXD1/SDO10 | 3'h01 | • | - | - |
| | TI04/TO04 | 3'h03 | • | - | - |
| | PCLBUZ1 | 3'h07 | • | - | - |
| | GPIO | 3'h00 | • | - | - |

Table 4.1.1 (7/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PC05 | RXD1/SDI10/SDA10 | 3'h01 | • | - | - |
| | TI05/TO05 | 3'h03 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC06 | SCLK01/SCL01 | 3'h01 | • | - | - |
| | TI06/TO06 | 3'h03 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC07 | SDI01/SDA01 | 3'h01 | • | - | - |
| | TI07/TO07 | 3'h03 | • | - | - |
| | KR7 | 3'h06 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC08 | SDO01 | 3'h01 | • | - | - |
| | TI00 | 3'h02 | • | - | - |
| | TO00 | 3'h03 | • | - | - |
| | KR6 | 3'h06 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC09 | SCLK00/SCL00 | 3'h01 | • | - | - |
| | TI01/TO01 | 3'h03 | • | - | - |
| | KR5 | 3'h06 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC10 | TXD2/SDO20 | 3'h01 | • | - | - |
| | TI02/TO02 | 3'h03 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC11 | RXD2/SDI20/SDA20 | 3'h01 | • | - | - |
| | TI03/TO03 | 3'h03 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC12 | TXD2/SDO20 | 3'h01 | • | - | - |
| | TI04/TO04 | 3'h03 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PC13 | SCLK10/SCL10 | 3'h01 | • | • | - |
| | TI05/TO05 | 3'h03 | • | • | - |
| | RTC1HZ | 3'h04 | • | • | - |
| | GPIO | 3'h00 | • | • | - |
| PC14 | SS10 | 3'h01 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PD00 | GPIO | 3'h00 | • | • | • |
| PD01 | GPIO | 3'h00 | • | • | - |

Table 4.1.1 (8/8)

| Port name | Alternate function | Digital output function setting register pxxcfg[2:0] | Function | | |
|-----------|--------------------|--|----------|--------|-------|
| | | | 64LQFP | 48LQFP | 40QFN |
| PD02 | SCLK20/SCL20 | 3'h01 | • | - | - |
| | TI02/TO02 | 3'h03 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PD03 | RXD0/SDI00/SDA00 | 3'h01 | • | • | • |
| | SDAA0 | 3'h02 | • | • | • |
| | TI01/TO01 | 3'h03 | • | • | • |
| | SPI0_NSS | 3'h05 | • | • | • |
| | PCLBUZ1 | 3'h07 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PD04 | SCLK10/SCL10 | 3'h01 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PD05 | SCLK20/SCL20 | 3'h01 | • | - | - |
| | GPIO | 3'h00 | • | - | - |
| PD06 | SCLA0 | 3'h02 | • | • | - |
| | KR3 | 3'h06 | • | • | - |
| | GPIO | 3'h00 | • | • | - |
| PD07 | SCLK00/SCL00 | 3'h01 | • | • | - |
| | SDAA0 | 3'h02 | • | • | - |
| | KR2 | 3'h06 | • | • | - |
| | GPIO | 3'h00 | • | • | - |
| PH01 | TXD1/SDO10 | 3'h01 | • | • | • |
| | SDAA0 | 3'h02 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PH02 | RXD1/SDI10/SDA10 | 3'h01 | • | • | • |
| | SCLA0 | 3'h02 | • | • | • |
| | TI01/TO01 | 3'h03 | • | • | • |
| | GPIO | 3'h00 | • | • | • |
| PH03 | GPIO | 3'h00 | • | • | • |
| PH04 | GPIO | 3'h00 | • | • | • |
| VDD | Power supply | - | • | • | • |
| VSS | Ground | - | • | • | • |

4.2 Port alternate function

Table 4.2.1 (1/2)

| Function name | I/O | Function description |
|--|-----|---|
| ANI0 ~ ANI25 | I | A/D converter analog inputs |
| INTP0 ~ INTP5 | I | External interrupt request inputs Designation of active edges: rising edge, falling edge, double edges |
| VCnIN0, VCnIN1, VCnIN2 | I | Comparator inputs |
| VCOUT0, VCOUT1 | O | Comparator outputs |
| OPA0-DA, OPA0-FB | I/O | OPA inputs |
| OPA0 | O | OPA outputs |
| KR0 ~ KR7 | I | Key interrupt inputs |
| CLKBUZ0, CLKBUZ1 | O | Clock outputs/buzzer outputs |
| RTC1HZ | O | Correction clock (1Hz) output for real-time clock |
| RESETB | I | Active-low system reset input; if the external reset is not used, it must be connected directly or through a resistor to V_{DD} . |
| IrRxD | I | IrDA serial data inputs |
| IrTxD | O | IrDA serial data outputs |
| RxD0 ~ RxD2 | I | Serial data inputs of serial interfaces UART0, UART1, UART2 |
| TxD0 ~ TxD2 | O | Serial data outputs of serial interfaces UART0, UART1, UART2 |
| SCL00, SCL01, SCL10, SCL11, SCL20, SCL21 | O | Serial clock outputs of serial interfaces IIC00, IIC01, IIC10, IIC11, IIC20, IIC21 |
| SDA00, SDA01, SDA10, SDA11, SDA20, SDA21 | I/O | Serial data inputs/outputs of serial interfaces IIC00, IIC01, IIC10, IIC11, IIC20, IIC21 |
| SCLK00, SCLK01, SCLK10, SCLK11, SCLK20, SCLK21 | I/O | Serial clock inputs/outputs of serial interfaces SSPI00, SSPI01, SSPI10, SSPI11, SSPI20, SSPI21 |
| SDI00, SDI01, SDI10, SDI11, SDI20, SDI21 | I | Serial data inputs of serial interfaces SSPI00, SSPI01, SSPI10, SSPI11, SSPI20, SSPI21 |
| SS00, SS01, SS10, SS11, SS20, SS21 | I | Chip select inputs of serial interfaces SSPI00, SSPI01, SSPI10, SSPI11, SSPI20, SSPI21 |
| SDO00, SDO01, SDO10, SDO11, SDO20, SDO21 | O | Serial data outputs of SSPI00, SSPI01, SSPI10, SSPI11, SSPI20, SSPI21 |
| SPINSS | I | Chip select inputs of serial interface SPI |
| SPISCK | I/O | Serial clock inputs/outputs of serial interface SPI |
| SPIMISO | I/O | Serial data inputs/outputs of serial interface SPI |
| SPIMOSI | I/O | Serial data inputs/outputs of serial interface SPI |

Table 4.2.1 (2/2)

| Function name | I/O | Function description |
|---------------------|-----|--|
| SCLA0 | I/O | Serial clock inputs/outputs of serial interface IICA0 |
| SDAA0 | I/O | Serial data inputs/outputs of serial interface IICA0 |
| TI00 ~ TI07 | I | 16-bit Timer8 external counting clock/capture trigger inputs |
| TO00 ~ TO07 | O | 16-bit Timer8 outputs |
| TI00_GATE~TI07_GATE | I | 16-bit Timer8 gate inputs |
| TA_TO | O | Timer A outputs |
| TA_TI | I | Timer A inputs |
| TA_TON | O | Timer A reverse outputs |
| X1, X2 | — | Resonators for main system clock connection |
| EXCLK | I | External clock inputs for main system clock |
| XT1, XT2 | — | Resonators for slave system clock connection |
| EXCLKS | I | External clock inputs for subsystem clock |
| VDD | — | Power supply |
| AVREFP | I | Positive (+) reference voltage inputs for A/D converter |
| AVREFM | I | Negative (-) reference voltage inputs for A/D converter |
| VSS | — | Ground |
| SWDIO | I/O | SWD data interface |
| SWCLK | I | SWD clock interface |

Remark: As a measure against noise and lock-up, a bypass capacitor (approximately 0.1μF) must be connected between V_{DD} and V_{SS} with the shortest possible distance and using thicker wiring. (n=0, 1)

5 Function Summary

5.1 ARM® Cortex®-M0+ core

The ARM Cortex-M0+ processor is the latest generation of ARM processors designed for embedded systems. It offers a low-cost platform aimed at meeting the needs of microcontrollers with few pins and low power consumption while delivering excellent computing performance and advanced system interrupt response.

The Cortex-M0+ is a 32-bit RISC processor that provides superior code efficiency and high-performance expectations compared to 8-bit and 16-bit devices of similar memory size. It features 32 address lines, allowing for up to 4GB of memory space.

The BAT32G127 incorporates the embedded ARM core, making it compatible with all ARM tools and software.

5.2 Memory

5.2.1 Flash memory

The BAT32G127 has a built-in flash memory that can be programmed, erased and rewritten. It has the following features:

- Programs and data share 128K storage.
- 2.5KB dedicated data Flash memory.
- Support page erasure, the size of each page is 512byte, and erase time is 4ms.
- Support byte/half-word/word (32bit) programming, and the programming time is 24us.

5.2.2 SRAM

The BAT32G127 contains 8KB of embedded SRAM.

5.3 Enhanced DMA controller

It has a built-in enhanced DMA (Direct Memory Access) controller that enables data transfer between memories without using the CPU.

- Support DMA boot by peripheral function interrupts, enabling real-time control by communication, timer and A/D.
- The transfer source/target field is optional for the full address space range (when the flash field is used as the target address, the flash needs to be preset to the programming mode).
- Support 4 modes (normal transfer mode, repeat transfer mode, block transfer mode and chain transfer mode).

5.4 Linkage controller

The linkage controller links the output events by each peripheral function with the peripheral function trigger sources. This enables collaborative operation between peripheral functions without using the CPU.

The linkage controller has the following functions:

- It can link event signals together to realize the linkage of peripheral functions.
- There are 16 types of event input and 6 types of event triggering.

5.5 LCD controller/driver

The LCD supports 4COM*42SEG/6COM*40SEG/8COM*38SEG

Functions are as follows:

- Waveform A or waveform B can be selected.
- LCD driver voltage generation circuit can switch between internal boost, capacitor split and external resistance division.
- Automatically output segment signals and common signals by automatically reading the display data register.
- Can select from 16 reference voltages (contrast adjustment) generated when the boost circuit is running.
- Enable LCD blinking display.

5.6 Clock generation and startup

A clock generation circuit is a circuit that generates a clock to the CPU and peripheral hardware. There are three types of system clocks and clock oscillation circuits.

5.6.1 Main system clock

- X1 oscillation circuit: The resonator can be connected to pins (X1 and X2) to generate a clock oscillation of 1~20MHz, and the oscillation can be stopped by executing a deep sleep command or setting MSTOP.
- High-speed on-chip oscillator (high-speed OCO): Oscillation can be performed by selecting the frequency by the option byte. After released, the CPU starts running at this high-speed on-chip oscillator clock by default. Oscillation can be stopped by executing a deep sleep command or setting the HIOSTOP bit. The frequency set by the option byte can be changed through the frequency selection register of the high-speed on-chip oscillator. The maximum frequency is 32MHz with an accuracy $\pm 1.0\%$.
- Input external clock from pin (X2): (1~20MHz), and the input of the external main system clock can be invalidated by executing a deep sleep command or setting the MSTOP bit.

5.6.2 Subsystem clock

- XT1 oscillator circuit: A 32.768kHz clock oscillation can be generated by connecting a 32.768kHz resonator to the pins (XT1 and XT2), and the oscillation can be stopped by setting the XTSTOP bit.
- An external clock input by the pin (XT2): 32.768kHz, and the external clock input can be disabled by setting the XTSTOP bit.

5.6.3 Low-speed on-chip oscillator clock

- Low-speed on-chip oscillator (low-speed OCO): generate a 32kHz (TYP.) clock oscillation. The low-speed on-chip oscillator clock cannot be used as the CPU clock. Only the following peripheral hardware can run off the low-speed on-chip oscillator clock:
 - Watchdog timer (WWDT)
 - Real time clock (RTC)
 - 15-bit interval timer

5.7 Power management

5.7.1 Power supply mode

V_{DD} : External power supply, voltage range: 1.8 to 5.5V.

5.7.2 Power-on reset

The power-on reset circuit (POR) has the following functions.

- An internal reset signal is generated when power is applied. If the supply voltage (V_{DD}) is greater than the detection voltage (V_{POR}), the reset is released. However, the reset state must be maintained by a voltage detection circuit or an external reset until the operating voltage range is reached.
- Compare the supply voltage (V_{DD}) and the detection voltage (V_{POR}), when $V_{DD} < V_{POR}$, an internal reset signal is generated. However, when the power supply drops, it must be shifted to the deep sleep mode or set to the reset state by the voltage detection circuit or external reset before falling below the operating voltage range. If operation is to be restarted, it must be verified that the power supply voltage has returned to within the operating voltage range.

5.7.3 Voltage detection

The voltage detection circuit sets the operating mode and detection voltage (V_{LVDH} , V_{LVDL} , V_{LVD}) via option bytes. The voltage detection (LVD) circuit has the following functions:

- Compare the supply voltage (V_{DD}) and the detection voltage (V_{LVDH} , V_{LVDL} , V_{LVD}) and generate an internal reset or interrupt request signal.
- The sense voltage of the supply voltage (V_{LVDH} , V_{LVDL} , V_{LVD}) can be selected by option bytes.
- Can run in deep sleep mode.
- When the power supply rises, it must be maintained in the reset state by voltage detection circuitry or an external reset before reaching the operating voltage range. When the power supply drops, it must be switched to deep sleep mode before it is less than the operating voltage range, or set to reset by voltage detection circuit or external reset.
- The operating voltage range varies depending on the setting of user option bytes.

5.8 Low-power mode

The BAT32G127 supports two low-power modes to achieve the best compromise between low power consumption, short start-up time, and available wake-up sources:

- **Sleep mode:** Sleep mode is entered by executing the sleep instruction. Sleep mode is a mode to stop the CPU running clock. If the high-speed system clock oscillator circuit or the high-speed on-chip oscillator is oscillating before the sleep mode is set, each clock continues to oscillate. Although this mode does not allow the operating current to be reduced to the level of deep sleep mode, it is an effective mode when processing is to be restarted immediately by an interrupt request or when frequent intermittent operation is to be performed.
- **Deep sleep mode:** Deep sleep mode is entered by executing the deep sleep instruction. Deep sleep mode is a mode that stops the oscillation of the high-speed system clock oscillator and high-speed on-chip oscillator and stops the whole system. The operating current of the chip can be greatly reduced. Since the deep sleep mode can be canceled by an interrupt request, intermittent operation is also possible. However, in the case of the X1 clock, since it is necessary to wait for the oscillation to stabilize when releasing the deep sleep mode, it is necessary to select the sleep mode if it is necessary to start processing immediately by an interrupt request.

