GigaDevice Semiconductor Inc.

GD32F205xx
ARM® Cortex®-M3 32-bit MCU

Datasheet
Revision 2.6
(Jun. 2023)
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1. General description

The GD32F205xx device belongs to the performance line of GD32 MCU Family. It is a new 32-bit general-purpose microcontroller based on the ARM® Cortex®-M3 RISC core with best cost-performance ratio in terms of processing capacity, reduced power consumption and peripheral set. The Cortex®-M3 is a next generation processor core which is tightly coupled with a Nested Vectored Interrupt Controller (NVIC), SysTick timer and advanced debug support.

The GD32F205xx device incorporates the ARM® Cortex®-M3 32-bit processor core operating at 120 MHz frequency with flash accesses zero wait states to obtain maximum efficiency. It provides up to 3072 KB on-chip flash memory and 256 KB SRAM memory. An extensive range of enhanced I/Os and peripherals connected to two APB buses. The devices offer up to three 12-bit 2 MSPS ADCs, two 12-bit DACs, up to ten 16-bit general timers, two 16-bit basic timers plus two 16-bit PWM advanced timers, as well as standard and advanced communication interfaces: up to three SPIs, three I2Cs, four USARTs and four UARTs, two I2Ss, two CANs, a SDIO, a USBFS. Additional peripherals as TFT-LCD Interface (TLI) and EXMC interface with SDRAM extension support are included.

The device operates from a 2.6 to 3.6V power supply and available in -40 to +85 °C temperature range. Several power saving modes provide the flexibility for maximum optimization of power consumption, an especially important consideration in low power applications.

The above features make GD32F205xx devices suitable for a wide range of interconnection and advanced applications, especially in areas such as industrial control, consumer and handheld equipment, embedded modules, human machine interface, security and alarm systems, automotive navigation and so on.
## 2. Device overview

### 2.1. Device information

#### Table 2-1. GD32F205xx devices features and peripheral list

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<tr>
<td>Code area (KB)</td>
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<tr>
<td>Data area (KB)</td>
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<td>Total (KB)</td>
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</tr>
<tr>
<td>SRAM (KB)</td>
<td>128</td>
</tr>
<tr>
<td>General timer (16-bit)</td>
<td>10</td>
</tr>
<tr>
<td>Advanced timer (16-bit)</td>
<td>2</td>
</tr>
<tr>
<td>SysTick</td>
<td>1</td>
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<tr>
<td>Basic timer (16-bit)</td>
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<tr>
<td>Watchdog</td>
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<td>RTC</td>
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<td>CAN</td>
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<td>TLI</td>
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<td>GPIO</td>
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<td>ADC (CHs)</td>
<td>3(16)</td>
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## Table 2-1. GD32F205xx devices features and peripheral list (continued)

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<tr>
<td>Code area (KB)</td>
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<td>Data area (KB)</td>
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<tr>
<td>Total (KB)</td>
<td>256</td>
</tr>
<tr>
<td>SRAM (KB)</td>
<td>128</td>
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<tr>
<td>General timer (16-bit)</td>
<td>10</td>
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<tr>
<td>Advanced timer (16-bit)</td>
<td>2</td>
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<tr>
<td>SysTick</td>
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<tr>
<td>Basic timer (16-bit)</td>
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</tr>
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<td>Watchdog (16-bit)</td>
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<tr>
<td>RTC</td>
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<td>USART</td>
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<tr>
<td>UART</td>
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<tr>
<td>I2C</td>
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<td>SPI/I2S</td>
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<tr>
<td>GPIO</td>
<td>114</td>
</tr>
<tr>
<td>EXMC/SDRAM</td>
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</tr>
<tr>
<td>ADC (CHs)</td>
<td>3(24)</td>
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<tr>
<td>DAC</td>
<td>2</td>
</tr>
<tr>
<td>Package</td>
<td>LQFP144</td>
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2.2. Block diagram

Figure 2-1. GD32F205xx block diagram
2.3. Pinouts and pin assignment

Figure 2-2. GD32F205Zx LQFP144 pinouts
Figure 2-3. GD32F205Vx LQFP100 pinouts
Figure 2-4. GD32F205Rx LQFP64 pinouts
### 2.4. Memory map

Table 2-2 GD32F205xx memory map

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<th>Bus</th>
<th>Address</th>
<th>Peripherals</th>
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<td>EXMC - SDRAM</td>
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<td>0xA000 1000 - 0xBFFF FFFF</td>
<td>Reserved</td>
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<td>EXMC - SWREG</td>
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<td>EXMC - PC CARD</td>
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<td>EXMC - NAND</td>
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2.5. Clock tree

Figure 2-5. GD32F205xx clock tree

Legend:
- HXTAL: High speed crystal oscillator
- LXTAL: Low speed crystal oscillator
- IRC8M: Internal 8M RC oscillators
- IRC40K: Internal 40K RC oscillator
2.6. Pin definitions

2.6.1. GD32F205Zx LQFP144 pin definitions

Table 2-3. GD32F205Zx LQFP144 pin definitions

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Alternate: SPI1_NSS, I2C1_SMBA, USART2_CK, TIMER0_BRKIN, I2S1_WS, CAN1_RX
PB13 | 74 | I/O | 5VT | Default: PB13
Alternate: SPI1_SCK, USART2_CTS, TIMER0_CH0_ON, I2S1_CK, CAN1_TX
PB14 | 75 | I/O | 5VT | Default: PB14
Alternate: SPI1_MISO, USART2_RTS, TIMER0_CH1_ON, TIMER11_CH0
PB15 | 76 | I/O | 5VT | Default: PB15
Alternate: SPI1_MOSI, TIMER0_CH2_ON, I2S1_SD, TIMER11_CH1
PD8 | 77 | I/O | 5VT | Default: PD8
Alternate: EXMC_D13
Remap: USART2_TX
PD9 | 78 | I/O | 5VT | Default: PD9
Alternate: EXMC_D14
Remap: USART2_RX
PD10 | 79 | I/O | 5VT | Default: PD10
Alternate: EXMC_D15
Remap: USART2_CK, TLI_B3
PD11 | 80 | I/O | 5VT | Default: PD11
Alternate: EXMC_A16/EXC_CLE
Remap: USART2_CTS
PD12 | 81 | I/O | 5VT | Default: PD12
Alternate: EXMC_A17/EXC_ALE
Remap: TIMER3_CH0, USART2_RTS
PD13 | 82 | I/O | 5VT | Default: PD13
Alternate: EXMC_A18
Remap: TIMER3_CH1
VSS_8 | 83 | P | | Default: VSS_8
VDD_8 | 84 | P | | Default: VDD_8
PD14 | 85 | I/O | 5VT | Default: PD14
Alternate: EXMC_D0
Remap: TIMER3_CH2
PD15 | 86 | I/O | 5VT | Default: PD15
Alternate: EXMC_D1
Remap: TIMER3_CH3
PG2 | 87 | I/O | 5VT | Default: PG2
Alternate: EXMC_A12
PG3 | 88 | I/O | 5VT | Default: PG3
Alternate: EXMC_A13
PG4 | 89 | I/O | 5VT | Default: PG4
Alternate: EXMC_A14, EXMC_BA0
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**Notes:**

(1) Type: I = input, O = output, P = power.

(2) I/O Level: 5VT = 5 V tolerant.
### 2.6.2. GD32F205Vx LQFP100 pin definitions

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<td>5VT</td>
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**Notes:**

(1) Type: I = input, O = output, P = power.

(2) I/O Level: 5VT = 5 V tolerant.
## 2.6.3. GD32F205Rx LQFP64 pin definitions

### Table 2-5. GD32F205Rx LQFP64 pin definitions

<table>
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<tr>
<th>Pin Name</th>
<th>Pins</th>
<th>Pin Type(1)</th>
<th>I/O Level(2)</th>
<th>Functions description</th>
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**Notes:**

(1) Type: I = input, O = output, P = power.

(2) I/O Level: 5VT = 5 V tolerant.
3. Functional description

3.1. ARM® Cortex®-M3 core

The Cortex®-M3 processor is the latest generation of ARM® processors for embedded systems. It has been developed to provide a low-cost platform that meets the needs of MCU implementation, with a reduced pin count and low-power consumption, while delivering outstanding computational performance and an advanced system response to interrupts.

- 32-bit ARM® Cortex®-M3 processor core
- Up to 120 MHz operation frequency
- Single-cycle multiplication and hardware divider
- Integrated Nested Vectored Interrupt Controller (NVIC)
- 24-bit SysTick timer

The Cortex®-M3 processor is based on the ARMv7 architecture and supports both Thumb and Thumb-2 instruction sets. Some system peripherals listed below are also provided by Cortex®-M3:

- Internal Bus Matrix connected with ICode bus, DCode bus, system bus, Private Peripheral Bus (PPB) and debug accesses (AHB-AP)
- Nested Vectored Interrupt Controller (NVIC)
- Flash Patch and Breakpoint (FPB)
- Data Watchpoint and Trace (DWT)
- Instrument Trace Macrocell (ITM)
- Memory Protection Unit (MPU)
- Serial Wire JTAG Debug Port (SWJ-DP)
- Trace Port Interface Unit (TPIU)

3.2. On-chip memory

- Up to 3072 Kbytes of flash memory, including code flash and data flash.
- The region of the MCU executing instructions without waiting time is up to 512K bytes (In case that Flash size equal to 256K or 512K, all memory is no waiting time. If Flash size greater than 512K, no waiting time within first 384K.). A long delay when CPU fetches the instructions out of the range.
- Up to 256 Kbytes of SRAM.

The ARM® Cortex®-M3 processor is structured in Harvard architecture which can use separate buses to fetch instructions and load/store data. 3072 Kbytes of inner flash at most, which includes code flash and data flash is available for storing programs and data, and there is no waiting time within code flash area when CPU executes instructions. Up to 256 Kbytes of inner SRAM is composed of SRAM0, SRAM1, and SRAM2 that can be accessed at same time. Table 2-2 GD32F205xx memory map shows the memory map of the GD32F205xx
3.3. Clock, reset and supply management

- Internal 8 MHz factory-trimmed RC and external 3 to 25 MHz crystal oscillator
- Internal 40 KHz RC calibrated oscillator and external 32.768 KHz crystal oscillator
- Integrated system clock PLL
- 2.6 to 3.6 V application supply and I/Os
- Supply Supervisor: POR (Power On Reset), PDR (Power Down Reset), and low voltage detector (LVD)

The Clock Control Unit (CCU) provides a range of oscillator and clock functions. These include speed internal RC oscillator and external crystal oscillator, high speed and low speed two types. Several prescalers allow the frequency configuration of the AHB and two APB domains. The maximum frequency of the AHB/APB2/APB1 domains is 120/120/60 MHz. See Figure 2-5, GD32F205xx clock tree for details on the clock tree.

The Reset Control Unit (RCU) controls three kinds of reset: system reset resets the processor core and peripheral IP components. Power-on reset (POR) and power-down reset (PDR) are always active, and ensures proper operation starting from 2.6 V and down to 1.8V. The device remains in reset mode when V_{DD} is below a specified threshold. The embedded low voltage detector (LVD) monitors the power supply, compares it to the voltage threshold and generates an interrupt as a warning message for leading the MCU into security.

Power supply schemes:
- V_{DD} range: 2.6 to 3.6 V, external power supply for I/Os and the internal regulator. Provided externally through V_{DD} pins.
- V_{SSA}, V_{DDA} range: 2.6 to 3.6 V, external analog power supplies for ADC, reset blocks, RCs and PLL. V_{DDA} and V_{SSA} must be connected to V_{DD} and V_{SS}, respectively.
- V_{BAT} range: 1.8 to 3.6 V, power supply for RTC, external clock 32 KHz oscillator and backup registers (through power switch) when V_{DD} is not present.

3.4. Boot modes

At startup, boot pins are used to select one of three boot options:
- Boot from main flash memory (default)
- Boot from system memory
- Boot from on-chip SRAM

The boot loader is located in the internal boot ROM memory (system memory). It is used to reprogram the flash memory by using USART0 (PA9 and PA10), USART1 (PD5 and PD6) and USB (PA9, PA10, PA11 and PA12). It also can be used to transfer and update the flash memory code, the data and the vector table sections. In default condition, boot from bank 0 of flash memory is selected. It also supports to boot from bank 1 of flash memory by setting...
3.5. Power saving modes

The MCU supports three kinds of power saving modes to achieve even lower power consumption. They are sleep mode, deep-sleep mode, and standby mode. These operating modes reduce the power consumption and allow the application to achieve the best balance between the CPU operating time, speed and power consumption.

- **Sleep mode**
  In sleep mode, only the clock of CPU core is off. All peripherals continue to operate and any interrupt/event can wake up the system.

- **Deep-sleep mode**
  In deep-sleep mode, all clocks in the 1.2V domain are off, and all of the high speed crystal oscillator (IRC8M, HXTAL) and PLL are disabled. Only the contents of SRAM and registers are retained. Any interrupt or wakeup event from EXTI lines can wake up the system from the deep-sleep mode including the 16 external lines, the RTC alarm, the LVD output, and USB wakeup. When exiting the deep-sleep mode, the IRC8M is selected as the system clock.

- **Standby mode**
  In standby mode, the whole 1.2V domain is power off, the LDO is shut down, and all of IRC8M, HXTAL and PLL are disabled. The contents of SRAM and registers (except backup registers) are lost. There are four wakeup sources for the standby mode, including the external reset from NRST pin, the RTC alarm, the FWDGT reset, and the rising edge on WKUP pin.

3.6. Analog to digital converter (ADC)

- 12-bit SAR ADC engine with up to 2 MSPS conversion rate
- 12-bit, 10-bit, 8-bit or 6-bit configurable resolution
- Hardware oversampling ratio adjustable from 2 to 256x improves resolution to 16-bit
- Conversion range: $V_{SSA}$ to $V_{DDA}$ (2.6 to 3.6 V)
- Temperature sensor

Up to three 12-bit 2 MSPS multi-channel ADC are integrated in the device. It is a total of up to 16 multiplexed external channels with 2 internal channels for temperature sensor and voltage reference measurement. The conversion range is between $2.6 < V_{DDA} < 3.6$ V. An on-chip 16-bit hardware oversample scheme improves performances while off-loading the related computational burden from the MCU. An analog watchdog block can be used to detect the channels, which are required to remain within a specific threshold window. A configurable channel management block of analog inputs also can be used to perform conversions in single, continuous, scan or discontinuous mode to support more advanced usages.

The ADC can be triggered from the events generated by the general level 0 timers (TIMERx)
and the advanced timers (TIMER0 and TIMER7) with internal connection. The temperature sensor can be used to generate a voltage that varies linearly with temperature. It is internally connected to the ADC_IN16 input channel which is used to convert the sensor output voltage into a digital value.

3.7. Digital to analog converter (DAC)

- 12-bit DAC converter of independent output channel
- 8-bit or 12-bit mode in conjunction with the DMA controller

The 12-bit buffered DAC channel is used to generate variable analog outputs. The DAC is designed with integrated resistor strings structure. The DAC channels can be triggered by the timer update outputs or EXTI with DMA support. The maximum output value of the DAC is $V_{REF+}$.

3.8. DMA

- 14 channels DMA controller and each channel are configurable (7 for DMA0 and 7 for DMA1)
- Peripherals supported: Timers, ADC, SPIs, I2Cs, USARTs, DAC, I2S and SDIO

The flexible general-purpose DMA controllers provide a hardware method of transferring data between peripherals and/or memory without intervention from the CPU, thereby freeing up bandwidth for other system functions. Three types of access method are supported: peripheral to memory, memory to peripheral, memory to memory.

Each channel is connected to fixed hardware DMA requests. The priorities of DMA channel requests are determined by software configuration and hardware channel number. Transfer size of source and destination are independent and configurable.

3.9. General-purpose inputs/outputs (GPIOs)

- Up to 114 fast GPIOs, all mappable on 16 external interrupt lines
- Analog input/output configurable
- Alternate function input/output configurable

There are up to 114 general purpose I/O pins (GPIO) in GD32F205xx, named PA0 ~ PA15, PB0 ~ PB15, PC0 ~ PC15, PD0 ~ PD15, PE0 ~ PE15, PF0 ~ PF15, PG0 ~ PG15, PH0 ~ PH1 to implement logic input/output functions. Each of the GPIO ports has related control and configuration registers to satisfy the requirements of specific applications. The external interrupts on the GPIO pins of the device have related control and configuration registers in the Interrupt/event controller (EXTI). The GPIO ports are pin-shared with other alternative functions (AFs) to obtain maximum flexibility on the package pins. Each of the GPIO pins can
be configured by software as output (push-pull or open-drain), as input (with or without pull-up or pull-down) or as peripheral alternate function. Most of the GPIO pins are shared with digital or analog alternate functions. All GPIOs are high-current capable except for analog inputs.

3.10. Timers and PWM generation

- Two 16-bit advanced timer (TIMER0 & TIMER7), ten 16-bit general timers (TIMER1 ~ TIMER4, TIMER8 ~ TIMER13), and two 16-bit basic timer (TIMER5 & TIMER6)
- Up to 4 independent channels of PWM, output compare or input capture for each general timer and external trigger input
- 16-bit, motor control PWM advanced timer with programmable dead-time generation for output match
- Encoder interface controller with two inputs using quadrature decoder
- 24-bit SysTick timer down counter
- 2 watchdog timers (free watchdog timer and window watchdog timer)

The advanced timer (TIMER0 & TIMER7) can be used as a three-phase PWM multiplexed on 6 channels. It has complementary PWM outputs with programmable dead-time generation. It can also be used as a complete general timer. The 4 independent channels can be used for input capture, output compare, PWM generation (edge- or center-aligned counting modes) and single pulse mode output. If configured as a 16-bit general timer, it has the same functions as the TIMERrx timer. It can be synchronized with external signals or to interconnect with other general timers together which have the same architecture and features.

The general timer, known as TIMER1 ~ TIMER4, TIMER8 ~ TIMER13 can be used for a variety of purposes including general time, input signal pulse width measurement or output waveform generation such as a single pulse generation or PWM output, up to 4 independent channels for input capture/output compare. The general timer is based on a 16-bit auto-reload up/down counter and a 16-bit prescaler. TIMER1 ~ TIMER4 and TIMER8/TIMER11 also supports an encoder interface with two inputs using quadrature decoder.

The basic timer, known as TIMER5 & TIMER6, are mainly used for DAC trigger generation. They can also be used as a simple 16-bit time base.

The GD32F205xx have two watchdog peripherals, free watchdog timer and window watchdog timer. They offer a combination of high safety level, flexibility of use and timing accuracy.

The free watchdog timer includes a 12-bit down-counting counter and an 8-bit prescaler, it is clocked from an independent 40 KHz internal RC and as it operates independently of the main clock, it can operate in deep-sleep and standby modes. It can be used either as a watchdog to reset the device when a problem occurs, or as a free-running timer for application timeout management.

The window watchdog timer is based on a 7-bit down counter that can be set as free-running. It can be used as a watchdog to reset the device when a problem occurs. It is clocked from
the main clock. It has an early wakeup interrupt capability and the counter can be frozen in debug mode.

The SysTick timer is dedicated for OS, but could also be used as a standard down counter.

The features are shown below:
- A 24-bit down counter
- Auto reload capability
- Maskable system interrupt generation when the counter reaches 0
- Programmable clock source

### 3.11. Real time clock (RTC) and backup registers

- 32-bit up-counter with a programmable 20-bit prescaler
- Alarm function
- Interrupt and wake-up event
- 84 bytes backup registers for data protection

The real time clock is an independent timer which provides a set of continuously running counters in backup registers to provide a real calendar function, and provides an alarm interrupt or an expected interrupt. It is not reset by a system or power reset, or when the device wakes up from standby mode. A 20-bit prescaler is used for the time base clock and is by default configured to generate a time base of 1 second from a clock at 32.768 KHz from external crystal oscillator.

The backup registers are located in the backup domain that remains powered-on by $V_{BAT}$ even if $V_{DD}$ power is shut down, they are forty two 16-bit (84 bytes) registers for data protection of user application data, and the wake-up action from standby mode or system reset do not affect these registers.

In addition, the backup registers can be used to implement the tamper detection, RTC calibration function and waveform detection.