In any of these modes, the registers, flags, and data memories remain as they were before being set to standby mode, and the status of the output latches and output buffers of the input/output ports is also maintained.

5.9 Reset function

A reset signal can be generated by the following seven methods:

- (1) An external reset is input via the RESETB pin.
- (2) An internal reset is generated by programmed runaway detection of the watchdog timer.
- (3) An internal reset is generated by comparing the supply voltage and the detection voltage of POR.
- (4) An internal reset is generated by comparing the supply voltage and the detection voltage of LVD.
- (5) An internal reset is generated by a RAM parity error.
- (6) An internal reset is generated by accessing to the illegal memory.
- (7) Software reset

The internal reset is the same as the external reset, and after the reset signal is generated, the procedure is executed from the addresses written in 0000H and 0001H.

5.10 Interrupt function

The Cortex-M0+ processor has a built-in Nested Vector Interrupt Controller (NVIC) that supports up to 32 interrupt request (IRQ) inputs, a non-maskable interrupt (NMI) input, and multiple internal exceptions.

The product handles 32 maskable interrupt requests (IRQs) and 1 non-maskable interrupt (NMI), as described in the corresponding section of the User's Manual. The actual number of interrupt sources varies by product.

5.11 Real-time clock (RTC)

Functions of real-time clock (RTC) are show as below.

- Holds counters for years, months, weeks, days, hours, minutes, and seconds
- Fixed cycle break (cycles: 0.5 seconds, 1 second, 1 minute, 1 hour, 1 day, 1 month)
- Alarm clock interrupt (alarm clock: week, hour, minute)
- 1Hz pin out capability
- Support prescalers of subsystem clock or main system clock as RTC operation clocks.
- Real-time clock interrupt signals (INTRTC) can be used to wake up in deep sleep mode.
- Watch error correction with high accuracy

Year, month, week, day, hour, minute and second counters are only available if the subsystem clock (32.768kHz) or main system clock prescaler is selected as the RTC operation clock. When the low-speed on-chip oscillator clock (32kHz) is selected, only the fixed-cycle interrupt function can be used.

5.12 Watchdog timer

The 1- channel WWDT and 17-bit watchdog timer operation are set by option byte count. The watchdog timer operates on a low-speed on-chip oscillator clock (32KHz). The watchdog timer is used to detect program instability. When program instability is detected, an internal reset signal is generated.

The following are judged to be program instability:

- When the watchdog timer counter overflows
- When a bit operation instruction is executed on the watchdog timer enable register (WDTE)
- When writing data other than "ACH" to the WDTE register
- When writing data to the WDTE register during window closure

5.13 SysTick timer

This timer is exclusive to real-time operating systems, but can also be used as a standard decrement counter.

It is characterized by the generation of a maskable system interrupt when the 24-bit decrementing counter self-loading capacity counter reaches zero.

5.14 Timer8

This product has a built-in Timer8, a timer unit containing an 8-channel 16-bit timer. Each 16-bit timer is called a “channel” and can be used as an independent timer or in combination with multiple channels for advanced timer functions.

For details of each function, refer to the table below.

| Independent channel operation function | Multi-channel linkage operation function |
|---|--|
| <ul style="list-style-type: none"> ● Interval timer ● Square wave output ● External event counter ● Frequency divider ● Input pulse interval measurement ● Input signal high/low width measurement ● Delay counter | <ul style="list-style-type: none"> ● Single trigger pulse output ● PWM output ● Multiple PWM output |

5.14.1 Independent channel operation function

The independent channel operation function is a function that allows you to use any channel independently of other channel operation modes. The independent channel operation function is used in the following modes:

- (1) Interval timer: It can be used as a reference timer for generating interrupts at fixed intervals (INTTM).
- (2) Square wave output: Whenever an INTTM interrupt is generated, a flip is triggered to output a 50% duty cycle square wave from the timer output pin (TO).
- (3) External event counter: Count the effective edge of the input signal of the timer input pin (TI) and can be used as an event counter to generate an interrupt if the specified number of times is reached.
- (4) Divider function (limited to channel 0 of unit 0): divide the input clock of the timer input pin (TI00) and output it from the output pin (TO00).
- (5) Measurement of input pulse interval: The interval between input pulses is measured by starting counting at the effective edge of the input pulse signal at the timer input pin (TI) and capturing the count value at the effective edge of the next pulse.
- (6) High/low width measurement of input signal: Measure the high or low width of the input signal by starting counting on one edge of the input signal of the timer input pin (TI) and capturing the count value on the other edge.
- (7) Delay counter: Starts counting at the effective edge of the input signal at the timer input pin (TI) and generates an interrupt after an arbitrary delay period has elapsed.

5.14.2 Multi-channel linkage operation function

The multi-channel linkage operation function is a function that combines the master channel (the reference timer for the main control period) and the slave channel (the timer that follows the operation of the master channel). The multi-channel linkage function can be used in the following modes:

- (1) Single trigger pulse output: Two channels are used in pairs to generate a single trigger pulse that can arbitrarily set the output timing and pulse width.
- (2) PWM (Pulse Width Modulation) output: Two channels are used in pairs to generate pulses that can set the period and duty cycle arbitrarily.
- (3) Multiple PWM (Pulse Width Modulation) output: Up to 7 PWM signals of any duty cycle can be generated at a fixed period by expanding the PWM function and using one master channel and multiple slave channels.

5.14.3 8-bit timer operation function

The 8-bit timer operation function uses the 16-bit timer channel as the function of two 8-bit timer channels. (Only Channel 1 and Channel 3 can be used).

5.14.4 LIN-bus support function

The Timer8 (channel 3 only) unit can be used to check whether the received signal in the LIN-bus communication is suitable for the LIN-bus communication format.

- 1) Wake-up signal detection: The low-level width is measured by starting counting on the falling edge of the input signal on the UART serial data input pin (RxD) and capturing the count value on the rising edge. If the low width is greater than or equal to a fixed value, it is considered a wake-up signal.
- 2) Detection of the break field: After a wake-up signal is detected, the low-level width is measured by starting counting from the falling edge of the input signal of the UART serial data input pin (RxD) and capturing the count value on the rising edge. If the width of the low level is greater than or equal to a fixed value, it is considered to be a break field.
- 3) Measurement of sync field pulse width: After detecting the break field, measure the low- and high-level widths of the input signal of the UART serial data input pin (RxD). The baud rate is calculated from the bit interval of the synchronization field measured in this way.

5.15 TimerA

Timer A is a 16-bit timer capable of pulse output, measuring the width and period of external input pulses, and counting external events.

The 16-bit timer consists of a reload register and a down-counting counter. The reload register and the down-counting counter share the same address. Accessing the TA0 register allows access to both the reload register and the counter.

5.16 15-bit interval timer

This product has a built-in 15-bit interval timer that generates interrupts (INTIT) at any pre-set time interval, which can be used to wake up from deep sleep mode.

5.17 Clock output/buzzer output controller

The clock output controller is used to provide a clock to the peripheral ICs, and the buzzer output controller is used to output a square wave at the buzzer frequency. The clock output or buzzer output is realized by dedicated pins.

5.18 Universal serial communication unit

This product has a built-in general-purpose serial communication unit, and each unit has up to 8 serial communication channels. It can realize standard SPI, simplified SPI, UART and simple I²C communication functions. Taking the 64-pin product as an example, the functions of each channel are assigned as follows.

5.18.1 3-wire serial interface (SSPI)

Data is transmitted and received synchronously with the serial clock (SCK) output of the master device.

This is a clock-synchronous communication interface that communicates using a total of three communication lines: one serial clock (SCK), one transmit serial data (SO), and one receive serial data (SI).

[Data transmission and reception]

- Data length of 7 to 16 bits
- Phase control of data transmission and reception
- MSB/LSB first
- Level setting for transmitting and receiving data

[Clock control]

- Master or slave selection
- Phase control of input/output clock
- Transfer cycles generated by prescalers and channel internal counters
- Maximum transfer rate

Master communication: Max. $F_{CLK}/2$

Slave communication: Max. $F_{MCK}/6$

[Interrupt function]

- Transfer end interrupt, buffer null interrupt

[Error detection flag]

- Overflow error

5.18.2 UART

This function enables asynchronous communication over two lines, serial data transmission (TxD) and serial data reception (RxD). Using these two communication lines, data is transmitted and received asynchronously (using the internal baud rate) with other communicating parties in the data frame (consisting of start bits, data, parity bits, and stop bits). Full-duplex UART communication can be implemented by using two channels, dedicated transmitting (even channels) and dedicated receiving (odd channels), and LIN-bus can also be supported by combining a Timer8 unit and an external interrupt (INTP0).

[Data transmission and reception]

- Data length of 7, 8, 9 or 16 bits
- MSB/LSB first
- Level setting for transmitting and receiving data, selection of reverse phase
- Parity bit appending, parity check function
- Stop bit appending

[Interrupt function]

- Transfer end interrupt and buffer null interrupt
- Frame error and parity check error

[Error detection flag]

- Frame error, parity error, overflow error

[LIN-bus function]

- Detection of wake-up signal
- Detection of break field (BF)
- Measurement of synchronous field, calculation of baud rate

5.18.3 Simplified I²C

It is a function to synchronize clock communication with multiple devices through two lines of serial clock (SCL) and serial data (SDA). Since this simplified I²C is designed for single communication with devices such as Flash memory, and A/D converters, it is used only as a master device. The start and stop conditions, like the operation control registers, must comply with the AC characteristics and are handled by the software.

[Data transmission and reception]

- Master transmission, master reception (limited to the master function of single master)
- ACK output function, ACK detection function
- 8-bit data length (when transmitting the addresses, specify the addresses with the highest 7 bits, and use the lowest bit for R/W control)
- Start and stop conditions are generated by software

[[Interrupt function]

- Transfer end interruption

[Error detection flag]

- ACK error, overflow error

[Simplified I²C unsupported features]

- Slave transmission, slave reception
- Multi-master function (arbitration failure detection function)
- Wait detection function

5.19 Standard serial interface SPI

The standard serial interface SPI has the following two modes:

- 1) Run-stop mode: This is the mode used when serial transfer is not performed, which reduces power consumption.
- 2) 3-wire serial I/O mode: This mode transmits 8-bit or 16-bit data to multiple devices over 3 wires of a serial clock (SCK) and 2 serial data buses (MISO and MOSI).

5.20 Standard serial interface IICA

The serial interface IICA has the following three modes:

- 1) Run-stop mode: This is the mode used when serial transfer is not performed, which reduces power consumption.
- 2) I²C bus mode (support multi-master): This mode transmits 8-bit data to multiple devices over 2 wires of a serial clock (SCLA) and a serial data bus (SDAA). In accordance with the I²C bus format, the master device can generate “start conditions”, “address”, “indication of transmission direction”, “data” and “stop conditions” on the serial data bus for the slave devices. The slave device automatically detects the received status and data by hardware. This feature simplifies the I²C bus control part of the application program. Since the SCLA and SDAA pins of the serial interface IICA are used as open drain outputs, pull-up resistors are required for the serial clock line and the serial data bus.
- 3) Wake-up mode: In deep sleep mode, when an extension code or a local station address is received from the master device, the deep sleep mode can be released by generating an interrupt request signal (INTIICA). This is set via the IICA control register.

5.21 Analog-to-digital converter (ADC)

This product has a built-in 12-bit resolution analog-to-digital converter, SARADC, which converts analog inputs to digital values and controls the A/D conversion of up to 26 analog channels (ANI0~ANI25).

The ADC contains the following functions:

- 12-bit resolution, slew rate: 0.71MSPS.
- Triggering mode: support software triggering, hardware triggering and hardware triggering in standby state.
- Channel selection: support single-channel select mode and multi-channel scan mode.
- Conversion mode: support single conversion and continuous conversion.
- Operating voltage: support $1.8V \leq V_{DD} \leq 5.5V$ operating voltage range.
- It can detect the built-in reference voltage (1.45V) and temperature sensors.

The ADC can set various A/D conversion modes by combining the modes described below.

| | | |
|---------------------------------|---|--|
| Trigger mode | Software trigger | Start the conversion by operating the software. |
| | Hardware-trigger no-wait mode | The conversion is started by detecting a hardware trigger. |
| | Hardware trigger wait mode | In the conversion standby state when the power is cut off, the power is turned on by detecting the hardware trigger, and the conversion starts automatically after the A/D power stabilization waiting time. |
| Channel select mode | Select mode | Select 1 channel of analog input for A/D conversion. |
| | Scan mode | Four consecutive channels can be selected as analog inputs for sequential A/D conversion. Four consecutive channels from ANI0 to ANI25 can be selected as analog inputs. |
| Conversion mode | Single conversion mode | Perform an A/D conversion for the selected channel. |
| | Continuous conversion mode | Perform continuous A/D conversions for the selected channel until stopped by the software. |
| Sample time/ conversion time | Number of sample clocks/ conversion clocks | The sampling time can be set by register, the default value of sampling clock number is 13.5 clk, and the minimum value of conversion clock number is 31.5 clk. |

5.22 Digital-to-analog converter (D/A)

The D/A converter is an 8-bit resolution converter that converts digital inputs to analog signals and controls the analog outputs. It has the following functions.

- 8-bit resolution
- R-2R ladder network
- Analog output voltage
8-bit resolution: $V_{DD} * m8 / 256$ (m8: DACSi register set value)
- Operation modes
Normal mode, real-time output mode

Remark: i=0

5.23 Operational amplifier (OPA)

This product includes an operational amplifier (OPA) with the following features:

- Supports rail-to-rail operation
- The OPA can operate in constant current mode or buffer mode; the buffer mode can be used to test OPA offset
- The negative feedback terminal of the OPA supports either an internal constant current resistor or an external pin OPA_FB
- The analog input at the positive terminal of the OPA can be selected from either the built-in 5-bit DAC of the op-amp module or the 8-bit DAC provided with this product
- The output of the OPA can be used as an analog input for the A/D converter or as a positive terminal analog input for the comparator 0 (CMP0)

5.24 Comparator (CMP)

This product has built-in two-channel comparators CMP0 and CMP1 with the following features:

- Can select comparator high speed mode, comparator low speed mode, or comparator window mode.
- The external reference input and internal reference voltage can be selected for the reference voltage.
- The cancellation width of the noise cancellation digital filter can be selected.
- Can detect the active edge of the comparator output and generate an interrupt signal.
- Can detect the active edge of the comparator output and output the event signal to the linkage controller.

5.25 Two-wire serial debug port (SW-DP)

The ARM's SW-DP interface allows connection to the microcontroller via a serial line debugging tool.

5.26 Safety functions

5.26.1 Flash CRC function (high-speed CRC, universal CRC)

This detects data errors in the flash memory by performing CRC operations.

The following two CRCs can be used according to the application or purpose of use.

- High-speed CRC: During the initialization routine, it can stop the CPU and check the entire code flash area at high speed.
- Universal CRC: This can be used for multi-purpose checking during CPU operation, not limited to the code flash area.

5.26.2 RAM parity error detection function

This detects parity errors when reading RAM data.

5.26.3 SFR guard function

This prevents SFRs from being rewritten when the CPU freezes.

5.26.4 Illegal memory access detection function

This detects illegal access to a invalid memory areas (asuch as areas where no memory is allocated and areas to which access is restricted).

5.26.5 Frequency detection function

Able to use the Timer8 unit to self-test the CPU or peripheral hardware clock frequencies.

5.26.6 A/D test function

The A/D converter is self-tested by A/D converting the positive (+) reference voltage, the negative (-) reference voltage, the analog input channel (ANI), the temperature sensor output voltage, and the internal reference voltage.

5.26.7 Digital output signal level detection function for input/output ports

When the input/output port is in output mode, the output level of the pin can be read.

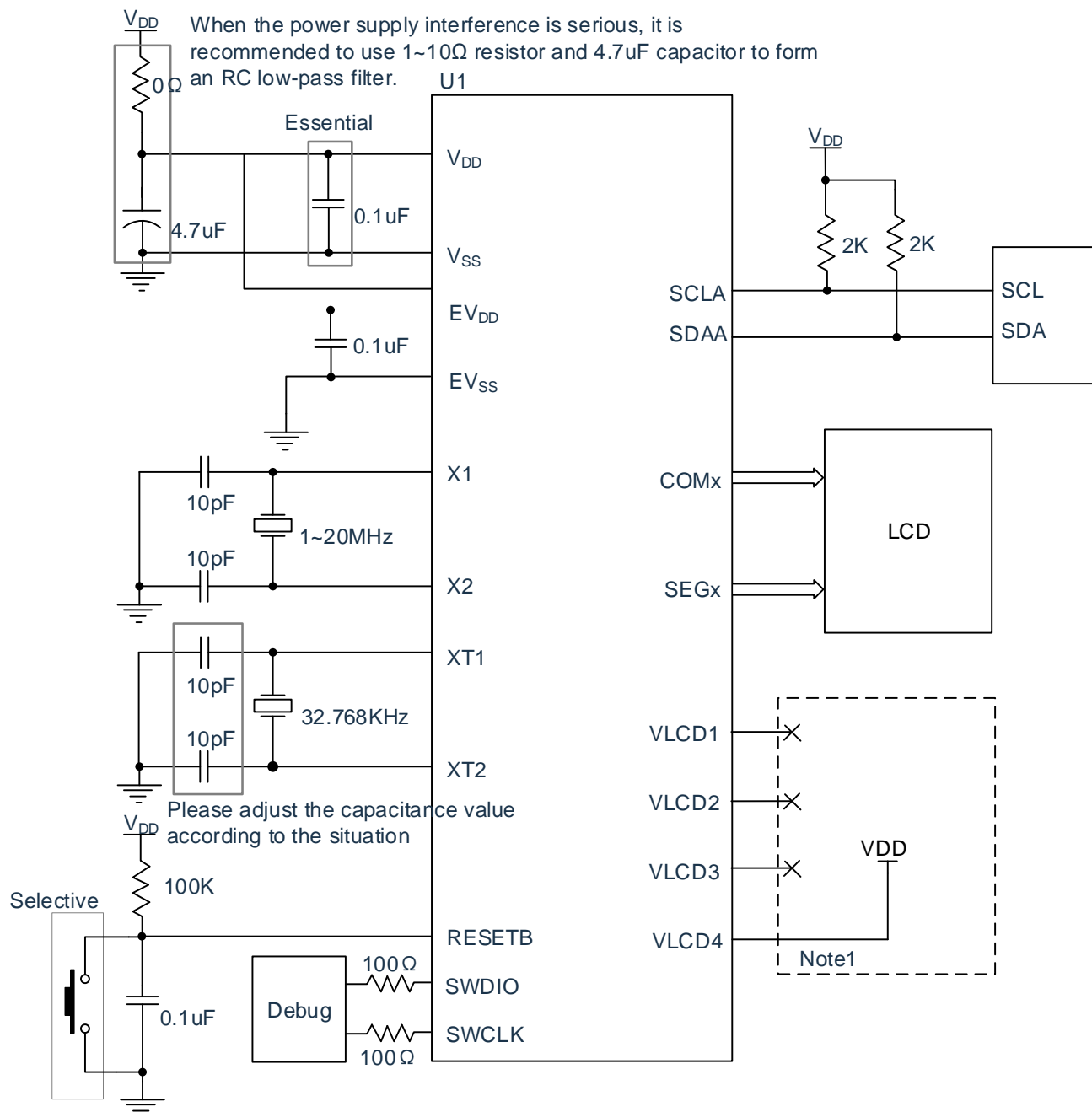
5.27 Key function

A key interrupt (INTKR) can be generated by inputting the falling edge of the key interrupt input pins (KR0~KR7).

6 Electrical Characteristics

6.1 Typical application peripheral circuit

The reference diagram for the connection of peripheral circuits for typical MCU applications is as follows:



Note 1: This connection is for internal resistor voltage divider. For more information about LCD driver power generation, please refer to section 19.6 in User Manual.

6.2 Absolute maximum voltage ratings

Absolute maximum voltage ratings (1/2) ($T_A = -40 \sim 105^\circ\text{C}$)

| Item | Symbol | Condition | Rating | Unit |
|----------------------|----------|--|---|------|
| Supply voltage | V_{DD} | - | $-0.5 \sim +6.5$ | V |
| Input voltage | V_I | PA00~PA15, PB00~PB15, PC00~PC14 PD00~PD07, PH01~PH04, RESETB/PH00 | $-0.3 \sim V_{DD} + 0.3$ ^{Note 1} | V |
| Output voltage | V_O | PA00~PA15, PB00~PB15, PC00~PC14 PD00~PD07, PH00~PH04 | $-0.3 \sim V_{DD} + 0.3$ ^{Note 1} | V |
| Analog input voltage | V_{AI} | ANI0~ANI25 | $-0.3 \sim V_{DD} + 0.3$ and $-0.3 \sim AV_{REF}(+) + 0.3$ ^{Note 1,2} | V |

Note 1: No more than 6.5V.

Note 2: The pin of the A/D conversion target cannot exceed $AV_{REF}(+) + 0.3$.

Caution: Even if one item in each item instantly exceeds the absolute maximum rating, it may reduce the quality of the product. The absolute maximum ratings are the ratings that may cause physical damage to the product, and the product must be used in a state that do not exceed the ratings.

Remark:

1. Unless otherwise specified, the characteristics of alternate-function pins are the same as the characteristics of the port pins.
2. $AV_{REF}(+)$: A/D converter positive (+) reference voltage
3. V_{SS} : Reference voltage.
4. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

Absolute maximum voltage ratings (2/2) (TA= -40~105°C)

| Item | Symbol | Condition | | Rating | Unit |
|-------------|------------------|---|-------------------------------------|--|------|
| LCD voltage | V _{LI1} | V _{L1} input voltage ^{Note 1} | | -0.3~+2.8 | V |
| | V _{LI2} | V _{L2} input voltage ^{Note 1} | | -0.3~+6.5 | V |
| | V _{LI3} | V _{L3} input voltage ^{Note 1} | | -0.3~+6.5 | V |
| | V _{LI4} | V _{L4} input voltage ^{Note 1} | | -0.3~+6.5 | V |
| | V _{LI5} | CAPL, CAPH input voltage ^{Note 1} | | -0.3~+6.5 | V |
| | V _{LO1} | V _{L1} output voltage | | -0.3~+6.5 | V |
| | V _{LO2} | V _{L2} output voltage | | -0.3~+6.5 | V |
| | V _{LO3} | V _{L3} output voltage | | -0.3~+6.5 | V |
| | V _{LO4} | V _{L4} output voltage | | -0.3~+6.5 | V |
| | V _{LO5} | CAPL, CAPH output voltage ^{Note 1} | | -0.3~+6.5 | V |
| | V _{LO6} | COM0~COM7, | External resistance division method | -0.3~V _{DD} +0.3 ^{Note 2} | V |
| | | SEG0~SEG41 | Capacitor split method | -0.3~V _{DD} +0.3 ^{Note 2} | V |
| | | output voltage | Internal voltage boosting method | -0.3~V _{LI4} +0.3 ^{Note 2} | V |

Note 1: These values are the absolute maximum ratings specified when applying voltage to the V_{L1}, V_{L2}, V_{L3}, and V_{L4} pins, and are not the recommended applied voltage values. In the case of the internal voltage boosting method and the capacitor split method, the V_{L1}, V_{L2}, V_{L3}, and V_{L4} pins must be connected to V_{SS} by a capacitor (0.47uF±30%), and a capacitor (0.47uF±30%) must also be connected between the CAPL pin and the CAPH pin.

Note 2: No more than 6.5V.

Remark: Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.3 Absolute maximum current ratings

($T_A = -40 \sim 105^\circ\text{C}$)

| Item | Symbol | Condition | | Rating | Unit |
|-------------------------------|------------------|----------------------------------|---|---------|------|
| Output current, high | I _{OH1} | Per pin | PA00~PA15, PB00~PB15, PC00~PC14 PD00~PD07, PH00~PH02 | -40 | mA |
| | | Total of all pins -170mA | PA00~PA01, PB00~PB07 | -70 | mA |
| | | | PB00~PB07, PC00~PC01 | -100 | mA |
| | I _{OH2} | Per pin | PH03~PH04 | -3 | mA |
| | | Pin total | | -15 | mA |
| Output current, low | I _{OL1} | Per pin | PA00~PA14, PB00~PB14, PC00~PC14 PD00~PD07, PH00~PH02 | 40 | mA |
| | | Total of all pins 170mA | PA00~PB01, PA00~PB07 | 100 | mA |
| | | | PB00~PB07, PD00~PD01 | 120 | mA |
| | I _{OL2} | Per pin | PH03~PH04 | 15 | mA |
| | | Total of all pins | | 45 | mA |
| Operating ambient temperature | T _A | In normal operation mode | | -40~105 | ℃ |
| | | In flash memory programming mode | | | |
| Storage temperature | T _{stg} | - | | -65~150 | ℃ |

Caution: Even if one item in each item instantly exceeds the absolute maximum rating, it may reduce the quality of the product. The absolute maximum rating is the rating that may cause physical damage to the product, and the product must be used in a state that do not exceed the ratings.

Remark:

1. Unless otherwise specified, the characteristics of alternate-function pins are the same as the characteristics of the port pins.
2. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.4 Oscillation circuit characteristics

6.4.1 X1, XT1 characteristics

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Resonator | Condition | Min. | Typ. | Max. | Unit |
|--|---------------------------|-------------------|------|--------|------|------|
| X1 clock oscillation frequency (F_X) | Ceramic/crystal resonator | - | 1.0 | - | 20.0 | MHz |
| X1 clock oscillation stabilization time | Ceramic/crystal resonator | 20MHz, C=10pF | - | 15 | - | ms |
| X1 clock oscillation feedback resistor | Ceramic/crystal resonator | - | 0.6 | - | 1.8 | MΩ |
| XT1 clock oscillation frequency (F_{XT}) | Crystal resonator | - | 32 | 32.768 | 35 | KHz |
| XT1 clock oscillation stabilization time | Crystal resonator | 32.768KHz, C=10pF | - | 2 | - | s |

Remark:

1. It only indicates the frequency tolerance range of the oscillation circuit, and the instruction execution time should be referred to the AC characteristics.
2. Please ask the resonator manufacturer to evaluate the circuit after installation, and use it after confirming the oscillation characteristics.
3. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.4.2 On-chip oscillator characteristics

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Resonator | Condition | Min. | Typ. | Max. | Unit |
|--|------------------------------------|--------|------|--------|------|
| High-speed on-chip oscillator clock frequency (F_{IH}) ^{Note 1,2} | - | 1.0 | - | 32.0 | MHz |
| High-speed on-chip oscillator stabilization time (T_{SU}) | - | - | 12 | - | us |
| High-speed on-chip oscillator clock frequency accuracy | $T_A = 0 \sim 70^\circ\text{C}$ | -2.5 | - | +2.5 | % |
| | $T_A = -10 \sim 105^\circ\text{C}$ | -4.5 | - | +4.5 | % |
| | $T_A = -40 \sim 105^\circ\text{C}$ | -7.0 | - | +7.0 | % |
| Low-speed on-chip oscillator clock frequency (F_{IL}) | - | 26.214 | 32.0 | 39.322 | KHz |

Note 1: Select the frequency of the high-speed on-chip oscillator via option bytes.

Note 2: It only indicates the characteristics of the oscillation circuit, so please refer to the AC characteristics for the instruction execution time.