### 3.12. Inter-integrated circuit (I2C)

- Up to three I2C bus interfaces can support both master and slave mode with a frequency up to 400 KHz
- Provide arbitration function, optional PEC (packet error checking) generation and checking
- Supports 7-bit and 10-bit addressing mode and general call addressing mode

The I2C interface is an internal circuit allowing communication with an external I2C interface which is an industry standard two line serial interface used for connection to external hardware. These two serial lines are known as a serial data line (SDA) and a serial clock line (SCL). The I2C module provides transfer rate of up to 100 KHz in standard mode and up to 400 KHz in fast mode. The I2C module also has an arbitration detect function to prevent the
situation where more than one master attempts to transmit data to the I2C bus at the same time. A CRC-8 calculator is also provided in I2C interface to perform packet error checking for I2C data.

3.13. Serial peripheral interface (SPI)

- Up to three SPI interfaces with a frequency of up to 30 MHz
- Support both master and slave mode
- Hardware CRC calculation and transmit automatic CRC error checking
- Quad wire configuration available in master mode (only in SPI0)

The SPI interface uses 4 pins, among which are the serial data input and output lines (MISO & MOSI), the clock line (SCK) and the slave select line (NSS). Both SPIs can be served by the DMA controller. The SPI interface may be used for a variety of purposes, including simplex synchronous transfers on two lines with a possible bidirectional data line or reliable communication using CRC checking. Quad-SPI master mode is also supported in SPI0.

3.14. Universal synchronous/asynchronous receiver transmitter (USART/UART)

- Up to four USARTs and four UARTs with operating frequency up to 7.5 MHz
- Supports both asynchronous and clocked synchronous serial communication modes
- IrDA SIR encoder and decoder support
- LIN break generation and detection
- ISO 7816-3 compliant smart card interface

The USART (USART0, USART1, USART2, USART5) and UART (UART3, UART4, UART6, UART7) are used to transmit data between parallel and serial interfaces, provides a flexible full duplex data exchange using synchronous or asynchronous transfer. It is also commonly used for RS-232 standard communication. The USART/UART includes a programmable baud rate generator which is capable of dividing the system clock to produce a dedicated clock for the USART/UART transmitter and receiver. The USART/UART also supports DMA function for high speed data communication.

3.15. Inter-IC sound (I2S)

- Two I2S bus Interfaces with sampling frequency from 8 KHz to 192 KHz, multiplexed with SPI1 and SPI2
- Support either master or slave mode audio
- Sampling frequencies from 8 KHz up to 192 KHz are supported.

The Inter-IC sound (I2S) bus provides a standard communication interface for digital audio
applications by 3-wire serial lines. GD32F205xx contain an I2S-bus interface that can be operated with 16/32-bit resolution in master or slave mode, pin multiplexed with SPI1 and SPI2. The audio sampling frequencies from 8 KHz to 192 KHz is supported with less than 0.5% accuracy error.

3.16. **Universal serial bus full-speed interface (USBFS)**

- One USB device/host full-speed Interface with frequency up to 12 Mbit/s
- Internal main PLL for USB CLK compliantly

The Universal Serial Bus (USB) is a 4-wire bus with 4 bidirectional endpoints. The device controller enables 12 Mbit/s data exchange with integrated transceivers in device/host mode. Full-speed peripheral is compliant with the USB 2.0 specification. Transaction formatting is performed by the hardware, including CRC generation and checking. The status of a completed USB transfer or error condition is indicated by status registers. An interrupt is also generated if enabled. The dedicated 48 MHz clock is generated from the internal main PLL (the clock source must use a HXTAL crystal oscillator) and the operating frequency divided from APB1 should be 12 MHz above.

3.17. **Controller area network (CAN)**

- Two CAN2.0B interface with communication frequency up to 1 Mbit/s
- Internal main PLL for CAN CLK compliantly

Controller area network (CAN) is a method for enabling serial communication in field bus. The CAN protocol has been used extensively in industrial automation and automotive applications. It can receive and transmit standard frames with 11-bit identifiers as well as extended frames with 29-bit identifiers. Each CAN has three mailboxes for transmission and two FIFOs of three message deep for reception. It also provides 28 scalable/configurable identifier filter banks for selecting the incoming messages needed and discarding the others.

3.18. **External memory controller (EXMC)**

- Supported external memory: SRAM, PSRAM, ROM and NOR-Flash, NAND Flash and PC card, SDRAM with up to 32-bit data bus
- Provide ECC calculating hardware module for NAND Flash memory block
- Two SDRAM banks with independent configuration, up to 13-bits Row Address, 11-bits Column Address, 2-bits internal banks address
- SDRAM Memory size: 4x16Mx32bit(256 MB), 4x16Mx16bit (128 MB), 4x16Mx8bit (64 MB)

External memory controller (EXMC) is an abbreviation of external memory controller. It is divided into several sub-banks for external device support, each sub-bank has its own chip
selection signal but at one time, only one bank can be accessed. The EXMC support code execution from external memory except NAND Flash and PC card. The EXMC also can be configured to interface with the most common LCD module of Motorola 6800 and Intel 8080 series and reduce the system cost and complexity.

The EXMC of GD32F205xx in LQFP144 package also supports synchronous dynamic random access memory (SDRAM). It translates AHB transactions into the appropriate SDRAM protocol, and meanwhile, makes sure the access time requirements of the external SDRAM devices are satisfied.

3.19. Secure digital input and output card interface (SDIO)

- Support SD2.0/SDIO2.0/MMC4.2 host interface

The Secure Digital Input and Output Card Interface (SDIO) provides access to external SD memory cards specifications version 2.0, SDIO card specification version 2.0 and multi-media card system specification version 4.2 with DMA supported. In addition, this interface is also compliant with CE-ATA digital protocol rev1.1.

3.20. TFT LCD interface (TLI)

- 24-bit RGB Parallel Pixel Output; 8 bits-per-pixel (RGB888)
- Supports up to SVGA (800x600) resolution

The TFT LCD interface provides a parallel digital RGB (Red, Green, Blue) and signals for horizontal, vertical synchronization, pixel clock and data enable as output to interface directly to a variety of LCD (Liquid Crystal Display) and TFT (Thin Film Transistor) panels. A built-in DMA engine continuously move data from system memory to TLI and then, output to an external LCD display. Two separate layers are supported in TLI, as well as layer window and blending function.

3.21. Debug mode

- Serial wire JTAG debug port (SWJ-DP)

The ARM® SWJ-DP Interface is embedded and is a combined JTAG and serial wire debug port that enables either a serial wire debug or a JTAG probe to be connected to the target.

3.22. Package and operation temperature

- LQFP144 (GD32F205Zx), LQFP100 (GD32F205Vx), LQFP64 (GD32F205Rx)
- Operation temperature range: -40°C to +85°C (industrial level)
4. Electrical characteristics

4.1. Absolute maximum ratings

The maximum ratings are the limits to which the device can be subjected without permanently damaging the device. Note that the device is not guaranteed to operate properly at the maximum ratings. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

Table 4-1. Absolute maximum ratings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>External voltage range</td>
<td>VSS - 0.3</td>
<td>VSS + 3.6</td>
<td>V</td>
</tr>
<tr>
<td>VDDA</td>
<td>External analog supply voltage</td>
<td>VSSA - 0.3</td>
<td>VSSA + 3.6</td>
<td>V</td>
</tr>
<tr>
<td>VBAT</td>
<td>External battery supply voltage</td>
<td>VSSA - 0.3</td>
<td>VSS + 3.6</td>
<td>V</td>
</tr>
<tr>
<td>VIN</td>
<td>Input voltage on 5V tolerant pin</td>
<td>VSS - 0.3</td>
<td>VDD + 3.6</td>
<td>V</td>
</tr>
<tr>
<td>ΔVDDX</td>
<td>Variations between different VDD power pins</td>
<td>—</td>
<td>50</td>
<td>mV</td>
</tr>
<tr>
<td>VSSX-VSS</td>
<td>Variations between different ground pins</td>
<td>—</td>
<td>50</td>
<td>mV</td>
</tr>
<tr>
<td>IO</td>
<td>Maximum current for GPIO pins</td>
<td>—</td>
<td>±25</td>
<td>mA</td>
</tr>
<tr>
<td>TA</td>
<td>Operating temperature range</td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
</tr>
<tr>
<td>PD</td>
<td>Power dissipation at TA = 85°C of LQFP144</td>
<td>—</td>
<td>820</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Power dissipation at TA = 85°C of LQFP100</td>
<td>—</td>
<td>697</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Power dissipation at TA = 85°C of LQFP64</td>
<td>—</td>
<td>647</td>
<td>mW</td>
</tr>
<tr>
<td>TSTG</td>
<td>Storage temperature range</td>
<td>-65</td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>TJ</td>
<td>Maximum junction temperature</td>
<td>—</td>
<td>125</td>
<td>°C</td>
</tr>
</tbody>
</table>

(1) Guaranteed by design, not tested in production.
(2) All main power and ground pins should be connected to an external power source within the allowable range.
(3) VDD maximum value cannot exceed 5.5 V.
(4) It is recommended that VDD and VDDA are powered by the same source. The maximum difference between VDD and VDDA does not exceed 300 mV during power-up and operation.

4.2. Recommended DC characteristics

Table 4-2. DC operating conditions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min(1)</th>
<th>Typ</th>
<th>Max(1)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>Supply voltage</td>
<td>—</td>
<td>2.6</td>
<td>3.3</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>VDDA</td>
<td>Analog supply voltage</td>
<td>Same as VDD</td>
<td>2.6</td>
<td>3.3</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>VBAT</td>
<td>Battery supply voltage</td>
<td>—</td>
<td>1.8(2)</td>
<td>—</td>
<td>3.6</td>
<td>V</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) In the application which VBAT supply the backup domains, if the VBAT voltage drops below the minimum value, when VDD is powered on again, it is necessary to refresh the registers of backup domains and enable LXTAL again.

Figure 4-1. Recommended power supply decoupling capacitors
(1) The VREFP and VREFN pins are only available on no less than 100-pin packages, or else the VREFP and VREFN pins are not available and internally connected to VDDA and VSSA pins.

(2) All decoupling capacitors need to be as close as possible to the pins on the PCB board.