Remark: Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.5 DC characteristics

6.5.1 Pin characteristics

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} = V_{DD} \leq 5.5\text{V}$, $V_{SS} = V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|--|------------------|---|---|------|------|-------------------------|------|
| Output current, high ^{Note 1} | I _{OH1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH02 Per pin | 1.8V≤EV _{DD} ≤5.5V -40~85°C | - | - | -12.0 ^{Note 2} | mA |
| | | | 1.8V≤EV _{DD} ≤5.5V 85~105°C | - | - | -6.0 ^{Note 2} | |
| | | PA14~PA15, PB03~PB09, PC00~PC03, PC10~PC14, PD00~PD03, PH00~PH02 Total (when duty cycle≤ 70% ^{Note3}) | 4.0V≤V _{DD} ≤5.5V 40~85°C | - | - | -50.0 | mA |
| | | | 4.0V≤EV _{DD} ≤5.5V 85~105°C | - | - | -30.0 | |
| | | | 2.4V≤V _{DD} <4.0V | - | - | -15mA | mA |
| | | | 1.8V≤V _{DD} <2.4V | - | - | -10mA | mA |
| | | PA00~PA13, PB00~PB02, PB10~PB15, PC04~PC09, PD04~PD07 Total (when duty cycle≤ 70% ^{Note3}) | 4.0V≤V _{DD} ≤5.5V 40~85°C | - | - | -50.0 | mA |
| | | | 4.0V≤EV _{DD} ≤5.5V 85~105°C | - | - | -30.0 | |
| | | | 2.4V≤V _{DD} <4.0V | - | - | -15mA | mA |
| | | | 1.8V≤V _{DD} <2.4V | - | - | -10mA | mA |
| | | Total (when duty cycle≤ 70% ^{Note3}) | 4.0V≤V _{DD} ≤5.5V 40~85°C | - | - | -100.0 | mA |
| | | | 4.0V≤EV _{DD} ≤5.5V 85~105°C | - | - | -60.0 | |
| | | | 2.4V≤V _{DD} <4.0V | - | - | -30mA | |
| | | | 1.8V≤V _{DD} <2.4V | - | - | -20mA | |
| | I _{OH2} | PH03 ~ PH04 Per pin | 1.8V≤EV _{DD} ≤5.5V | - | - | -2.5 ^{Note 2} | mA |
| | | Total (when duty cycle≤ 70% ^{Note3}) | 1.8V≤EV _{DD} ≤5.5V | - | - | -5 | mA |

Note 1: This is the value of current that guarantees the operation of the device even if current flows from the V_{DD} pin to the output pins.

Note 2: The total current value cannot be exceeded.

Note 3: This is the output current value for the "Duty cycle \leq 70% condition".

The following formula can be used to calculate the output current value when the duty cycle is changed to $>70\%$ (when the duty cycle is changed to $n\%$).

- Total pin output current = $(I_{OH} \times 0.7) / (n \times 0.01)$

<Calculation example> $I_{OH} = -10.0\text{mA}$, $n = 80\%$

Total pin output current = $(-10.0 \times 0.7) / (80 \times 0.01) \approx -8.7\text{mA}$

The current at each pin does not vary by duty cycle and will not flow above the absolute maximum rating.

Caution: Setting to N-channel open drain mode will not output a high level.

Remark:

1. Unless otherwise specified, the characteristics of alternate-function pins are the same as the characteristics of the port pins.
2. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq \text{EV}_{\text{DD}} = \text{V}_{\text{DD}} \leq 5.5\text{V}$, $\text{V}_{\text{SS}} = \text{EV}_{\text{SS}} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit | |
|---------------------------------------|------------------|---|---|------|----------------------|----------------------|----|
| Output current, low ^{Note 1} | I _{OL1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH02 Per pin | 1.8V≤EV _{DD} ≤5.5V -40~85°C | - | - | 30 ^{Note 2} | mA |
| | | 1.8V≤EV _{DD} ≤5.5V 85~105°C | - | - | 15 ^{Note 2} | | |
| | | PA14~PA15, PB03~PB09, PC00~PC03, PC10~PC14, PD00~PD03, PH00~PH02 Total (when duty cycle≤70% ^{Note3}) | 4.0V≤V _{DD} ≤5.5V 40~85°C | - | - | 60 | mA |
| | | 4.0V≤EV _{DD} ≤5.5V 85~105°C | - | - | 45 | | |
| | | 2.4V≤V _{DD} <4.0V | - | - | 25 | mA | |
| | | 1.8V≤V _{DD} <2.4V | - | - | 15 | mA | |
| | | PA00~PA13, PB00~PB02, PB10~PB15, PC04~PC09, PD04~PD07 Total (when duty cycle≤70% ^{Note3}) | 4.0V≤V _{DD} ≤5.5V 40~85°C | - | - | 60 | mA |
| | | 4.0V≤EV _{DD} ≤5.5V 85~105°C | - | - | 45 | | |
| | | 2.4V≤V _{DD} <4.0V | - | - | 25 | mA | |
| | | 1.8V≤V _{DD} <2.4V | - | - | 15 | mA | |
| | | Total (when duty cycle≤70% ^{Note3}) | 4.0V≤V _{DD} ≤5.5V 40~85°C | - | - | 120 | mA |
| | | 4.0V≤EV _{DD} ≤5.5V 85~105°C | - | - | 90 | | |
| | | 2.4V≤V _{DD} <4.0V | - | - | 50 | | |
| | | 1.8V≤V _{DD} <2.4V | - | - | 30 | | |
| | I _{OL2} | PH03 ~ PH04 Per pin | 1.8V≤EV _{DD} ≤5.5V | - | - | 8 ^{Note 2} | mA |
| | | Total (when duty cycle≤70% ^{Note3}) | 1.8V≤EV _{DD} ≤5.5V | - | - | 15 | mA |

Note 1: This is the value of current that guarantees the operation of the device even if current flows from the output pins to the V_{SS} pin.

Note 2: The total current value cannot be exceeded.

Note 3: This is the output current value for the "Duty cycle \leq 70% condition".

The following formula can be used to calculate the output current value when the duty cycle is changed to $>70\%$ (n% duty cycle).

$$\bullet \text{ Total output current} = (\text{I}_{\text{OL}} \times 0.7) / (n \times 0.01)$$

<Calculation example> $\text{I}_{\text{OL}} = 10.0\text{mA}$, $n = 80\%$

$$\text{Total output current} = (10.0 \times 0.7) / (80 \times 0.01) \approx 8.7\text{mA}$$

The current at each pin does not vary by duty cycle and will not flow above the absolute maximum

rating.

Remark:

1. Unless otherwise specified, the characteristics of alternate-function pins are the same as the characteristics of the port pins.
2. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|----------------------------|-----------------------|---|---------------|-------------|------|-------------|------|
| Power supply input voltage | V_{DD} EV_{DD} | - | | 1.8 | - | 5.5 | V |
| Power ground input voltage | V_{SS} EV_{SS} | - | | -0.3 | - | - | V |
| Input voltage, high | V_{IH1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH04 | Schmitt input | $0.8V_{DD}$ | - | V_{DD} | V |
| Input voltage, low | V_{IL1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH04 | Schmitt input | 0 | - | $0.2V_{DD}$ | V |

Caution: Setting to N-channel open drain mode will not output a high level.

Remark:

1. Unless otherwise specified, the characteristics of alternate-function pins are the same as the characteristics of the port pins.
2. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

$(T_A = -40 \sim 105^{\circ}\text{C}, 1.8\text{V} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|-------------------------|------------------|---|--|----------------------|------|------|------|
| Output voltage, high | V _{OH1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH02 | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH1} = -12.0\text{mA}$ | V _{DD} -1.5 | - | - | V |
| | | | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH1} = -6.0\text{mA}$ | V _{DD} -0.7 | - | - | V |
| | | | $2.4\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH1} = -3.0\text{mA}$ | V _{DD} -0.6 | - | - | V |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH1} = -2.0\text{mA}$ | V _{DD} -0.5 | - | - | V |
| | V _{OH2} | PH03~PH04 | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH2} = -2.5\text{mA}$ | V _{DD} -1.5 | - | - | V |
| | | | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH2} = -1.5\text{mA}$ | V _{DD} -0.7 | - | - | V |
| | | | $2.4\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH2} = -0.6\text{mA}$ | V _{DD} -0.6 | - | - | V |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OH2} = -0.3\text{mA}$ | V _{DD} -0.5 | - | - | V |
| Output voltage, low | V _{OL1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH02 | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL1} = 30.0\text{mA}$ | - | - | 1.2 | V |
| | | | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL1} = 15.0\text{mA}$ | - | - | 0.7 | V |
| | | | $2.4\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL1} = 8.0\text{mA}$ | - | - | 0.4 | V |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL1} = 3.0\text{mA}$ | - | - | 0.4 | V |
| | V _{OL2} | PH03~PH04 | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL2} = 8.0\text{mA}$ | - | - | 1.2 | V |
| | | | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL2} = 4.0\text{mA}$ | - | - | 0.7 | V |
| | | | $2.4\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL2} = 2.0\text{mA}$ | - | - | 0.4 | V |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $I_{OL2} = 1.0\text{mA}$ | - | - | 0.4 | V |

Remark:

1. Unless otherwise specified, the characteristics of alternate-function pins are the same as the characteristics of the port pins.
2. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

$(T_A = -40 \sim 105^{\circ}\text{C}, 1.8\text{V} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|-------------------------------|------------|---|--|------|------|------|------------------|
| Input leakage current, high | I_{LH1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH02 | $V_I = V_{DD}$ | - | - | 1 | μA |
| | I_{LH2} | RESETB/PH00 | $V_I = V_{DD}$ | - | - | 1 | μA |
| | I_{LH3} | PH03~PH04 (XT1, XT2) | $V_I = V_{DD}$, when an input port and external clock are inputting | - | - | 1 | μA |
| | | | $V_I = V_{DD}$, when connecting a resonator | - | - | 10 | μA |
| Input leakage current, low | I_{LIL1} | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH02 | $V_I = V_{SS}$ | - | - | -1 | μA |
| | I_{LIL2} | RESETB/PH00 | $V_I = V_{SS}$ | - | - | -1 | μA |
| | I_{LIL3} | PH03~PH04 (XT1, XT2) | $V_I = V_{SS}$, when an input port and external clock are inputting | - | - | -1 | μA |
| | | | $V_I = V_{SS}$, when connecting a resonator | - | - | -10 | μA |
| Internal pull-up resistance | R_U | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH00~PH02 | $V_I = V_{SS}$, when inputting a port | 10 | 30 | 100 | $\text{K}\Omega$ |
| Internal pull-down resistance | R_D | PA00~PA15, PB00~PB15 PC00~PC14, PD00~PD07 PH01~PH02 | $V_I = V_{DD}$, when inputting a port | 10 | 30 | 100 | $\text{K}\Omega$ |

Remark:

1. Unless otherwise specified, the characteristics of alternate-function pins are the same as the characteristics of the port pins.
2. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.5.2 Power supply current characteristics

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | | | | Min. | Typ. | Max. | Unit | |
|--------------------------|------------------------------|----------------------------------|-------------------------------|---|-------------------------------|------|------|------|------|----|
| Supply current Note 1 | IDD1 | Run mode | High-speed on-chip oscillator | FHOCO=32MHz, FIH=32MHz ^{Note3} | | - | 3.0 | 6.5 | mA | |
| | | | High-speed main system clock | FMX=20MHz ^{Note 2} | Square wave input | - | 3.7 | 5.0 | mA | |
| | | | | | Crystal oscillator connection | - | 3.7 | 5.0 | | |
| | | | Subsystem clock operation | FSUB=32.768KHz ^{Note4} | Square wave input | - | 11.0 | 85 | uA | |
| | | | | | Crystal oscillator connection | - | 11.0 | 85 | | |
| | Low-speed on-chip oscillator | FIL=32KHz ^{Note8} | | - | 5.1 | 80 | uA | | | |
| | IDD2 | Sleep mode | High-speed on-chip oscillator | FHOCO=32MHz, FIH=32MHz ^{Note3} | | - | 0.9 | 4.5 | mA | |
| | | | High-speed main system clock | FMX=20MHz ^{Note 2} | Square wave input | - | 0.7 | 4.0 | mA | |
| | | | | | Crystal oscillator connection | - | 0.7 | 4.0 | | |
| | | | Subsystem clock operation | FSUB=32.768KHz ^{Note5} | Square wave input | - | 1.85 | 35 | uA | |
| | | | | | Crystal oscillator connection | - | 1.85 | 35 | | |
| | Low-speed on-chip oscillator | FIL=32KHz ^{Note8} | | - | 1.05 | 35 | uA | | | |
| | IDD3 ^{Note6} | Deep sleep mode ^{Note7} | TA= -40℃~25℃ VDD=3.0V | | | | - | 0.7 | 1.2 | uA |
| | | | TA= -40℃~85℃ VDD=3.0V | | | | - | 0.7 | 12 | |
| | | | TA= -40℃~105℃ VDD=3.0V | | | | - | 0.7 | 20 | |

Note 1: This is the total current through V_{DD}, including input leakage current fixed to V_{DD} or V_{SS} on the input pin. Typical value: CPU is in multiplication instruction execution (I_{DD1}) and does not include external operating current. Maximum Value: The CPU is in multiply instruction execution (I_{DD1}) and contains external operating current, but does not include current to the A/D converter, LVD circuitry, I/O ports, and internal pull-up or pull-down resistors, nor does it include the current when overwriting the data flash memory.

Note 2: This is when the high-speed on-chip oscillator and the subsystem clock are stopped.

Note 3: This is when the high-speed main and subsystem clock are stopped.

Note 4: This is when the high-speed on-chip oscillator and the high-speed main system clock are stopped.

Note 5: This is when the high-speed on-chip oscillator and the high-speed main system clock are stopped.

Contains current to the RTC, but does not include current to 15-bit interval timers and watchdog timers.

Note 6: Current flowing to the RTC, 15-bit interval timer and watchdog timer is not included. The MDSET[1:0] of the LCDM0 register needs to be set to b'11.

Note 7: For current values when the subsystem clock is running in deep sleep mode, refer to current values when the subsystem clock is running in sleep mode.

Note 8: This is when the high-speed on-chip oscillator, the high-speed main system clock and the subsystem clock are stopped.