**Table 4-3. Clock frequency**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>fHCLK</td>
<td>AHB clock frequency</td>
<td>—</td>
<td>—</td>
<td>120</td>
<td>MHz</td>
</tr>
<tr>
<td>fAPB1</td>
<td>APB1 clock frequency</td>
<td>—</td>
<td>—</td>
<td>60</td>
<td>MHz</td>
</tr>
<tr>
<td>fAPB2</td>
<td>APB2 clock frequency</td>
<td>—</td>
<td>—</td>
<td>120</td>
<td>MHz</td>
</tr>
</tbody>
</table>

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

**Table 4-4. Operating conditions at Power up/ Power down**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>tVDD</td>
<td>VDD rise time rate</td>
<td>—</td>
<td>0</td>
<td>∞</td>
<td>µs/V</td>
</tr>
<tr>
<td>tVCC</td>
<td>VCC fall time rate</td>
<td>20</td>
<td>∞</td>
<td>∞</td>
<td>µs/V</td>
</tr>
</tbody>
</table>

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

**Table 4-5. Start-up timings of Operating conditions**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Typ</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>tstart-up</td>
<td>Start-up time</td>
<td>Clock source from HXTAL</td>
<td>246</td>
<td>ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clock source from IRC8M</td>
<td>246</td>
<td></td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.

(2) After power-up, the start-up time is the time between the rising edge of NRST high and the main function.

(3) PLL is off.
Table 4-6. Power saving mode wakeup timings characteristics(1)(2)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Typ</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>t_{Sleep}</td>
<td>Wakeup from Sleep mode</td>
<td>3.64</td>
<td>μs</td>
</tr>
<tr>
<td>t_{Deep-sleep}</td>
<td>Wakeup from Deep-sleep mode (LDO On)</td>
<td>5.19</td>
<td>μs</td>
</tr>
<tr>
<td></td>
<td>Wakeup from Deep-sleep mode (LDO in low power mode)</td>
<td>5.19</td>
<td>μs</td>
</tr>
<tr>
<td>t_{Standby}</td>
<td>Wakeup from Standby mode</td>
<td>192</td>
<td>ms</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) The wakeup time is measured from the wakeup event to the point at which the application code reads the first instruction under the below conditions: $V_{DD} = V_{DDA} = 3.3$ V, IRC8M = System clock = 8 MHz.

4.3. Power consumption

The power measurements specified in the tables represent that code with data executing from on-chip Flash with the following specifications.

Table 4-7. Power consumption characteristics(2)(3)(4)(5)(6)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ(1)</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supply current (Run mode)</td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, System clock=120 MHz, All peripherals enabled</td>
<td>—</td>
<td>95.52</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td>I_{DD}+ I_{DDA}</td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, System clock=120 MHz, All peripherals disabled</td>
<td>—</td>
<td>55.23</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, System clock=108 MHz, All peripherals enabled</td>
<td>—</td>
<td>86.22</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, System clock=72MHz, All peripherals enabled</td>
<td>—</td>
<td>50.05</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, System clock=72MHz, All peripherals disabled</td>
<td>—</td>
<td>58.42</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Supply current (Sleep mode)</td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, CPU clock off, System clock=120 MHz, All peripherals enabled</td>
<td>—</td>
<td>34.32</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, CPU clock off, System clock=120 MHz, All peripherals disabled</td>
<td>—</td>
<td>59.46</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, HXTAL=25MHz, IRC40K on, RTC on</td>
<td>—</td>
<td>1.23</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Supply current (Deep-Sleep mode)</td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, LDO in Run mode, IRC40K on, RTC on</td>
<td>—</td>
<td>1.18</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, LDO in Low Power mode, IRC40K on, RTC on</td>
<td>—</td>
<td>1.02</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Supply current (Standby mode)</td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, LXTAL off, IRC40K on, RTC on</td>
<td>—</td>
<td>7.47</td>
<td>—</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, LXTAL off, IRC40K on, RTC off</td>
<td>—</td>
<td>7.35</td>
<td>—</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD} = V_{DDA} = 3.3$ V, LXTAL off, IRC40K off, RTC off</td>
<td>—</td>
<td>6.13</td>
<td>27.5</td>
<td>μA</td>
</tr>
<tr>
<td>I_{BAT}</td>
<td>Battery supply current</td>
<td>$V_{BAT} = 3.6$ V, LXTAL on, RTC on, LXTAL High driving</td>
<td>—</td>
<td>1.65</td>
<td>—</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{BAT} = 3.3$ V, LXTAL on, RTC on, LXTAL High driving</td>
<td>—</td>
<td>1.55</td>
<td>—</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{BAT} = 2.6$ V, LXTAL on, RTC on, LXTAL High driving</td>
<td>—</td>
<td>1.40</td>
<td>—</td>
<td>μA</td>
</tr>
</tbody>
</table>
### 4.4. EMC characteristics

EMS (electromagnetic susceptibility) includes ESD (Electrostatic discharge, positive and negative) and FTB (Burst of Fast Transient voltage, positive and negative) testing result is given in the Table 4-8. EMS characteristics, based on the EMS levels and classes compliant with IEC 61000 series standard.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Level/Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;ESD&lt;/sub&gt;</td>
<td>Voltage applied to all device pins to induce a functional disturbance</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 3.3 V, T&lt;sub&gt;A&lt;/sub&gt; = +25 °C, conforms to IEC 61000-4-2</td>
<td>3B</td>
</tr>
<tr>
<td>V&lt;sub&gt;FTB&lt;/sub&gt;</td>
<td>Fast transient voltage burst applied to induce a functional disturbance through 100 pF on VDD and VSS pins</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 3.3 V, T&lt;sub&gt;A&lt;/sub&gt; = +25 °C, conforms to IEC 61000-4-4</td>
<td>4A</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
### 4.5. Power supply supervisor characteristics

#### Table 4-9. Power supply supervisor characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{LVD}$&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>Low voltage Detector level selection</td>
<td>$LVDT&lt;2:0&gt; = 000$(rising edge)</td>
<td>---</td>
<td>2.19</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 000$(falling edge)</td>
<td>---</td>
<td>2.08</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 001$(rising edge)</td>
<td>---</td>
<td>2.29</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 001$(falling edge)</td>
<td>---</td>
<td>2.19</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 010$(rising edge)</td>
<td>---</td>
<td>2.39</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 010$(falling edge)</td>
<td>---</td>
<td>2.29</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 011$(rising edge)</td>
<td>---</td>
<td>2.5</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 011$(falling edge)</td>
<td>---</td>
<td>2.39</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 100$(rising edge)</td>
<td>---</td>
<td>2.6</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 100$(falling edge)</td>
<td>---</td>
<td>2.48</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 101$(rising edge)</td>
<td>---</td>
<td>2.68</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 101$(falling edge)</td>
<td>---</td>
<td>2.58</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 110$(rising edge)</td>
<td>---</td>
<td>2.79</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 110$(falling edge)</td>
<td>---</td>
<td>2.68</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 111$(rising edge)</td>
<td>---</td>
<td>2.89</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$LVDT&lt;2:0&gt; = 111$(falling edge)</td>
<td>---</td>
<td>2.78</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td>$V_{LVDhyst}$&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>LVD hysteresis</td>
<td>---</td>
<td>---</td>
<td>100</td>
<td>---</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{POR}$&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>Power on reset threshold</td>
<td></td>
<td>2.32</td>
<td>2.40</td>
<td>2.48</td>
<td>V</td>
</tr>
<tr>
<td>$V_{PDR}$&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>Power down reset threshold</td>
<td></td>
<td>1.72</td>
<td>1.80</td>
<td>1.88</td>
<td>V</td>
</tr>
<tr>
<td>$V_{PORhyst}$&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>PDR hysteresis</td>
<td>---</td>
<td>---</td>
<td>600</td>
<td>---</td>
<td>mV</td>
</tr>
<tr>
<td>$\text{RSTTEMP}$&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>Reset temporization</td>
<td>---</td>
<td>---</td>
<td>2</td>
<td>---</td>
<td>ms</td>
</tr>
</tbody>
</table>

---

<sup>(1)</sup> Based on characterization, not tested in production.

<sup>(2)</sup> Guaranteed by design, not tested in production.
4.6. Electrical sensitivity

The device is strayed in order to determine its performance in terms of electrical sensitivity. Electrostatic discharges (ESD) are applied directly to the pins of the sample. Static latch-up (LU) test is based on the two measurement methods.

Table 4-10. ESD characteristics\(^{(1)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{ESD(HBM)})</td>
<td>Electrostatic discharge voltage (human body model)</td>
<td>(T_A=25 , ^\circ C; ) JS-001-2014</td>
<td>—</td>
<td>—</td>
<td>5000</td>
<td>V</td>
</tr>
<tr>
<td>(V_{ESD(CDM)})</td>
<td>Electrostatic discharge voltage (charge device model)</td>
<td>(T_A=25 , ^\circ C; ) JS-002-2014</td>
<td>—</td>
<td>—</td>
<td>500</td>
<td>V</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Based on characterization, not tested in production.

Table 4-11. Static latch-up characteristics\(^{(1)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>LU</td>
<td>I-test</td>
<td>(T_A=25 , ^\circ C; ) JESD78</td>
<td>—</td>
<td>—</td>
<td>±100</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>(V_{supply} ) over voltage</td>
<td>(T_A=25 , ^\circ C; )</td>
<td>—</td>
<td>—</td>
<td>5.4</td>
<td>V</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Based on characterization, not tested in production.
4.7. **External clock characteristics**

Table 4-12. High speed external clock (HXTAL) generated from a crystal/ceramic characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_{HXTAL}(1)</td>
<td>Crystal or ceramic frequency</td>
<td>2.6 V ≤ VDD ≤ 3.6 V</td>
<td>4</td>
<td>25</td>
<td>32</td>
<td>MHz</td>
</tr>
<tr>
<td>R_F(2)</td>
<td>Feedback resistor</td>
<td>VDD = 3.3 V</td>
<td>—</td>
<td>400</td>
<td>—</td>
<td>kΩ</td>
</tr>
<tr>
<td>C_{HXTAL}(2)(3)</td>
<td>Recommended matching capacitance on OSCIN and OSCOUT</td>
<td></td>
<td>—</td>
<td>20</td>
<td>30</td>
<td>pF</td>
</tr>
<tr>
<td>Ducy_{HXTAL}(2)</td>
<td>Crystal or ceramic duty cycle</td>
<td></td>
<td>—</td>
<td>30</td>
<td>50</td>
<td>70%</td>
</tr>
<tr>
<td>g_m(2)</td>
<td>Oscillator transconductance</td>
<td>Startup</td>
<td>—</td>
<td>25</td>
<td>—</td>
<td>mA/V</td>
</tr>
<tr>
<td>I_{DDHXTAL}(1)</td>
<td>Crystal or ceramic operating current</td>
<td>VDD = 3.3 V, T_A = 25 °C</td>
<td>—</td>
<td>1.69</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td>t_{SUHXTAL}(1)</td>
<td>Crystal or ceramic startup time</td>
<td>VDD = 3.3 V, T_A = 25 °C</td>
<td>—</td>
<td>0.46</td>
<td>—</td>
<td>ms</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.
(3) C_{HXTAL1} = C_{HXTAL2} = 2*(C_{LOAD} - C_S). For C_{HXTAL1} and C_{HXTAL2}, it is recommended matching capacitance on OSCIN and OSCOUT. For C_{LOAD}, it is crystal/ceramic load capacitance, provided by the crystal or ceramic manufacturer. For C_S, it is PCB and MCU pin stray capacitance.

Table 4-13. High speed external clock characteristics (HXTAL in bypass mode)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_{HXTAL_ext}(1)</td>
<td>External clock source or oscillator frequency</td>
<td>VDD = 3.3 V</td>
<td>1</td>
<td>—</td>
<td>50</td>
<td>MHz</td>
</tr>
<tr>
<td>V_{HXTALH}(2)</td>
<td>OSCIN input pin high level voltage</td>
<td>VDD = 3.3 V</td>
<td>0.7</td>
<td>VDD</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>V_{HXTALL}(2)</td>
<td>OSCIN input pin low level voltage</td>
<td>VSS</td>
<td>—</td>
<td>0.3</td>
<td>VDD</td>
<td>V</td>
</tr>
<tr>
<td>t_{HL(HXTAL)}(2)</td>
<td>OSCIN high or low time</td>
<td>—</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t_{RF(HXTAL)}(2)</td>
<td>OSCIN rise or fall time</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>10</td>
<td>ns</td>
</tr>
<tr>
<td>C_{IN}(2)</td>
<td>OSCIN input capacitance</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>—</td>
<td>pF</td>
</tr>
<tr>
<td>Ducy_{HXTAL}(2)</td>
<td>Duty cycle</td>
<td></td>
<td>40</td>
<td>—</td>
<td>60</td>
<td>%</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.
Table 4-14. Low speed external clock (LXTAL) generated from a crystal/ceramic characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f_{LXTAL} )(^{(1)} )</td>
<td>Crystal or ceramic frequency</td>
<td>( V_{DD} = 3.3 ) V</td>
<td>—</td>
<td>32.768</td>
<td>—</td>
<td>kHz</td>
</tr>
<tr>
<td>( C_{LXTAL} )(^{(2)})(^{(3)} )</td>
<td>Recommended matching capacitance on OSC32IN and OSC32OUT</td>
<td>—</td>
<td>—</td>
<td>15</td>
<td>—</td>
<td>pF</td>
</tr>
<tr>
<td>( D_{ucy})(_{LXTAL})(^{(2)} )</td>
<td>Crystal or ceramic duty cycle</td>
<td>—</td>
<td>30</td>
<td>—</td>
<td>70</td>
<td>%</td>
</tr>
<tr>
<td>( g_{m} )(^{(2)} )</td>
<td>Oscillator transconductance</td>
<td>Lower driving capability</td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>μA/V</td>
</tr>
<tr>
<td></td>
<td>Medium low driving capability</td>
<td>—</td>
<td>6</td>
<td>—</td>
<td>—</td>
<td>μA/V</td>
</tr>
<tr>
<td></td>
<td>Medium high driving capability</td>
<td>—</td>
<td>12</td>
<td>—</td>
<td>—</td>
<td>μA/V</td>
</tr>
<tr>
<td></td>
<td>Higher driving capability</td>
<td>—</td>
<td>18</td>
<td>—</td>
<td>—</td>
<td>μA/V</td>
</tr>
<tr>
<td>( I_{DDLX_{TAL}} )(^{(1)} )</td>
<td>LXTAL oscillator operating current</td>
<td>( LXTAL)DRI[1:0]=10</td>
<td>—</td>
<td>1.14</td>
<td>—</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( LXTAL)DRI[1:0]=11</td>
<td>—</td>
<td>1.65</td>
<td>—</td>
<td>μA</td>
</tr>
<tr>
<td>( t_{SULX_{TAL}} )(^{(1)})(^{(4)} )</td>
<td>LXTAL oscillator startup time</td>
<td>( LXTAL)DRI[1:0]=10</td>
<td>—</td>
<td>0.56</td>
<td>—</td>
<td>s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( LXTAL)DRI[1:0]=11</td>
<td>—</td>
<td>0.4</td>
<td>—</td>
<td>s</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.
(3) \( C_{LXTAL1} = C_{LXTAL2} = 2 \times (C_{LOAD} - C_{S}) \). For \( C_{LXTAL1} \) and \( C_{LXTAL2} \), it is recommended matching capacitance on OSC32IN and OSC32OUT. For \( C_{LOAD} \), it is crystal/ceramic load capacitance, provided by the crystal or ceramic manufacturer. For \( C_{S} \), it is PCB and MCU pin stray capacitance.
(4) \( t_{SULX_{TAL}} \) is the startup time measured from the moment it is enabled (by software) to the 32.768 kHz oscillator stabilization flags is SET. This value varies significantly with the crystal manufacturer.

Table 4-15. Low speed external user clock characteristics (LXTAL in bypass mode)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f_{LXTAL_ext} )(^{(1)} )</td>
<td>External clock source or oscillator frequency</td>
<td>( V_{DD} = 3.3 ) V</td>
<td>—</td>
<td>32.768</td>
<td>1000</td>
<td>kHz</td>
</tr>
<tr>
<td>( V_{LXTAL} )(^{(2)} )</td>
<td>OSC32IN input pin high level voltage</td>
<td>—</td>
<td>0.7 ( V_{DD} )</td>
<td>—</td>
<td>( V_{DD} )</td>
<td>V</td>
</tr>
<tr>
<td>( V_{LXTAL} )(^{(2)} )</td>
<td>OSC32IN input pin low level voltage</td>
<td>—</td>
<td>( V_{SS} )</td>
<td>—</td>
<td>0.3 ( V_{DD} )</td>
<td>V</td>
</tr>
<tr>
<td>( t_{H/L_LXTAL} )(^{(2)} )</td>
<td>OSC32IN high or low time</td>
<td>—</td>
<td>450</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{R/F_LXTAL} )(^{(2)} )</td>
<td>OSC32IN rise or fall time</td>
<td>—</td>
<td>—</td>
<td>50</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( C_{IN} )(^{(2)} )</td>
<td>OSC32IN input capacitance</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>—</td>
<td>pF</td>
</tr>
<tr>
<td>( D_{ucy})(_{LXTAL} )(^{(2)} )</td>
<td>Duty cycle</td>
<td>—</td>
<td>30</td>
<td>50</td>
<td>70</td>
<td>%</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.
4.8. Internal clock characteristics

Table 4-16. High speed internal clock (IRC8M) characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>fIRC8M</td>
<td>High Speed Internal Oscillator (IRC8M) frequency</td>
<td>V_{DD} = V_{DDA} = 3.3 V</td>
<td>8</td>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td>ACCIRC8M</td>
<td>IRC8M oscillator Frequency accuracy, Factory-trimmed</td>
<td>V_{DD} = V_{DDA} = 3.3 V, T_{A} = -40 °C ~ +85 °C(1)</td>
<td>-0.9 to 0.4</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>IRC8M oscillator Frequency accuracy, User trimming step(1)</td>
<td>V_{DD} = V_{DDA} = 3.3 V, T_{A} = 25 °C</td>
<td>1.0</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>DucyIRC8M(2)</td>
<td>IRC8M oscillator duty cycle</td>
<td>V_{DD} = V_{DDA} = 3.3 V</td>
<td>45</td>
<td>50</td>
<td>55</td>
<td>%</td>
</tr>
<tr>
<td>IDDAIRC8M(1)</td>
<td>IRC8M oscillator operating current</td>
<td>V_{DD} = V_{DDA} = 3.3 V, fIRC8M = 8 MHz</td>
<td>75</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>tSUIRC8M(1)</td>
<td>IRC8M oscillator startup time</td>
<td>V_{DD} = V_{DDA} = 3.3 V, fIRC8M = 8 MHz</td>
<td>1.87</td>
<td></td>
<td></td>
<td>μs</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.

Table 4-17. Low speed internal clock (IRC40K) characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>fIRC40K(1)</td>
<td>Low Speed Internal oscillator (IRC40K) frequency</td>
<td>V_{DD} = V_{DDA} = 3.3 V, T_{A} = -40 °C ~ +85 °C</td>
<td>40</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>IDDAIRC40K(2)</td>
<td>IRC40K oscillator operating current</td>
<td>V_{DD} = V_{DDA} = 3.3 V, T_{A} = 25 °C</td>
<td>1</td>
<td></td>
<td></td>
<td>μA</td>
</tr>
<tr>
<td>tSUIRC40K(2)</td>
<td>IRC40K oscillator startup time</td>
<td>V_{DD} = V_{DDA} = 3.3 V, T_{A} = 25 °C</td>
<td>109</td>
<td></td>
<td></td>
<td>μs</td>
</tr>
</tbody>
</table>

(1) Guaranteed by design, not tested in production.
(2) Based on characterization, not tested in production.
### 4.9. PLL characteristics

#### Table 4-18. PLL characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_{PLL1}</td>
<td>PLL input clock frequency</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>25</td>
<td>MHz</td>
</tr>
<tr>
<td>f_{PLL2}</td>
<td>PLL output clock frequency</td>
<td>—</td>
<td>16</td>
<td>—</td>
<td>120</td>
<td>MHz</td>
</tr>
<tr>
<td>f_{VCO}</td>
<td>PLL VCO output clock frequency</td>
<td>—</td>
<td>32</td>
<td>—</td>
<td>240</td>
<td>MHz</td>
</tr>
<tr>
<td>t_{LOCK}</td>
<td>PLL lock time</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>300</td>
<td>μs</td>
</tr>
<tr>
<td>I_{DDA}</td>
<td>Current consumption on V_{DDA}</td>
<td>VCO freq = 240 MHz</td>
<td>—</td>
<td>450</td>
<td>—</td>
<td>μA</td>
</tr>
<tr>
<td>Jitter_{PLL}</td>
<td>Cycle to cycle Jitter (rms) System clock</td>
<td>—</td>
<td>35</td>
<td>—</td>
<td>—</td>
<td>ps</td>
</tr>
<tr>
<td></td>
<td>Cycle to cycle Jitter (peak to peak) System clock</td>
<td>—</td>
<td>371</td>
<td>—</td>
<td>—</td>
<td>ps</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.
(3) Value given with main PLL running.
4.10. Memory characteristics