Remark:

1. F_{HOCO} : High-speed on-chip oscillator clock frequency, F_{IH} : High-speed on-chip oscillator system clock frequency
2. F_{SUB} : External subsystem clock frequency (XT1/ XT2 clock oscillation frequency)
3. F_{MX} : External main system clock frequency (X1/ X2 clock oscillation frequency).
4. F_{IL} : Low-speed on-chip oscillator clock frequency
5. Typical temperature condition: $T_A=25^{\circ}\text{C}$.
6. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

$(T_A = -40 \sim 105^{\circ}\text{C}, 1.8\text{V} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | | | | Min. | Typ. | Max. | Unit |
|--|---|-------------------------------------|--|---------------------------|---|------|------|------|------|
| Low speed on-chip oscillator operating current | I _{FIL} ^{Note 1} | - | | | | - | 0.2 | - | uA |
| RTC operating current | I _{RTC} ^{Note 1,2,3} | - | | | | - | 0.04 | - | uA |
| 15-bit interval timer operating current | I _{IT} ^{Note 1,2,4} | - | | | | - | 0.02 | - | uA |
| Watchdog timer operating current | I _{WDT} ^{Note 1,2,5} | F _{IL} =32KHz | | | | - | 0.22 | - | uA |
| A/D converter operating current | I _{ADC} ^{Note 1,6} | ADC HS mode @32MHz | | | | - | 2.2 | - | mA |
| | | ADC HS mode @4MHz | | | | - | 1.3 | - | mA |
| | | ADC LC mode @16MHz | | | | - | 1.1 | - | mA |
| | | ADC LC mode @4MHz | | | | - | 0.8 | - | mA |
| OPA operating current | | Per channel | | | | - | 135 | 150 | uA |
| CMP operating current | I _{CMP} ^{Note 1,9} | Per channel | | | - | - | 60 | 100 | uA |
| | | | | | - | - | 80 | 140 | uA |
| LVD operating current | I _{LVD} ^{Note 1,7} | - | | | | - | 0.08 | | uA |
| LCD operating current | I _{LCD1} ^{Note 1,10,11} | External resistance division method | LCD=F _{SUB} | 1/3 bias 4 time slices | V _{DD} =5.0V V _{L4} =5.0V | - | 0.04 | 0.2 | uA |
| | I _{LCD2} ^{Note 1,10} | Internal voltage boosting method | F _{LCD} =F _{SUB} LCD clock=128 Hz | 1/3 bias 4 time slices | V _{DD} =3.0V V _{L4} =3.0V (V _{LCD} =04H) | - | 0.85 | 2.2 | uA |
| | | | | | V _{DD} =5.0V V _{L4} =5.1V (V _{LCD} =12H) | - | 1.0 | 4.0 | |
| | I _{LCD3} ^{Note 1,10} | Capacitor split method | F _{LCD} =F _{SUB} LCD clock =128Hz | 1/3 bias 4 time slices | V _{DD} =3.0V V _{L4} =3.0V | - | 0.2 | 0.5 | |

Note 1: This is the current flowing through V_{DD} .

Note 2: This is when the high-speed on-chip oscillator and the high-speed system clock are stopped.

Note 3: This is the current that flows only to the real-time clock (RTC) (excluding the operating current of

the low-speed on-chip oscillator and the XT1 oscillation circuit). In the case of a real-time clock operating in run mode or sleep mode, the current value of the microcontroller is I_{DD1} or I_{DD2} plus the I_{RTC} value. In addition, I_{FIL} must be added when selecting a low-speed on-chip oscillator. When the subsystem clock is running, I_{DD2} contains the operating current of the real-time clock.

Note 4: This is the current that flows only to the 15-bit interval timer (excluding the operating current of the low-speed on-chip oscillator and XT1 oscillation circuit). In the case of 15-bit interval timer operation in run mode or sleep mode, the current value of the microcontroller is I_{DD1} or I_{DD2} plus the I_{IT} value. In addition, I_{FIL} must be added when selecting a low-speed on-chip oscillator.

Note 5: This is the current that flows only to the watchdog timer (including the operating current of the low-speed on-chip oscillator). In the case of watchdog timer operation, the current value of the microcontroller is I_{DD1} or I_{DD2} or I_{DD3} plus I_{WDT} .

Note 6: This is the current that only flows to the A/D converter. In the case of A/D converter operation in run mode or sleep mode, the current value of the microcontroller is I_{DD1} or I_{DD2} plus the I_{ADC} value.

Note 7: This is the current that only flows to the LVD circuit. In the case of LVD circuit operation, the current value of the microcontroller is I_{DD1} or I_{DD2} or I_{DD3} plus the value of I_{LVD} .

Note 8: This is the current that only flows to the D/A converter. In the case of D/A converter operation in run mode or sleep mode, the current value of the microcontroller is I_{DD1} or I_{DD2} plus the I_{DAC} value.

Note 9: This is the current that only flows to the comparator circuit. In the case of comparator circuit operation, the current value of the microcontroller is I_{DD1} or I_{DD2} or I_{DD3} plus the I_{CMP} value.

Note 10: This refers to the current flowing to the LCD controller/driver only. In both operating mode and HALT mode, the current value of the BAT32G127 microcontroller is the power supply current (I_{DD1} or I_{DD2}) plus the LCD operating current (I_{LCD1} , I_{LCD2} , or I_{LCD3}). This does not include the current flowing to the LCD display. Typical and maximum values are based on the following conditions:

- The 20-pin is configured for segment function, with all LEDs on.
- The system clock is set to F_{SUB} , and the LCD clock is 128 Hz (LCDC0=07H).
- Configured with 4 time slices and 1/3 bias.

Note 11: When using an external resistance division method, the current flowing to the external divider resistor is not included.

Remark:

1. F_{IL} : Low-speed on-chip oscillator clock frequency
2. Typical temperature condition: $T_A=25^{\circ}\text{C}$.
3. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.6 AC characteristics

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|---|--------------------------|--|--|------------------|------|------|------|
| Instruction cycle (min instruction execution time) | T_{CY} | Main system clock (F_{MAIN}) operation | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 0.03125 | - | 1 | us |
| | | Subsystem clock (F_{SUB}) operation | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 28.5 | 30.5 | 31.3 | us |
| External system clock frequency | F_{EX} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | 1.0 | - | 20.0 | MHz |
| | F_{EXS} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | 32.0 | - | 35.0 | KHz |
| External system clock input high-level width, low-level width | T_{EXH} T_{EXL} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | 24 | - | - | ns |
| | T_{EXHS} T_{EXLS} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | 13.7 | - | - | us |
| TI00 ~ TI07 inputs high-level width, low-level width | T_{TIH} T_{TIL} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $1/F_{MCK} + 10$ | - | - | ns |
| TO00 ~ TO07 output frequency | F_{TO} | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | - | - | 16 | MHz |
| | | $2.4\text{V} \leq V_{DD} < 4.0\text{V}$ | | - | - | 8 | MHz |
| | | $1.8\text{V} \leq V_{DD} < 2.4\text{V}$ | | - | - | 4 | MHz |
| CLKBUZ0 CLKBUZ1 output frequency | F_{PCL} | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | - | - | 16 | MHz |
| | | $2.4\text{V} \leq V_{DD} < 4.0\text{V}$ | | - | - | 8 | MHz |
| | | $1.8\text{V} \leq V_{DD} < 2.4\text{V}$ | | - | - | 4 | MHz |
| Interrupt input high-level width, low-level width | T_{INTH} T_{INTL} | INTP0 ~ INTP5 | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 1 | - | - | us |
| Key interrupt input high-level width, low-level width | T_{KR} | KR0 ~ KR7 | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 250 | - | - | ns |
| RESETB low-level width | T_{RSL} | - | | 10 | - | - | us |

Remark:

1. F_{MCK} : Timer8 operating clock frequency.
2. Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.7 Peripheral functions characteristics

6.7.1 Universal interface unit

1) UART mode

($T_A = -40 \sim 85^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Condition | Specification value | | Unit |
|---------------|--|---------------------|-------------|------|
| | | Min. | Max. | |
| Transfer rate | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | - | $F_{MCK}/6$ | bps |
| | | - | 10.6 | Mbps |

($T_A = 85 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Condition | Specification value | | Unit |
|---------------|--|---------------------|--------------|------|
| | | Min. | Max. | |
| Transfer rate | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | - | $F_{MCK}/12$ | bps |
| | | - | 5.3 | Mbps |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

2) 3-wire SPI mode (master mode, internal clock output)

 $(T_A = -40 \sim 105^{\circ}\text{C}, 1.8\text{V} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | | -40 ~ 85°C | | 85 ~ 105°C | | Unit |
|-------------------------------|------------------------|---|--|-----------------|------|-----------------|------|------|
| | | | | Min. | Max. | Min. | Max. | |
| SCLKp cycle time | T_{KCY1} | $T_{KCY1} \geq 2/F_{CLK}$ | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 62.5 | - | 125 | - | ns |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 125 | - | 250 | - | ns |
| SCLKp high/low level width | T_{KH1} T_{KL1} | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $T_{KCY1}/2-5$ | - | $T_{KCY1}/2-10$ | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $T_{KCY1}/2-19$ | - | $T_{KCY1}/2-38$ | - | ns |
| SDIp set-up time (for SCLKp↑) | T_{SIK1} | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | 17 | - | 33 | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | 28 | - | 55 | - | ns |
| SDIp hold time (for SCLKp↑) | T_{KSI1} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | 5 | - | 10 | - | ns |
| Delay time from SCLKp↓→SDOp | T_{KSO1} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C=20\text{pF}$ <small>Note 1</small> | | - | 5 | - | 10 | ns |

Note 1: C is the load capacitance of the SCLKp, SDOp output lines.

Caution: Through the Port Input Mode Register and Port Output Mode Register, the SDIp pin is selected as the normal input buffer and the SDOp pin and SCLKp pin are selected as the normal output mode.

Remark: This specification is guaranteed by the design, and is not tested in mass production.

3) 3-wire SPI mode (slave mode, external clock input)

 $(T_A = -40 \sim 105^\circ\text{C}, 1.8\text{V} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | | -40 ~ 85°C | | 85 ~ 105°C | | Unit |
|----------------------------------|------------------------|---|-----------------------------|-------------------------------|-----------------|---------------------------------|-----------------|------|
| | | | | Min. | Max. | Min. | Max. | |
| SCLKp cycle time | T_{KCY2} | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ | $20\text{MHz} < F_{MCK}$ | $8/F_{MCK}$ | - | $16/F_{MCK}$ | - | ns |
| | | | $F_{MCK} \leq 20\text{MHz}$ | $6/F_{MCK}$ | - | $12/F_{MCK}$ | - | ns |
| | | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | $16\text{MHz} < F_{MCK}$ | $8/F_{MCK}$ | - | $16/F_{MCK}$ | - | ns |
| | | | $F_{MCK} \leq 16\text{MHz}$ | $6/F_{MCK}$ | - | $12/F_{MCK}$ | - | ns |
| | | $2.4\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $6/F_{MCK}$ and ≥ 500 | - | $12/F_{MCK}$ and ≥ 1000 | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $6/F_{MCK}$ and ≥ 750 | - | $12/F_{MCK}$ and ≥ 1500 | - | ns |
| SCLKp high/low level width | T_{KH2} T_{KL2} | $4.0\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $T_{KCY1}/2-7$ | - | $T_{KCY1}/2-14$ | - | ns |
| | | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $T_{KCY1}/2-8$ | - | $T_{KCY1}/2-16$ | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $T_{KCY1}/2-18$ | - | $T_{KCY1}/2-36$ | - | ns |
| SDIp set-up time (for SCLKp↑) | T_{SIK2} | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $1/F_{MCK}+20$ | - | $1/F_{MCK}+40$ | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $1/F_{MCK}+30$ | - | $1/F_{MCK}+60$ | - | ns |
| SDIp hold time (for SCLKp↑) | T_{KSI2} | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | | $1/F_{MCK}+31$ | - | $1/F_{MCK}+62$ | - | ns |
| Delay time from SCLKp↓→SDOp | T_{KSO2} | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C=30\text{pF}$ <small>Note 1</small> | | - | $2/F_{MCK}+44$ | - | $2/F_{MCK}+66$ | ns |
| | | $2.4\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C=30\text{pF}$ <small>Note 1</small> | | - | $2/F_{MCK}+75$ | - | $2/F_{MCK}+113$ | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C=30\text{pF}$ <small>Note 1</small> | | - | $2/F_{MCK}+100$ | - | $2/F_{MCK}+150$ | ns |

Note 1: C is the load capacitance of the SCLKp, SDOp output lines.

Caution: Through the Port Input Mode Register and Port Output Mode Register, the SDIp and SCLKp pins are selected as the normal input buffers and the SDOp pin is selected as the normal output mode.

Remark: This specification is guaranteed by the design, and is not tested in mass production.

4) 4-wire SPI mode (slave mode, external clock input)

 $(T_A = -40 \sim 105^\circ\text{C}, 1.8\text{V} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | | -40 ~ 85°C | | 85 ~ 105°C | | Unit |
|----------------------|------------|-------------|--|-------------------|------|-------------------|------|------|
| | | | | Min. | Max. | Min. | Max. | |
| SSI00 set-up time | T_{SSIK} | DAPmn= 0 | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 120 | - | 240 | - | ns |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 200 | - | 400 | - | ns |
| | | DAPmn= 1 | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | $1/F_{MCK} + 120$ | - | $1/F_{MCK} + 240$ | - | ns |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | $1/F_{MCK} + 200$ | - | $1/F_{MCK} + 400$ | - | ns |
| SSI00 hold time | T_{KSSI} | DAPmn= 0 | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | $1/F_{MCK} + 120$ | - | $1/F_{MCK} + 240$ | - | ns |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | $1/F_{MCK} + 200$ | - | $1/F_{MCK} + 400$ | - | ns |
| | | DAPmn= 1 | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 120 | - | 240 | - | ns |
| | | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ | 200 | - | 400 | - | ns |

Caution: Select the SDIp and SCLKp pins as the normal input buffers and the SDOp pin as the normal output mode via the Port Input Mode Register and Port Output Mode Register.

Remark: This specification is guaranteed by the design, and is not tested in mass production.