Table 4-19. Flash memory characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Typ&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Max&lt;sup&gt;(2)&lt;/sup&gt;</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE&lt;sub&gt;CYC&lt;/sub&gt;</td>
<td>Number of guaranteed program /erase cycles before failure (Endurance)</td>
<td>T&lt;sub&gt;A&lt;/sub&gt;=-40°C ~ +85°C</td>
<td>100</td>
<td>—</td>
<td>—</td>
<td>kcycles</td>
</tr>
<tr>
<td>t&lt;sub&gt;RET&lt;/sub&gt;</td>
<td>Data retention time</td>
<td>—</td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>years</td>
</tr>
<tr>
<td>t&lt;sub&gt;PROG&lt;/sub&gt;</td>
<td>Word programming time</td>
<td>T&lt;sub&gt;A&lt;/sub&gt;=-40°C ~ +85°C</td>
<td>—</td>
<td>37.5</td>
<td>170</td>
<td>us</td>
</tr>
<tr>
<td>t&lt;sub&gt;ERASE&lt;/sub&gt;</td>
<td>Page erase time</td>
<td>T&lt;sub&gt;A&lt;/sub&gt;=-40°C ~ +85°C</td>
<td>—</td>
<td>50</td>
<td>500</td>
<td>ms</td>
</tr>
<tr>
<td>t&lt;sub&gt;ERASE(256K)&lt;/sub&gt;</td>
<td>Mass erase time</td>
<td>T&lt;sub&gt;A&lt;/sub&gt;=-40°C ~ +85°C</td>
<td>4</td>
<td>32</td>
<td>—</td>
<td>s</td>
</tr>
<tr>
<td>t&lt;sub&gt;ERASE(512K)&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>8</td>
<td>64</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>t&lt;sub&gt;ERASE(1MB)&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>16</td>
<td>128</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>t&lt;sub&gt;ERASE(3MB)&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>32</td>
<td>256</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.

4.11. NRST pin characteristics

Table 4-20. NRST pin characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Max&lt;sup&gt;(2)&lt;/sup&gt;</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;LNRST(1)&lt;/sub&gt;</td>
<td>NRST Input low level voltage</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = V&lt;sub&gt;DDA&lt;/sub&gt; = 2.6 V</td>
<td>-0.3</td>
<td>—</td>
<td>0.3 V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;HNRST(1)&lt;/sub&gt;</td>
<td>NRST Input high level voltage</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = V&lt;sub&gt;DDA&lt;/sub&gt; = 0.7 V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; + 0.3</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;hyst(1)&lt;/sub&gt;</td>
<td>Schmidt trigger Voltage hysteresis</td>
<td>—</td>
<td>380</td>
<td>—</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;LNRST(1)&lt;/sub&gt;</td>
<td>NRST Input low level voltage</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = V&lt;sub&gt;DDA&lt;/sub&gt; = 3.3 V</td>
<td>-0.3</td>
<td>—</td>
<td>0.3 V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;HNRST(1)&lt;/sub&gt;</td>
<td>NRST Input high level voltage</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = V&lt;sub&gt;DDA&lt;/sub&gt; = 0.7 V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; + 0.3</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;hyst(1)&lt;/sub&gt;</td>
<td>Schmidt trigger Voltage hysteresis</td>
<td>—</td>
<td>380</td>
<td>—</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;LNRST(1)&lt;/sub&gt;</td>
<td>NRST Input low level voltage</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = V&lt;sub&gt;DDA&lt;/sub&gt; = 3.6 V</td>
<td>-0.3</td>
<td>—</td>
<td>0.3 V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;HNRST(1)&lt;/sub&gt;</td>
<td>NRST Input high level voltage</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = V&lt;sub&gt;DDA&lt;/sub&gt; = 0.7 V&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>—</td>
<td>—</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; + 0.3</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;hyst(1)&lt;/sub&gt;</td>
<td>Schmidt trigger Voltage hysteresis</td>
<td>—</td>
<td>—</td>
<td>420</td>
<td>—</td>
<td>mV</td>
</tr>
<tr>
<td>R&lt;sub&gt;p(2)&lt;/sub&gt;</td>
<td>Pull-up equivalent resistor</td>
<td>—</td>
<td>—</td>
<td>40</td>
<td>—</td>
<td>kΩ</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.
Figure 4-2. Recommended external NRST pin circuit

![Recommended external NRST pin circuit](image)

(1) Unless the voltage on NRST pin go below $V_{IL(NRST)}$ level, the device would not generate a reliable reset.

### 4.12. GPIO characteristics

#### Table 4-21. I/O port DC characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IL}$</td>
<td>Standard IO Low level input voltage</td>
<td>$2.6 \leq V_{DD} = V_{DDA} \leq 3.6$ V</td>
<td>—</td>
<td>—</td>
<td>0.3 $V_{DD}$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IL}$</td>
<td>5V-tolerant IO Low level input voltage</td>
<td>$2.6 \leq V_{DD} = V_{DDA} \leq 3.6$ V</td>
<td>—</td>
<td>—</td>
<td>0.3 $V_{DD}$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IH}$</td>
<td>Standard IO Low level input voltage</td>
<td>$2.6 \leq V_{DD} = V_{DDA} \leq 3.6$ V</td>
<td>0.7 $V_{DD}$</td>
<td>—</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IH}$</td>
<td>5V-tolerant IO Low level input voltage</td>
<td>$2.6 \leq V_{DD} = V_{DDA} \leq 3.6$ V</td>
<td>0.7 $V_{DD}$</td>
<td>—</td>
<td>—</td>
<td>V</td>
</tr>
</tbody>
</table>

### 50 MHz

| $V_{OL}$ | Low level output voltage for an IO Pin ($I_O = +8 \text{ mA}$) | $V_{DD} = 2.6$ V | 0.17 | — |
| $V_{OL}$ | Low level output voltage for an IO Pin ($I_O = +20 \text{ mA}$) | $V_{DD} = 3.3$ V | 0.16 | — |
| $V_{OL}$ | Low level output voltage for an IO Pin ($I_O = +20 \text{ mA}$) | $V_{DD} = 3.6$ V | 0.16 | — |
| $V_{CH}$ | High level output voltage for an IO Pin ($I_O = +8 \text{ mA}$) | $V_{DD} = 2.6$ V | 2.39 | — |
| $V_{CH}$ | High level output voltage for an IO Pin ($I_O = +20 \text{ mA}$) | $V_{DD} = 3.3$ V | 3.12 | — |
| $V_{CH}$ | High level output voltage for an IO Pin ($I_O = +20 \text{ mA}$) | $V_{DD} = 3.6$ V | 3.41 | — |

### 10 MHz

| $V_{OL}$ | High level output | $V_{DD} = 2.6$ V | 0.43 | — | V |

---
<table>
<thead>
<tr>
<th>Symbo</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD = 3.3 V</td>
<td>VDD = 3.6 V</td>
<td>VDD = 3.3 V</td>
<td>—</td>
<td>—</td>
<td>0.35</td>
<td>—</td>
</tr>
<tr>
<td>IIO = 12 mA</td>
<td>IIO = 15 mA</td>
<td>IIO = 20 mA</td>
<td>—</td>
<td>—</td>
<td>0.74</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>0.75</td>
<td>—</td>
</tr>
<tr>
<td>VDD = 3.3 V</td>
<td>VDD = 3.6 V</td>
<td>VDD = 3.3 V</td>
<td>—</td>
<td>—</td>
<td>0.69</td>
<td>—</td>
</tr>
<tr>
<td>VDD = 3.6 V</td>
<td>VDD = 3.6 V</td>
<td>VDD = 3.6 V</td>
<td>—</td>
<td>—</td>
<td>2.10</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>2.90</td>
<td>—</td>
</tr>
<tr>
<td>VDD = 3.3 V</td>
<td>VDD = 3.6 V</td>
<td>VDD = 3.3 V</td>
<td>—</td>
<td>—</td>
<td>3.22</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>—</td>
<td>—</td>
<td>3.01</td>
<td>—</td>
</tr>
<tr>
<td>VDD = 3.6 V</td>
<td>VDD = 3.6 V</td>
<td>VDD = 3.6 V</td>
<td>—</td>
<td>—</td>
<td>3.33</td>
<td>—</td>
</tr>
<tr>
<td>RPU(2)</td>
<td>Internal pull-up resistor</td>
<td>All pins</td>
<td>VIN = VSS</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>PA10</td>
<td>—</td>
<td>—</td>
<td>7.5</td>
<td>10</td>
<td>13.5</td>
</tr>
<tr>
<td>RPD(2)</td>
<td>Internal pull-down resistor</td>
<td>All pins</td>
<td>VIN = VDD</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>PA10</td>
<td>—</td>
<td>—</td>
<td>7.5</td>
<td>10</td>
<td>13.5</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.
(3) All pins except PC13 / PC14 / PC15 / PI8. Since PC13 to PC15 and PI8 are supplied through the Power Switch, which can only be obtained by a small current, the speed of GPIOs PC13 to PC15 and PI8 should not exceed 2 MHz when they are in output mode (maximum load: 30 pF).

Table 4.22. I/O port AC characteristics(1)(2)(4)
The I/O speed is configured using the GPIOx_CTL->MDy[1:0] bits. Refer to the GD32F20x user manual which is selected to set the GPIO port output speed.

4.13. ADC characteristics

Table 4-23. ADC characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{DDA} )^{(1)}</td>
<td>Operating voltage</td>
<td>—</td>
<td>2.6</td>
<td>3.3</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>( V_{IN} )^{(1)}</td>
<td>ADC input voltage range</td>
<td>—</td>
<td>0</td>
<td>—</td>
<td>( V_{REF} )</td>
<td>V</td>
</tr>
<tr>
<td>( V_{REFP} )^{(2)}</td>
<td>Positive Reference Voltage</td>
<td>—</td>
<td>2.6</td>
<td>—</td>
<td>( V_{DDA} )</td>
<td>V</td>
</tr>
<tr>
<td>( V_{REFN} )^{(2)}</td>
<td>Negative Reference Voltage</td>
<td>—</td>
<td>—</td>
<td>( V_{SSA} )</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>( f_{ADC} )^{(1)}</td>
<td>ADC clock</td>
<td>—</td>
<td>0.6</td>
<td>—</td>
<td>28</td>
<td>MHz</td>
</tr>
<tr>
<td>( f_s )^{(1)}</td>
<td>Sampling rate</td>
<td>12-bit</td>
<td>0.04</td>
<td>—</td>
<td>2</td>
<td>MSPS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-bit</td>
<td>0.05</td>
<td>—</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8-bit</td>
<td>0.06</td>
<td>—</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-bit</td>
<td>0.075</td>
<td>—</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>( V_{AIN} )^{(1)}</td>
<td>Analog input voltage</td>
<td>16 external; 2 internal</td>
<td>0</td>
<td>—</td>
<td>( V_{DDA} )</td>
<td>V</td>
</tr>
<tr>
<td>( R_{AIN} )^{(2)}</td>
<td>External input impedance</td>
<td>See Equation 1</td>
<td>—</td>
<td>—</td>
<td>137.5</td>
<td>kΩ</td>
</tr>
<tr>
<td>( R_{ADC} )^{(2)}</td>
<td>Input sampling switch resistance</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.45</td>
<td>kΩ</td>
</tr>
<tr>
<td>( C_{ADC} )^{(2)}</td>
<td>Input sampling capacitance</td>
<td>No pin/pad capacitance included</td>
<td>—</td>
<td>—</td>
<td>6.4</td>
<td>pF</td>
</tr>
<tr>
<td>( t_{CAL} )^{(2)}</td>
<td>Calibration time</td>
<td>( f_{ADC} = 28 ) MHz</td>
<td>—</td>
<td>3.035</td>
<td>—</td>
<td>μs</td>
</tr>
<tr>
<td>( t_s )^{(2)}</td>
<td>Sampling time</td>
<td>( f_{ADC} = 28 ) MHz</td>
<td>0.05</td>
<td>—</td>
<td>8.55</td>
<td>μs</td>
</tr>
<tr>
<td>( t_{CONV} )^{(2)}</td>
<td>Total conversion time (including sampling time)</td>
<td>12-bit</td>
<td>—</td>
<td>14</td>
<td>—</td>
<td>1/ ( f_{ADC} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10-bit</td>
<td>—</td>
<td>12</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8-bit</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-bit</td>
<td>—</td>
<td>8</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>( t_{SU} )^{(2)}</td>
<td>Startup time</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
<td>μs</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.

**Equation 1:** \( R_{AIN} \) max formula

\[
R_{AIN} < \frac{T_s}{f_{ADC} \cdot C_{ADC} \cdot \ln(2^{N+2})} - R_{ADC}
\]

The formula above (Equation 1) is used to determine the maximum external impedance allowed for an error below 1/4 of LSB. Here \( N = 12 \) (from 12-bit resolution).

Table 4-24. ADC RAIN max for \( f_{ADC} = 28 \) MHz

<table>
<thead>
<tr>
<th>( T_s ) (cycles)</th>
<th>( t_s ) (us)</th>
<th>( R_{AIN\ max} ) (KΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>0.05</td>
<td>0.4</td>
</tr>
<tr>
<td>7.5</td>
<td>0.26</td>
<td>3.8</td>
</tr>
<tr>
<td>13.5</td>
<td>0.48</td>
<td>7.3</td>
</tr>
<tr>
<td>28.5</td>
<td>1.01</td>
<td>15.9</td>
</tr>
<tr>
<td>41.5</td>
<td>1.48</td>
<td>23.4</td>
</tr>
<tr>
<td>Symbol</td>
<td>Parameter</td>
<td>Conditions</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>TL</td>
<td>VSENSE linearity with temperature</td>
<td>—</td>
</tr>
<tr>
<td>Avg_Slope</td>
<td>Average slope</td>
<td>—</td>
</tr>
<tr>
<td>V25</td>
<td>Voltage at 25 °C</td>
<td>—</td>
</tr>
<tr>
<td>$t_{S_temp} $ (2)</td>
<td>ADC sampling time when reading the temperature</td>
<td>—</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.
(2) Guaranteed by design, not tested in production.

### 4.15. DAC characteristics

**Table 4-26. DAC characteristics**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{DDA} $ (1)</td>
<td>Operating voltage</td>
<td>—</td>
<td>2.6</td>
<td>3.3</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{REFP} $(2)</td>
<td>Positive Reference Voltage</td>
<td>—</td>
<td>2.6</td>
<td>—</td>
<td>$V_{DDA}$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{REFN} $(2)</td>
<td>Negative Reference Voltage</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>$V_{SSA}$</td>
<td>V</td>
</tr>
<tr>
<td>$R_{LOAD} $(2)</td>
<td>Resistive load</td>
<td>Resistive load with buffer ON</td>
<td>5</td>
<td>—</td>
<td>—</td>
<td>kΩ</td>
</tr>
<tr>
<td>$R_{O} $(2)</td>
<td>Impedance output</td>
<td>Impedance output with buffer OFF</td>
<td>—</td>
<td>—</td>
<td>15</td>
<td>kΩ</td>
</tr>
<tr>
<td>$C_{LOAD} $(2)</td>
<td>Capacitive load</td>
<td>Capacitive load with buffer ON</td>
<td>—</td>
<td>—</td>
<td>50</td>
<td>pF</td>
</tr>
<tr>
<td>DAC_OUT min (2)</td>
<td>Lower DAC_OUT voltage</td>
<td>Lower DAC_OUT voltage with buffer ON</td>
<td>0.2</td>
<td>—</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>DAC_OUT max (2)</td>
<td>Higher DAC_OUT voltage</td>
<td>Higher DAC_OUT voltage with buffer ON</td>
<td>—</td>
<td>—</td>
<td>$V_{DDA}$</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher DAC_OUT voltage with buffer OFF</td>
<td>—</td>
<td>—</td>
<td>$V_{DDA}$ - 0.2</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With no load, worst code(0xF1C) on the input, $V_{REF+} = 3.6$ V</td>
<td>—</td>
<td>298</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>$T_{wakeup} $(2)</td>
<td>Wakeup from off state</td>
<td>—</td>
<td>5</td>
<td>10</td>
<td>—</td>
<td>μs</td>
</tr>
</tbody>
</table>
4.16. I2C characteristics

Table 4-27. I2C characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Standard mode</th>
<th>Fast mode</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>tSCL(H)</td>
<td>SCL clock high time</td>
<td>—</td>
<td>4.0</td>
<td>0.6</td>
<td>μs</td>
</tr>
<tr>
<td>tSCL(L)</td>
<td>SCL clock low time</td>
<td>—</td>
<td>4.7</td>
<td>1.3</td>
<td>μs</td>
</tr>
<tr>
<td>tSU(SDA)</td>
<td>SDA setup time</td>
<td>—</td>
<td>250</td>
<td>100</td>
<td>ns</td>
</tr>
<tr>
<td>tH(SDA)</td>
<td>SDA data hold time</td>
<td>—</td>
<td>0</td>
<td>3450</td>
<td>ns</td>
</tr>
<tr>
<td>tR(SDA/SCL)</td>
<td>SDA and SCL rise time</td>
<td>—</td>
<td>1000</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tF(SDA/SCL)</td>
<td>SDA and SCL fall time</td>
<td>—</td>
<td>300</td>
<td>300</td>
<td>ns</td>
</tr>
<tr>
<td>tH(STA)</td>
<td>Start condition hold time</td>
<td>—</td>
<td>4.0</td>
<td>0.6</td>
<td>μs</td>
</tr>
<tr>
<td>tSU(STA)</td>
<td>Repeated Start condition setup time</td>
<td>—</td>
<td>4.7</td>
<td>0.6</td>
<td>μs</td>
</tr>
<tr>
<td>tSU(STO)</td>
<td>Stop condition setup time</td>
<td>—</td>
<td>4.0</td>
<td>0.6</td>
<td>μs</td>
</tr>
<tr>
<td>tBUFF</td>
<td>Stop to Start condition time (bus free)</td>
<td>—</td>
<td>4.7</td>
<td>1.3</td>
<td>μs</td>
</tr>
</tbody>
</table>

(1) Guaranteed by design, not tested in production.
(2) To ensure the standard mode I2C frequency, \( f_{\text{PCLK1}} \) must be at least 2 MHz. To ensure the fast mode I2C frequency, \( f_{\text{PCLK1}} \) must be at least 4 MHz.
(3) The device should provide a data hold time of 300 ns at least in order to bridge the undefined region of the falling edge of SCL.

Figure 4-3. I2C bus timing diagram
4.17. SPI characteristics

Table 4-28. Standard SPI characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>fSCK</td>
<td>SCK clock frequency</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>30 MHz</td>
</tr>
<tr>
<td>tSCK(H)</td>
<td>SCK clock high time</td>
<td>—</td>
<td>14.67</td>
<td>16.67</td>
<td>18.67</td>
<td>ns</td>
</tr>
<tr>
<td>tSCK(L)</td>
<td>SCK clock low time</td>
<td>—</td>
<td>14.67</td>
<td>16.67</td>
<td>18.67</td>
<td>ns</td>
</tr>
</tbody>
</table>

**SPI master mode**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>tV(MO)</td>
<td>Data output valid time</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>8</td>
<td>ns</td>
</tr>
<tr>
<td>tSU(MI)</td>
<td>Data input setup time</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tH(MI)</td>
<td>Data input hold time</td>
<td>—</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

**SPI slave mode**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>tSU(NSS)</td>
<td>NSS enable setup time</td>
<td>—</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tH(NSS)</td>
<td>NSS enable hold time</td>
<td>—</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tA(SO)</td>
<td>Data output access time</td>
<td>—</td>
<td>9</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>fDIS(SO)</td>
<td>Data output disable time</td>
<td>—</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tV(SO)</td>
<td>Data output valid time</td>
<td>—</td>
<td>—</td>
<td>11</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>fSU(SI)</td>
<td>Data input setup time</td>
<td>—</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tH(SI)</td>
<td>Data input hold time</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

(1) Based on characterization, not tested in production.