5) Simplified IIC mode

 $(T_A = -40 \sim 105^{\circ}\text{C}, 1.8\text{V} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | -40 ~ 85°C | | 85 ~ 105°C | | Unit |
|-------------------------------|----------------------|--|--|------------------------|---|-----------------------|------|
| | | | Min. | Max. | Min. | Max. | |
| SCLr clock frequency | F_{SCL} | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 50\text{ pF}, R_b = 2.7\text{ k}\Omega$ | - | 1000 ^{Note 1} | - | 400 ^{Note 1} | KHz |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 100\text{ pF}, R_b = 3\text{ k}\Omega$ | - | 400 ^{Note 1} | - | 100 ^{Note 1} | KHz |
| | | $1.8\text{V} \leq V_{DD} \leq 2.7\text{V}$ $C_b = 100\text{ pF}, R_b = 5\text{ k}\Omega$ | - | 300 ^{Note 1} | - | 75 ^{Note 1} | KHz |
| Hold time when SCLr is low | T_{LOW} | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 50\text{ pF}, R_b = 2.7\text{ k}\Omega$ | 475 | - | 1200 | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 100\text{ pF}, R_b = 3\text{ k}\Omega$ | 1150 | - | 4600 | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 2.7\text{V}$ $C_b = 100\text{ pF}, R_b = 5\text{ k}\Omega$ | 1550 | - | 6500 | - | ns |
| Hold time when SCLr is high | T_{HIGH} | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 50\text{ pF}, R_b = 2.7\text{ k}\Omega$ | 475 | - | 1200 | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 100\text{ pF}, R_b = 3\text{ k}\Omega$ | 1150 | - | 4600 | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 2.7\text{V}$ $C_b = 100\text{ pF}, R_b = 5\text{ k}\Omega$ | 1550 | - | 6500 | - | ns |
| Data setup time (reception) | $T_{\text{SU: DAT}}$ | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 50\text{ pF}, R_b = 2.7\text{ k}\Omega$ | $1/F_{\text{MCK}} + 85^{\text{Note 2}}$ | - | $1/F_{\text{MCK}} + 220^{\text{Note 2}}$ | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 100\text{ pF}, R_b = 3\text{ k}\Omega$ | $1/F_{\text{MCK}} + 145^{\text{Note 2}}$ | - | $1/F_{\text{MCK}} + 580^{\text{Note 2}}$ | - | ns |
| | | $1.8\text{V} \leq V_{DD} \leq 2.7\text{V}$ $C_b = 100\text{ pF}, R_b = 5\text{ k}\Omega$ | $1/F_{\text{MCK}} + 230^{\text{Note 2}}$ | - | $1/F_{\text{MCK}} + 1200^{\text{Note 2}}$ | - | ns |
| Data hold time (transmission) | $T_{\text{HD: DAT}}$ | $2.7\text{V} \leq V_{DD} \leq 5.5\text{V}$ $C_b = 50\text{ pF}, R_b = 2.7\text{ k}\Omega$ | - | 305 | - | 770 | ns |

| | | | | | | | |
|--|--|--|---|-----|---|------|----|
| | | $1.8V \leq V_{DD} \leq 5.5V$ $C_b = 100 \text{ pF}$, $R_b = 3 \text{ k}\Omega$ | - | 355 | - | 1420 | ns |
| | | $1.8V \leq V_{DD} \leq 2.7V$ $C_b = 100 \text{ pF}$, $R_b = 5 \text{ k}\Omega$ | - | 405 | - | 2070 | ns |

Note 1: Set the value to $F_{MCK}/4$.

Note 2: Set the F_{MCK} value to keep the hold time of $SCLr = "L"$ and $SCLr = "H"$.

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.7.2 Serial interface IICA

1) I²C standard mode

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Specification value | | Unit |
|---|---------------|--|---------------------|------|------|
| | | | Min. | Max. | |
| SCLA0 clock frequency | F_{SCL} | Standard mode: $F_{CLK} \geq 1\text{MHz}$ | - | 100 | KHz |
| Set-up time of the start condition | $T_{SU: STA}$ | - | 4.7 | - | us |
| Hold time of the start condition ^{Note1} | $T_{HD: STA}$ | - | 4.0 | - | us |
| Hold time when SCLA0 is low | T_{LOW} | - | 4.7 | - | us |
| Hold time when SCLA0 is high | T_{HIGH} | - | 4.0 | - | us |
| Data set-up time (reception) | $T_{SU: DAT}$ | - | 250 | - | ns |
| Data hold time (transmission) ^{Note2} | $T_{HD: DAT}$ | - | 0 | 3.45 | us |
| Set-up time of the stop condition | $T_{SU: STO}$ | - | 4.0 | - | us |
| Bus idle time | T_{BUF} | - | 4.7 | - | us |

Note 1: Generate the first clock pulse after a start condition or a restart condition is generated.

Note 2: The maximum value of $T_{HD: DAT}$ needs to be guaranteed during normal transfer and needs to be waited during acknowledge (ACK).

Caution: The maximum value of C_b (communication line capacitance) for each mode and the value of R_b (communication line pull-up resistor value) at this time are as follows:

Standard mode: $C_b = 400\text{pF}$, $R_b = 2.7\text{K}\Omega$

Remark: This specification is guaranteed by the design, and is not tested in mass production.

2) I²C fast mode

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Specification value | | Unit |
|---|---------------|---|---------------------|------|------|
| | | | Min. | Max. | |
| SCLA0 clock frequency | F_{SCL} | Fast mode: $F_{CLK} \geq 3.5\text{MHz}$ | - | 400 | KHz |
| Set-up time of the start condition | $T_{SU: STA}$ | - | 0.6 | - | us |
| Hold time of the start condition ^{Note1} | $T_{HD: STA}$ | - | 0.6 | - | us |
| Hold time when SCLA0 is low | T_{LOW} | - | 1.3 | - | us |

| | | | | | |
|--|---------------|---|-----|-----|----|
| Hold time when SCLA0 is high | T_{HIGH} | - | 0.6 | - | us |
| Data set-up time (reception) | $T_{SU: DAT}$ | - | 100 | - | ns |
| Data hold time (transmission) ^{Note2} | $T_{HD: DAT}$ | - | 0 | 0.9 | us |
| Set-up time of the stop condition | $T_{SU: STO}$ | - | 0.6 | - | us |
| Bus idle time | T_{BUF} | - | 1.3 | - | us |

Note 1: Generate the first clock pulse after a start condition or a restart condition is generated.

Note 2: The maximum value of $T_{HD: DAT}$ needs to be guaranteed during normal transfer and needs to be waited during acknowledged (ACK).

Caution: The maximum value of C_b (communication line capacitance) for each mode and the value of R_b (pull-up resistor value of the communication line) at this time are as follows:

Fast mode: $C_b=320pF$, $R_b=1.1K\Omega$

Remark: This specification is guaranteed by the design, and is not tested in mass production.

3) I²C enhanced fast mode

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Specification value | | Unit |
|---|---------------|--|---------------------|------|------|
| | | | Min. | Max. | |
| SCLA0 clock frequency | F_{SCL} | Enhanced fast mode: $F_{CLK} \geq 10\text{MHz}$ | - | 1000 | KHz |
| Set-up time of the start condition | $T_{SU: STA}$ | - | 0.26 | - | us |
| Hold time of the start condition ^{Note1} | $T_{HD: STA}$ | - | 0.26 | - | us |
| Hold time when SCLA0 is low | T_{LOW} | - | 0.5 | - | us |
| Hold time when SCLA0 is high | T_{HIGH} | - | 0.26 | - | us |
| Data set-up time (reception) | $T_{SU: DAT}$ | - | 50 | - | ns |
| Data hold time (transmission) ^{Note2} | $T_{HD: DAT}$ | - | 0 | 0.45 | us |
| Set-up time of the stop condition | $T_{SU: STO}$ | - | 0.26 | - | us |
| Bus idle time | T_{BUF} | - | 0.5 | - | us |

Note 1: Generate the first clock pulse after a start condition or restart condition is generated.

Note 2: The maximum value of $T_{HD: DAT}$ needs to be guaranteed during normal transfer and needs to be waited during acknowledged (ACK).

Caution: The maximum value of C_b (communication line capacitance) for each mode and the value of R_b (pull-up resistor value of the communication line) at this time are as follows:

Enhanced fast mode: $C_b = 120\text{pF}$, $R_b = 1.1\text{K}\Omega$

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.8 Analog characteristics

6.8.1 A/D converter characteristics

Classification of A/D converter characteristics

| Input channel | Reference voltage | Reference voltage(+)=AV _{REFP} Reference voltage(-)=AV _{REFM} | Reference voltage(+)=V _{DD} Reference voltage (-)=V _{SS} |
|---|-------------------|--|---|
| ANI0~ANI25 | | Refer to 6.8.1(1) | Refer to 6.8.1(2) |
| Internal reference voltage, temperature sensor output voltage | | | |

(1) When selecting reference voltage (+)=AV_{REFP}/ANI0, reference voltage (-)=AV_{REFM}/ANI1

(T_A= -40~105°C, 1.8V≤AV_{REFP}≤V_{DD}≤5.5V, V_{SS}=0V, reference voltage (+)=AV_{REFP},

reference voltage (-)=AV_{REFM}=0V)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|---|-------------------|---|-------------------------------|---------------------------------------|------|--------------------|-------------------|
| Resolution | RES | - | | - | 12 | - | bit |
| Combined error ^{Note 1} | AINL | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | 3 | - | LSB |
| Conversion time ^{Note 3} | T _{CONV} | 12-bit resolution Conversion target: ANI0~ANI25 | 1.8V≤V _{DD} ≤5.5V | 45 | - | - | T _{MCLK} |
| | | 12-bit resolution Conversion target: internal reference voltage, temperature sensor output voltage, OPA output voltage | 1.8V≤V _{DD} ≤5.5V | 72 | - | - | T _{MCLK} |
| Zero scale error ^{Note1} | E _{ZS} | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | 0 | - | LSB |
| Full scale error ^{Note1} | E _{FS} | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | 0 | - | LSB |
| Integral linearity error ^{Note1} | ILE | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | - | ±1 | LSB |
| Differential linearity error ^{Note1} | DLE | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | - | ±1.5 | LSB |
| Analog input voltage | V _{AIN} | ANI0~ANI25 | | 0 | - | AV _{REFP} | V |
| | | Internal reference voltage (1.8V≤V _{DD} ≤5.5V) | | V _{BGR} ^{Note 2} | | V | |
| | | Temperature sensor output voltage (1.8V≤V _{DD} ≤5.5V) | | V _{TMPS25} ^{Note 2} | | V | |

Note 1: Excludes quantization error (±1/2 LSB).

Note 2: Please refer to 6.8.2 Characteristics of Temperature Sensor/ Internal Reference Voltage.

Note 3: T_{MCLK} is the action clock of the AD, T_{MCLK}=1/F_{ADC}, F_{ADC} is the AD operating frequency, up to 32MHz.

Remark: This specification is guaranteed by the design, and is not tested in mass production.

(2) When selecting reference voltage (+)=V_{DD}, reference voltage (-)=V_{SS}

(T_A= -40~105°C, 1.8V≤V_{DD}≤5.5V, V_{SS}=0V, reference voltage (+)=V_{DD}, reference voltage (-)=V_{SS})

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|--|-------------------|---|-------------------------------|---------------------------------------|------|-----------------|-------------------|
| Resolution | RES | - | | - | 12 | - | bit |
| Combined error ^{Note 1} | AINL | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | 6 | - | LSB |
| Conversion time ^{Note 3} | T _{CONV} | 12-bit resolution Conversion target: ANI0~ANI25 | 1.8V≤V _{DD} ≤5.5V | 45 | - | - | T _{MCLK} |
| | | 12-bit resolution Conversion target: internal reference voltage, temperature sensor output voltage, OPA output voltage | 1.8V≤V _{DD} ≤5.5V | 72 | - | - | T _{MCLK} |
| Zero scale error ^{Note1} | E _{ZS} | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | 0 | - | LSB |
| Full scale error ^{Note1} | E _{FS} | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | 0 | - | LSB |
| Integral linearity error ^{Note1} | ILE | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | - | ±2 | LSB |
| Differential linearity error ^{Note1} | DLE | 12-bit resolution | 1.8V≤AV _{REFP} ≤5.5V | - | - | ±3 | LSB |
| Analog input voltage | V _{AIN} | ANI0~ANI25 | | 0 | - | V _{DD} | V |
| | | Internal reference voltage (1.8V≤V _{DD} ≤5.5V) | | V _{BGR} ^{Note 2} | | V | |
| | | Temperature sensor output voltage (1.8V≤V _{DD} ≤5.5V) | | V _{TMPS25} ^{Note 2} | | V | |

Note 1: Excludes quantization error (±1/2 LSB).

Note 2: Please refer to 6.8.2 Characteristics of Temperature Sensor/ Internal Reference Voltage.

Note 3: T_{MCLK} is the action clock of the AD, T_{MCLK}=1/F_{ADC}, F_{ADC} is the AD operating frequency, up to 32MHz.

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.8.2 Characteristics of temperature sensor/internal reference voltage

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|-----------------------------------|--------------|--|------------------------|------|-----------------------|-------|
| Temperature sensor output voltage | V_{TMPS25} | ADS register=80H, $T_A=25^\circ\text{C}$ | - | 1.09 | - | V |
| Internal reference voltage | V_{BGR} | ADS register=81H | 1.38 ^{Note 1} | 1.45 | 1.5 ^{Note 1} | V |
| Temperature coefficient | F_{VTMPS} | - | - | -3.5 | - | mV/°C |
| Operation stabilization wait time | T_{AMP} | - | 5 | - | - | us |

Remark: Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.8.3 Comparator

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|-------------------|---|---------------------------------|----------|----------|------|
| Input offset voltage | V_{IOCOMP} | - | - | ± 10 | ± 40 | mV |
| Input voltage range | V_{ICMP} | - | 0 | - | V_{DD} | V |
| Internal reference voltage offset | ΔV_{IREF} | CmRVM register: 7FH ~ 80H (m = 0, 1) | - | - | ± 2 | LSB |
| | | Others | - | - | ± 1 | LSB |
| Response time | T_{CR}, T_{CF} | Input amplitude $\pm 100\text{mV}$ | - | 70 | 150 | ns |
| Operation stability time ^{Note 1} | T_{CMP} | CMPn=0->1 | $V_{DD} = 3.3 \sim 5.5\text{V}$ | - | 1 | us |
| | | | $V_{DD} = 1.8 \sim 3.3\text{V}$ | - | 3 | |
| Reference voltage stabilization time | T_{VR} | CVRE=0->1 ^{Note 2} | - | - | 20 | us |
| Operating current | I_{CMPDD} | Refer to 6.5.2 Power supply current characteristics | | | | |

Note 1: The time required from the comparator action enable (CMPnEN=0 ->1) to fulfill each DC/AC style requirement of the CMP.

Note 2: After the internal reference voltage generator is enabled (by setting the CVREm bit to 1; m = 0 to 1), the comparator output can be enabled only after the reference voltage stabilization time has elapsed (CnOE bit = 1; n = 0 to 1).

Remark: Low-temperature specification values are guaranteed by the design, and are not tested in mass production.

6.8.4 Operational Amplifier (OPA)

OPA electrical characteristics

$T_A = 25^{\circ}\text{C}$, $V_{DD} = 5\text{V}$, unless otherwise specified.

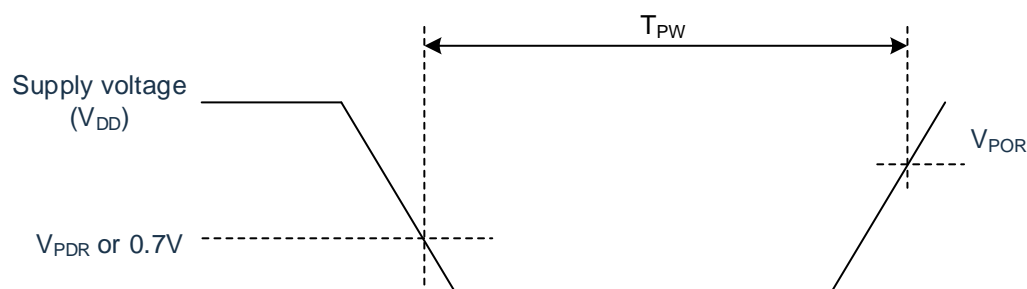
| Symbol | Item | Condition | Min. | Typ. | Max. | Unit |
|---------------------------|---------------------------------|--|------------|--------|----------------------------------|--------------------|
| V_{DD} | Supply voltage | - | 2.5 | - | 5.5 | V |
| I_Q | Quiescent current | $V_{OUT} = 2\text{V}$ | - | 0.5 | 0.8 | mA |
| I_{SD} | Shutdown current | - | - | 10 | - | nA |
| T_A | Operating temperature | - | -40 | 25 | 105 | $^{\circ}\text{C}$ |
| Input characteristics | | | | | | |
| V_{OS} | Input offset voltage | buffer mode, $V_{IN+} = 2.5\text{V}$ | -8 | - | 8 | mV |
| V_{CM} | Common mode input voltage range | - | 0.1 | - | $V_{DD} - 0.1$ | V |
| I_B | Input bias current | - | - | 10 | - | pA |
| Output characteristics | | | | | | |
| C_{LOAD} | Capacitive load | - | - | 10 | - | pF |
| V_{OH} | Maximum output voltage | $I_{LOAD} = 0.1\text{mA}$ $I_{LOAD} = 1\text{mA}$ | - - | - - | $V_{DD} - 0.1$ $V_{DD} - 0.3$ | V |
| V_{OL} | Minimum output voltage | $I_{LOAD} = 0.1\text{mA}$ $I_{LOAD} = 1\text{mA}$ | 0.1 0.3 | - - | - - | V |
| Frequency characteristics | | | | | | |
| A_{OL} | Open loop gain | $C_{LOAD} = 10\text{pF}$, buffer mode | - | 80 | - | dB |
| BW | Band width | $C_{LOAD} = 10\text{pF}$, buffer mode | - | 5 | - | MHz |
| PSRR | Power supply rejection ratio | - | - | -80 | - | dB |
| CMRR | Common mode rejection ratio | $-40^{\circ}\text{C} \sim 105^{\circ}\text{C}$ | - | -80 | - | dB |
| Transient characteristics | | | | | | |
| SR | Slew rate | $C_{LOAD} = 10\text{pF}$, buffer mode | - | 8 | - | V/ μs |
| T_{STB} | Stabilization time | - | - | - | 2 | μs |

6.8.5 POR circuit characteristics

($T_A = -40 \sim 105^\circ\text{C}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|------------------------------|-----------|-------------------------------|------|------|------|------|
| Detect voltage | V_{POR} | When the supply voltage rises | - | 1.50 | 1.75 | V |
| | V_{PDR} | When the supply voltage drops | 1.37 | 1.45 | 1.53 | V |
| Minimum pulse width Note1 | T_{PW} | - | 300 | - | - | us |

Note 1: This is the time required to reset the POR when V_{DD} falls below V_{PDR} . In addition, when the oscillation of the main system clock (F_{MAIN}) is stopped by setting bit0 (HISTOP) and bit7 (MSTOP) of the clock operation status control register (CSC) in the deep sleep mode, this is the time required for POR reset from the time when V_{DD} is lower than 0.7V to the time when it rises above V_{POR} .



Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.8.6 LVD circuit characteristics

1) Reset mode, interrupt mode

($T_A = -40 \sim 105^\circ\text{C}$, $V_{PDR} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---------------------|-------------|-------------------------------|------|------|------|------|
| Detection voltage | V_{LVD0} | When the supply voltage rises | - | 4.06 | 4.26 | V |
| | | When the supply voltage drops | 3.78 | 3.98 | - | V |
| | V_{LVD1} | When the supply voltage rises | - | 3.75 | - | V |
| | | When the supply voltage drops | - | 3.67 | - | V |
| | V_{LVD2} | When the supply voltage rises | - | 3.13 | - | V |
| | | When the supply voltage drops | - | 3.06 | - | V |
| | V_{LVD3} | When the supply voltage rises | - | 3.02 | - | V |
| | | When the supply voltage drops | - | 2.96 | - | V |
| | V_{LVD4} | When the supply voltage rises | - | 2.92 | - | V |
| | | When the supply voltage drops | - | 2.86 | - | V |
| | V_{LVD5} | When the supply voltage rises | - | 2.81 | - | V |
| | | When the supply voltage drops | - | 2.75 | - | V |
| | V_{LVD6} | When the supply voltage rises | - | 2.71 | - | V |
| | | When the supply voltage drops | - | 2.65 | - | V |
| | V_{LVD7} | When the supply voltage rises | - | 2.61 | - | V |
| | | When the supply voltage drops | - | 2.55 | - | V |
| | V_{LVD8} | When the supply voltage rises | - | 2.50 | - | V |
| | | When the supply voltage drops | - | 2.45 | - | V |
| | V_{LVD9} | When the supply voltage rises | - | 2.09 | - | V |
| | | When the supply voltage drops | - | 2.04 | - | V |
| | V_{LVD10} | When the supply voltage rises | - | 1.98 | - | V |
| | | When the supply voltage drops | - | 1.94 | - | V |
| | V_{LVD11} | When the supply voltage rises | - | 1.88 | 1.97 | V |
| | | When the supply voltage drops | 1.75 | 1.84 | - | V |
| Minimum pulse width | T_{LW} | - | 300 | - | - | us |
| Detection delay | - | - | - | - | 300 | us |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

2) Interrupt & reset mode

 $(T_A = -40 \sim 105^\circ\text{C}, V_{PDR} \leq V_{DD} \leq 5.5\text{V}, V_{SS} = 0\text{V})$

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit | |
|------------------------|--------------------|--|-----------------------|------------------------------|------|------|------|---|
| Interrupt & reset mode | V _{LVDB0} | V _{POC2} =0 V _{POC1} =0 V _{POC0} =1 | Falling reset voltage | | 1.78 | 1.84 | - | V |
| | V _{LVDB1} | | LVIS1=1 LVIS0=0 | Rising release reset voltage | - | 1.98 | 2.04 | V |
| | | | | Falling interrupt voltage | 1.88 | 1.94 | - | V |
| | V _{LVDB2} | | LVIS1=0 LVIS0=1 | Rising release reset voltage | - | 2.09 | - | V |
| | | | | Falling interrupt voltage | - | 2.04 | - | V |
| | V _{LVDB3} | | LVIS1=0 LVIS0=0 | Rising release reset voltage | - | 3.13 | - | V |
| | | Falling interrupt voltage | | - | 3.06 | - | V | |
| | V _{LVDC0} | V _{POC2} =0 V _{POC1} =1 V _{POC0} =0 | Falling reset voltage | | - | 2.45 | - | V |
| | V _{LVDC1} | | LVIS1=1 LVIS0=0 | Rising release reset voltage | - | 2.61 | - | V |
| | | | | Falling interrupt voltage | - | 2.55 | - | V |
| | V _{LVDC2} | | LVIS1=0 LVIS0=1 | Rising release reset voltage | - | 2.71 | - | V |
| | | | | Falling interrupt voltage | - | 2.65 | - | V |
| | V _{LVDC3} | | LVIS1=0 LVIS0=0 | Rising release reset voltage | - | 3.75 | - | V |
| | | Falling interrupt voltage | | - | 3.67 | - | V | |
| | V _{LVDD0} | V _{POC2} =0 V _{POC1} =1 V _{POC0} =1 | Falling reset voltage | | - | 2.75 | - | V |
| | V _{LVDD1} | | LVIS1=1 LVIS0=0 | Rising release reset voltage | - | 2.92 | - | V |
| | | | | Falling interrupt voltage | - | 2.86 | - | V |
| | V _{LVDD2} | | LVIS1=0 LVIS0=1 | Rising release reset voltage | - | 3.02 | - | V |
| | | | | Falling interrupt voltage | - | 2.96 | - | V |
| | V _{LVDD3} | | LVIS1=0 LVIS0=0 | Rising release reset voltage | - | 4.06 | 4.26 | V |
| | | Falling interrupt voltage | | 3.78 | 3.98 | - | V | |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.8.7 Rising slope characteristics of supply voltage

($T_A = -40 \sim 105^\circ\text{C}$, $V_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|--------------------------------|-----------|-----------|------|------|------|------|
| Rising slope of supply voltage | SV_{DD} | - | - | - | 54 | V/ms |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.8.8 LCD characteristics

6.8.8.3 Resistance division method

1) Static mode

($T_A = -40 \sim 105^\circ\text{C}$, $V_{L4}(\text{Min.}) \leq V_{DD} = EV_{DD} \leq 5.5\text{V}$, $V_{SS} = EV_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|-------------------|----------|-----------|------|------|----------|------|
| LCD drive voltage | V_{L4} | - | 2 | - | V_{DD} | V |

2) 1/2 bias, 1/4 bias

($T_A = -40 \sim 105^\circ\text{C}$, $V_{L4}(\text{Min.}) \leq V_{DD} = EV_{DD} \leq 5.5\text{V}$, $V_{SS} = EV_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|-------------------|----------|-----------|------|------|----------|------|
| LCD drive voltage | V_{L4} | - | 2.7 | - | V_{DD} | V |

3) 1/3 bias

($T_A = -40 \sim 105^\circ\text{C}$, $V_{L4}(\text{Min.}) \leq V_{DD} = EV_{DD} \leq 5.5\text{V}$, $V_{SS} = EV_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|-------------------|----------|-----------|------|------|----------|------|
| LCD drive voltage | V_{L4} | - | 2.5 | - | V_{DD} | V |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.8.8.4 Internal voltage boosting method

(1) 1/3 bias

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} = EV_{DD} \leq 5.5\text{V}$, $V_{SS} = EV_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|--|--------------|---|----------------|-----------|-----------|------|
| Variable range of LCD output voltage | V_{L1} | $V_{LCD}=03H$ | 0.90 | 1.00 | 1.08 | V |
| | | $V_{LCD}=04H$ | 0.95 | 1.05 | 1.13 | V |
| | | $V_{LCD}=05H$ | 1.00 | 1.10 | 1.18 | V |
| | | $V_{LCD}=06H$ | 1.05 | 1.15 | 1.23 | V |
| | | $V_{LCD}=07H$ | 1.10 | 1.20 | 1.28 | V |
| | | $V_{LCD}=08H$ | 1.15 | 1.25 | 1.33 | V |
| | | $V_{LCD}=09H$ | 1.20 | 1.30 | 1.38 | V |
| | | $V_{LCD}=0AH$ | 1.25 | 1.35 | 1.43 | V |
| | | $V_{LCD}=0BH$ | 1.30 | 1.40 | 1.48 | V |
| | | $V_{LCD}=0CH$ | 1.35 | 1.45 | 1.53 | V |
| | | $V_{LCD}=0DH$ | 1.40 | 1.50 | 1.58 | V |
| | | $V_{LCD}=0EH$ | 1.45 | 1.55 | 1.63 | V |
| | | $V_{LCD}=0FH$ | 1.50 | 1.60 | 1.68 | V |
| | | $V_{LCD}=10H$ | 1.55 | 1.65 | 1.73 | V |
| | | $V_{LCD}=11H$ | 1.60 | 1.70 | 1.78 | V |
| | | $V_{LCD}=12H$ | 1.65 | 1.75 | 1.83 | V |
| Doubler output voltage | V_{L2} | $C1 \sim C4$ ^{Note 1} $=0.47\mu\text{F}$ ^{Note 2} | $2V_{L1}-0.10$ | $2V_{L1}$ | $2V_{L1}$ | V |
| Tripler output voltage | V_{L4} | $C1 \sim C4$ ^{Note 1} $=0.47\mu\text{F}$ ^{Note 2} | $3V_{L1}-0.15$ | $3V_{L1}$ | $3V_{L1}$ | V |
| Set-up time of reference voltage ^{Note 2} | T_{VWAIT1} | - | 5.00 | - | - | ms |
| Voltage boost wait time ^{Note 3} | T_{VWAIT2} | $C1 \sim C4$ ^{Note 1} $=0.47\mu\text{F}$ ^{Note 2} | 500.00 | - | - | ms |

Note 1: This A capacitor connected between the LCD and the drive voltage pin.

C1: A capacitor connected between CAPH and CAPL.

C2: A capacitor connected between VL1 and GND.

C3: A capacitor connected between VL2 and GND.

C4: A capacitor connected between VL4 and GND.

$C1=C2=C3=C4=0.47\mu\text{F} \pm 30\%$

Note 2: This is the wait time from when the reference voltage is set via the VLCD register (when the reference voltage is used at the default value, it is selected as the internal voltage boosting method (The MDSET1 and MDSET0 of the LCDM0 register=01B)) to when the boost is started (VLCON=1).

Note 3: This is the wait time from the start of boosting (VLCON=1) until the display is enabled (LCDON=1).

Remark: This specification is guaranteed by the design, and is not tested in mass production.

(2) 1/4 bias

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} = EV_{DD} \leq 5.5\text{V}$, $V_{SS} = EV_{SS} = 0\text{V}$)

| Item | Symbol | Condition | | Min. | Typ. | Max. | Unit |
|--|---------------------|---|-----------------------|------------------------|------------------|------------------|------|
| Variable range of LCD output voltage | V _{L1} | C1~C5 ^{Note 1} =0.47uF ^{Note 2} | V _{LCD} =03H | 0.90 | 1.00 | 1.08 | V |
| | | | V _{LCD} =04H | 0.95 | 1.05 | 1.13 | V |
| | | | V _{LCD} =05H | 1.00 | 1.10 | 1.18 | V |
| | | | V _{LCD} =06H | 1.10 | 1.15 | 1.23 | V |
| | | | V _{LCD} =07H | 1.05 | 1.20 | 1.28 | V |
| | | | V _{LCD} =08H | 1.10 | 1.25 | 1.33 | V |
| | | | V _{LCD} =09H | 1.20 | 1.30 | 1.38 | V |
| Doubler output voltage | V _{L2} | C1~C5 ^{Note 1} =0.47uF ^{Note 2} | | 2V _{L1} -0.08 | 2V _{L1} | 2V _{L1} | V |
| Tripler output voltage | V _{L3} | C1~C5 ^{Note 1} =0.47uF ^{Note 2} | | 3V _{L1} -0.12 | 3V _{L1} | 3V _{L1} | V |
| Quadruply output voltage | V _{L4} | C1~C5 ^{Note 1} =0.47uF ^{Note 2} | | 3V _{L1} -0.16 | 4V _{L1} | 4V _{L1} | V |
| Set-up time of reference voltage ^{Note 2} | T _{VWAIT1} | - | | 5.00 | - | - | ms |
| Voltage boost wait time ^{Note 3} | T _{VWAIT2} | C1~C5 ^{Note 1} =0.47uF ^{Note 2} | | 500.00 | - | - | ms |

Note 1: This A capacitor connected between the LCD and the drive voltage pin.

C1: A capacitor connected between CAPH and CAPL.

C2: A capacitor connected between VL1 and GND.

C3: A capacitor connected between VL2 and GND.

C4: A capacitor connected between VL3 and GND.

C5: A capacitor connected between VL4 and GND.

$C1=C2=C3=C4=C5=0.47\mu\text{F} \pm 30\%$

Note 2: This is the wait time from when the reference voltage is set via the VLCD register (when the reference voltage is used at the default value, it is selected as the internal voltage boosting method (The MDSET1 and MDSET0 of the LCDM0 register=01B)) to when the boost is started (VLCON=1).

Note 3: This is the wait time from the start of boosting (VLCON=1) until the display is enabled (LCDON=1).

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.8.8.5 Capacitor split method

(1) 1/3 bias

($T_A = -40 \sim 105^\circ\text{C}$, $2.2\text{V} \leq V_{DD} = EV_{DD} \leq 5.5\text{V}$, $V_{SS} = EV_{SS} = 0\text{V}$)

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|-------------------|--|--------------------|-------------|--------------------|------|
| V_{L4} voltage | V_{L4} | $C1 \sim C4^{\text{Note 1}} = 0.47\mu\text{F}^{\text{Note 2}}$ | - | V_{DD} | - | V |
| V_{L2} voltage | V_{L2} | $C1 \sim C4^{\text{Note 1}} = 0.47\mu\text{F}^{\text{Note 2}}$ | $2/3V_{L4} - 0.1$ | $2/3V_{L4}$ | $2/3V_{L4} + 0.07$ | V |
| V_{L1} voltage | V_{L1} | $C1 \sim C4^{\text{Note 1}} = 0.47\mu\text{F}^{\text{Note 2}}$ | $1/3V_{L4} - 0.08$ | $1/3V_{L4}$ | $1/3V_{L4} + 0.08$ | V |
| Capacitor split wait time ^{Note 1} | T_{WAIT} | - | 100.00 | - | - | ms |

Note 1: This is the wait time from the start of boosting ($VLCON=1$) until the display is enabled ($LCDON=1$).

Note 2: This A capacitor connected between the LCD and the drive voltage pin.

C1: A capacitor connected between CAPH and CAPL.

C2: A capacitor connected between VL1 and GND.

C3: A capacitor connected between VL2 and GND.

C4: A capacitor connected between VL4 and GND.

$C1=C2=C3=C4=0.47\mu\text{F} \pm 30\%$

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.9 Memory characteristics

6.9.1 Flash memory

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Symbol | Item | Test condition | Min. | Max. | Unit |
|--------------------|----------------------|---|------|------|---------|
| T_{PROG} | Word program (32bit) | $T_A = -40 \sim 105^\circ\text{C}$ | 24 | 30 | us |
| T_{ERASE} | Sector erase (512B) | $T_A = -40 \sim 105^\circ\text{C}$ | 4 | 5 | ms |
| | Chip erase | $T_A = -40 \sim 105^\circ\text{C}$ | 20 | 40 | ms |
| N_{END} | Endurance | $T_A = -40 \sim 105^\circ\text{C}$ | 100 | - | Kcycles |
| T_{RET} | Data retention | 100Kcycles ^(Note 1) at $T_A = 105^\circ\text{C}$ | 20 | - | Years |

Note 1: Cycling performed over the whole temperature range.

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.9.2 RAM memory

($T_A = -40 \sim 105^\circ\text{C}$, $1.8\text{V} \leq V_{DD} \leq 5.5\text{V}$, $V_{SS} = 0\text{V}$)

| Symbol | Item | Test condition | Min. | Max. | Unit |
|----------------------|-----------------|------------------------------------|------|------|------|
| V_{RAMHOLD} | RAM hold vltage | $T_A = -40 \sim 105^\circ\text{C}$ | 0.8 | - | V |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

6.10 EMS characteristics

6.10.1 ESD eletrical characteristics

| Symbol | Item | Test condition | Grade |
|----------------|---|---|-------|
| $V_{ESD(HBM)}$ | Electrostatic discharge (Human-Body Model HBM) | $T_A = 25^{\circ}\text{C}$ conforming to JESD22-A114 | 3A |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

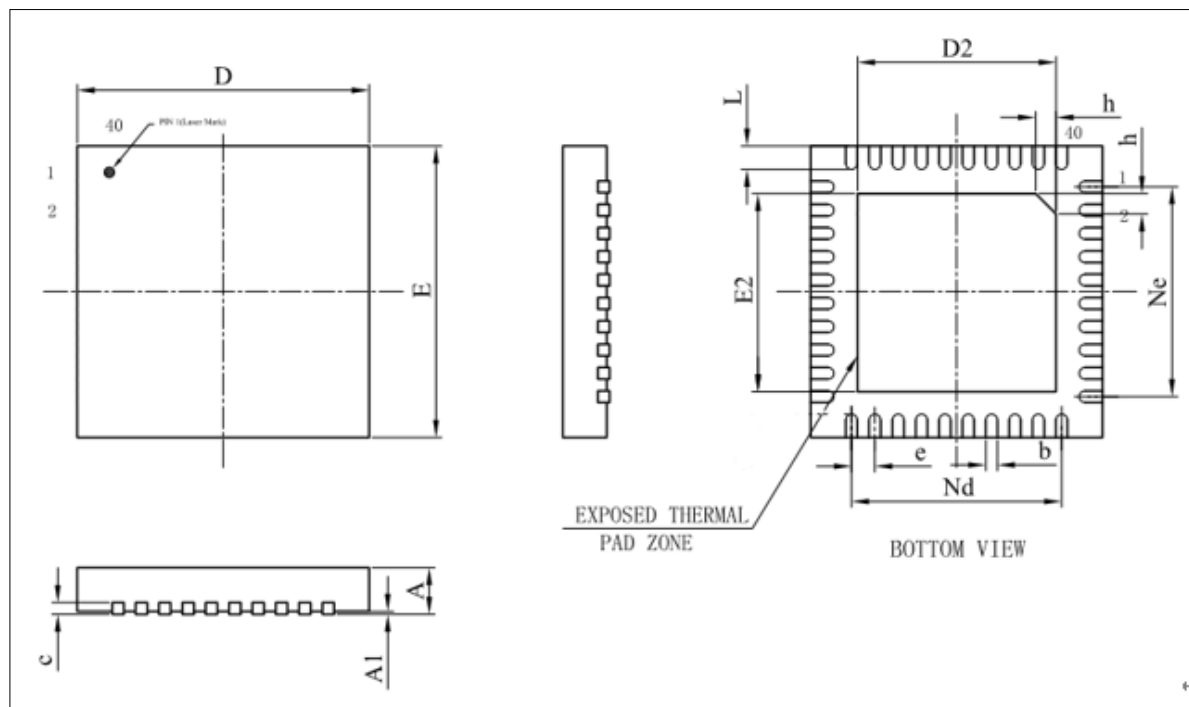
6.10.2 Latch-up electrical characteristics

| Symbol | Item | Test condition | Classification |
|--------|-----------------------|--|----------------|
| LU | Static latch-up class | $T_A = 25^{\circ}\text{C}$, conforming to JESD78F | I level B |

Remark: This specification is guaranteed by the design, and is not tested in mass production.

7 Package Dimensions

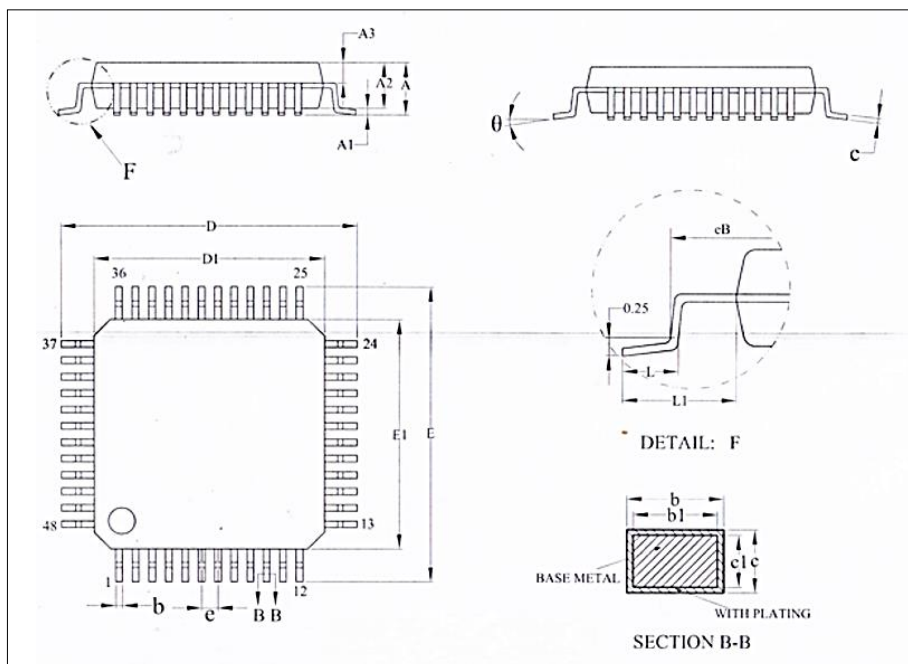
7.1 QFN40 (5x5mm, 0.4mm)



| Symbol | Millimeter | | |
|--------|------------|------|------|
| | Min | Nom | Max |
| A | 0.70 | 0.75 | 0.80 |
| A1 | - | 0.02 | 0.05 |
| b | 0.15 | 0.20 | 0.25 |
| c | 0.18 | 0.20 | 0.25 |
| D | 4.90 | 5.00 | 5.10 |
| D2 | 3.30 | - | 3.80 |
| e | 0.40BSC | | |
| Ne | 3.60BSC | | |
| Nd | 3.60BSC | | |
| E | 4.90 | 5.00 | 5.10 |
| E2 | 3.30 | - | 3.80 |
| L | 0.35 | 0.40 | 0.45 |
| h | 0.30 | 0.35 | 0.40 |

Caution: Package dimensions do not include mold flash or gate burrs.

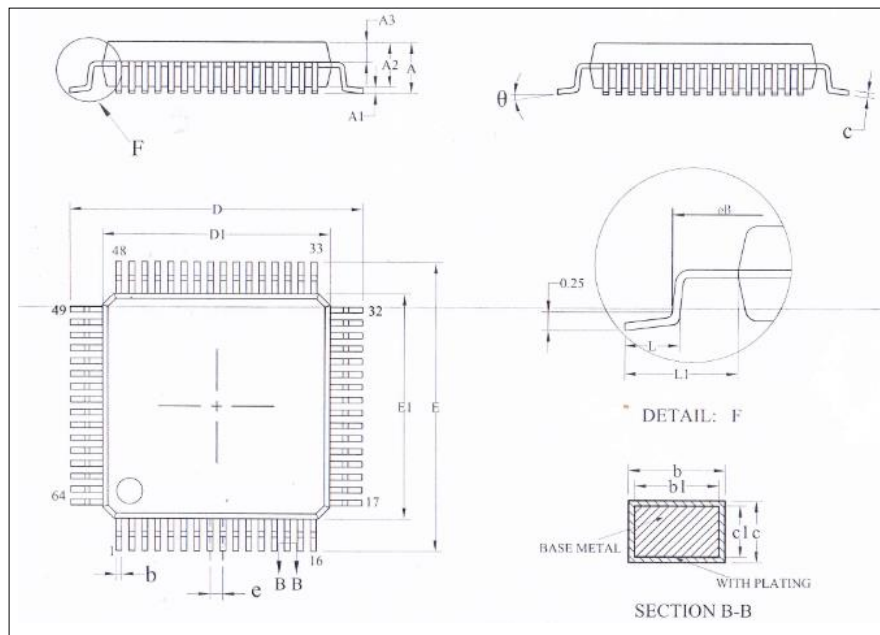
7.2 LQFP48 (7x7mm, 0.5mm)



| Symbol | Millimeter | | |
|--------|------------|------|------|
| | Min | Nom | Max |
| A | - | - | 1.60 |
| A1 | 0.05 | - | 0.15 |
| A2 | 1.30 | 1.40 | 1.50 |
| A3 | 0.59 | 0.64 | 0.69 |
| b | 0.18 | - | 0.26 |
| b1 | 0.17 | 0.20 | 0.23 |
| c | 0.13 | - | 0.18 |
| c1 | 0.12 | 0.13 | 0.14 |
| D | 8.80 | 9.00 | 9.20 |
| D1 | 6.90 | 7.00 | 7.10 |
| E | 8.80 | 9.00 | 9.20 |
| E1 | 6.90 | 7.00 | 7.10 |
| eB | 8.10 | - | 8.25 |
| e | 0.50BSC | | |
| L | 0.43 | - | 0.75 |
| L1 | 1.00REF | | |
| θ | 0° | - | 8° |

Caution: Package dimensions do not include mold flash or gate burrs.

7.3 LQFP64 (7x7, 0.4mm)



| Symbol | Millimeter | | |
|--------|------------|------|------|
| | Min | Nom | Max |
| A | - | - | 1.60 |
| A1 | 0.05 | - | 0.15 |
| A2 | 1.35 | 1.40 | 1.45 |
| A3 | 0.59 | 0.64 | 0.69 |
| b | 0.16 | - | 0.24 |
| b1 | 0.15 | 0.18 | 0.21 |
| c | 0.13 | - | 0.17 |
| c1 | 0.12 | 0.13 | 0.14 |
| D | 8.80 | 9.00 | 9.20 |
| D1 | 6.90 | 7.00 | 7.10 |
| E | 8.80 | 9.00 | 9.20 |
| E1 | 6.90 | 7.00 | 7.10 |
| eB | 8.10 | - | 8.25 |
| e | 0.40BSC | | |
| L | 0.45 | - | 0.75 |
| L1 | 1.00REF | | |
| θ | 0° | - | 7° |

Caution: Package dimensions do not include mold flash or gate burrs.

8 Revision History

| Version | Date | Description of changes |
|---------|-----------|------------------------|
| V1.0.0 | July 2025 | Official release |