Figure 4-4. SPI timing diagram - master mode
Figure 4-5. SPI timing diagram - slave mode
## 4.18. I2S characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f_{CK} )</td>
<td>Clock frequency</td>
<td>Master mode (data: 16 bits, Audio frequency = 96 kHz)</td>
<td>—</td>
<td>3.078</td>
<td>—</td>
<td>MHz</td>
</tr>
<tr>
<td>( t_H )</td>
<td>Clock high time</td>
<td>Slave mode</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>( t_L )</td>
<td>Clock low time</td>
<td>—</td>
<td>162</td>
<td>—</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>( t_{V(WS)} )</td>
<td>WS valid time</td>
<td>Master mode</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{H(WS)} )</td>
<td>WS hold time</td>
<td>Master mode</td>
<td>—</td>
<td>2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{SU(WS)} )</td>
<td>WS setup time</td>
<td>Slave mode</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{SU(SD_MR)} )</td>
<td>Data input setup time</td>
<td>Master mode</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{SU(SD_SR)} )</td>
<td>Data input setup time</td>
<td>Slave mode</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{H(SD_MR)} )</td>
<td>Data input hold time</td>
<td>Master receiver</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{V(SD_ST)} )</td>
<td>Data output valid time</td>
<td>Slave transmitter (after enable edge)</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{H(SD_ST)} )</td>
<td>Data output hold time</td>
<td>Slave transmitter (after enable edge)</td>
<td>6</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{V(SD_MT)} )</td>
<td>Data output valid time</td>
<td>Master transmitter (after enable edge)</td>
<td>—</td>
<td>—</td>
<td>5</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{H(SD_MT)} )</td>
<td>Data output hold time</td>
<td>Master transmitter (after enable edge)</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

(1) Guaranteed by design, not tested in production.
(2) Based on characterization, not tested in production.
Figure 4-6. I2S timing diagram - master mode

Figure 4-7. I2S timing diagram - slave mode
4.19. **USART characteristics**

Table 4-30. USART characteristics\(^{(1)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>fSCK</td>
<td>SCK clock frequency</td>
<td>f(_{PCLKx}) = 120 MHz</td>
<td>—</td>
<td>—</td>
<td>60</td>
<td>MHz</td>
</tr>
<tr>
<td>tSCK(H)</td>
<td>SCK clock high time</td>
<td>f(_{PCLKx}) = 120 MHz</td>
<td>8.3</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>tSCK(L)</td>
<td>SCK clock low time</td>
<td>f(_{PCLKx}) = 120 MHz</td>
<td>8.3</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Guaranteed by design, not tested in production.

4.20. **SDIO characteristics**

Table 4-31. SDIO characteristics\(^{(1)}\)\(^{(2)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>f(_{PP}) (^{(3)})</td>
<td>Clock frequency in data transfer mode</td>
<td>—</td>
<td>0</td>
<td>—</td>
<td>48</td>
<td>MHz</td>
</tr>
<tr>
<td>t(_{W(CKL)}) (^{(3)})</td>
<td>Clock low time</td>
<td>f(_{PP}) = 48 MHz</td>
<td>9.5</td>
<td>10.5</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{W(CKH)}) (^{(3)})</td>
<td>Clock high time</td>
<td>f(_{PP}) = 48 MHz</td>
<td>9.3</td>
<td>10.3</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

CMD, D inputs (referenced to CK) in MMC and SD HS mode

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(_{ISU}) (^{(4)})</td>
<td>Input setup time HS</td>
<td>f(_{PP}) = 48 MHz</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{IH}) (^{(4)})</td>
<td>Input hold time HS</td>
<td>f(_{PP}) = 48 MHz</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

CMD, D outputs (referenced to CK) in MMC and SD HS mode

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(_{OV}) (^{(3)})</td>
<td>Output valid time HS</td>
<td>f(_{PP}) = 48 MHz</td>
<td>—</td>
<td>—</td>
<td>13.8</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{OH}) (^{(3)})</td>
<td>Output hold time HS</td>
<td>f(_{PP}) = 48 MHz</td>
<td>12</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

CMD, D inputs (referenced to CK) in SD default mode

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(_{ISUD}) (^{(4)})</td>
<td>Input setup time SD</td>
<td>f(_{PP}) = 24 MHz</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{IHD}) (^{(4)})</td>
<td>Input hold time SD</td>
<td>f(_{PP}) = 24 MHz</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

CMD, D outputs (referenced to CK) in SD default mode

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(_{OVd}) (^{(3)})</td>
<td>Output valid default time SD</td>
<td>f(_{PP}) = 24 MHz</td>
<td>—</td>
<td>2.4</td>
<td>2.8</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{OHD}) (^{(3)})</td>
<td>Output hold default time SD</td>
<td>f(_{PP}) = 24 MHz</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) CLK timing is measured at 50% of V\(_{DD}\).
\(^{(2)}\) Capacitive load C\(_{L}\) = 30 pF.
\(^{(3)}\) Based on characterization, not tested in production.
\(^{(4)}\) Guaranteed by design, not tested in production.

4.21. **CAN characteristics**

Refer to Table 4-21. I/O port DC characteristics for more details on the input/output alternate function characteristics (CAN TX and CAN RX).
4.22. USBFS characteristics

Table 4-32. USBFS start up time

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>USFS STARTUP(1)</td>
<td>USBFS startup time</td>
<td>1</td>
<td>µs</td>
</tr>
</tbody>
</table>

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

Table 4-33. USBFS DC electrical characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input levels(1)</td>
<td>VDD</td>
<td>USBFS operating voltage</td>
<td>—</td>
<td>3</td>
<td>3.6</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>VDI</td>
<td>Differential input sensitivity</td>
<td>—</td>
<td>0.2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>VCM</td>
<td>Differential common mode range</td>
<td>Includes VDI range</td>
<td>0.8</td>
<td>—</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>VSE</td>
<td>Single ended receiver threshold</td>
<td>—</td>
<td>1.3</td>
<td>—</td>
<td>2.0</td>
</tr>
<tr>
<td>Output levels (2)</td>
<td>VIL</td>
<td>Static output level low</td>
<td>RL of 1.0 kΩ to 3.6 V</td>
<td>—</td>
<td>0.06</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>VIH</td>
<td>Static output level high</td>
<td>RL of 15 kΩ to VSS</td>
<td>2.8</td>
<td>3.3</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>RPD(2)</td>
<td>PA11, PA12(USBFS_DM/DP)</td>
<td>PB14, PB15(USBHS_DM/DP)</td>
<td>VIN = VDD</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PA9(USBFS_VBUS)</td>
<td>PB13(USBHS_VBUS)</td>
<td>0.72</td>
<td>0.9</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>RPUI(2)</td>
<td>PA11, PA12(USBFS_DM/DP)</td>
<td>PB14, PB15(USBHS_DM/DP)</td>
<td>VIN = VSS</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PA9(USBFS_VBUS)</td>
<td>PB13(USBHS_VBUS)</td>
<td>0.24</td>
<td>0.3</td>
<td>0.33</td>
</tr>
</tbody>
</table>

(1) Guaranteed by design, not tested in production.
(2) Based on characterization, not tested in production.

Table 4-34. USBFS full speed-electrical characteristics(1)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>tr</td>
<td>Rise time</td>
<td>CL = 50 pF</td>
<td>4</td>
<td>—</td>
<td>20</td>
<td>ns</td>
</tr>
<tr>
<td>tf</td>
<td>Fall time</td>
<td>CL = 50 pF</td>
<td>4</td>
<td>—</td>
<td>20</td>
<td>ns</td>
</tr>
<tr>
<td>trFM</td>
<td>Rise/ fall time matching</td>
<td>tr / tf</td>
<td>90</td>
<td>—</td>
<td>110</td>
<td>%</td>
</tr>
<tr>
<td>VCRS</td>
<td>Output signal crossover voltage</td>
<td>—</td>
<td>1.3</td>
<td>—</td>
<td>2.0</td>
<td>V</td>
</tr>
</tbody>
</table>

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

Figure 4-8. USBFS timings: definition of data signal rise and fall time
4.23. EXMC characteristics

Table 4-35. Asynchronous non-multiplexed SRAM/PSRAM/NOR read timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{\text{W(NE)}})</td>
<td>EXMC_NE low time</td>
<td>40.5</td>
<td>42.5</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{V(NOEX,NE)}})</td>
<td>EXMC_NEx low to EXMC_NOE low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(NE)}})</td>
<td>EXMC_NOE low time</td>
<td>40.5</td>
<td>42.5</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(NOEX,NOE)}})</td>
<td>EXMC_NOE high to EXMC_NE high hold time</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{V(A,NE)}})</td>
<td>EXMC_NEx low to EXMC_A valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{V(BL,NE)}})</td>
<td>EXMC_NEx low to EXMC_BL valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(DATA,NE)}})</td>
<td>Data to EXMC_NEx high setup time</td>
<td>32.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(DATA,NOE)}})</td>
<td>Data to EXMC_NOE high setup time</td>
<td>32.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(DATA,NOE)}})</td>
<td>Data hold time after EXMC_NOE high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(DATA,NE)}})</td>
<td>Data hold time after EXMC_NEx high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(NADV,NE)}})</td>
<td>EXMC_NEx low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(NADV)}})</td>
<td>EXMC_NADV low time</td>
<td>7.3</td>
<td>9.3</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) \(C_L = 30\) pF.
\(^{(2)}\) Guaranteed by design, not tested in production.
\(^{(3)}\) Based on configure: \(f_{\text{HCLK}} = 120\) MHz, AddressSetupTime = 0, AddressHoldTime = 1, DataSetupTime = 1.

Table 4-36. Asynchronous non-multiplexed SRAM/PSRAM/NOR write timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{\text{W(NE)}})</td>
<td>EXMC_NE low time</td>
<td>23.9</td>
<td>25.9</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{V(NWE,NE)}})</td>
<td>EXMC_NEx low to EXMC_NWE low</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(NWE)}})</td>
<td>EXMC_NWE low time</td>
<td>7.3</td>
<td>9.3</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(NE,NWE)}})</td>
<td>EXMC_NWE high to EXMC_NE high hold time</td>
<td>7.3</td>
<td>9.3</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{V(A,NE)}})</td>
<td>EXMC_NEx low to EXMC_A valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{V(NADV,NE)}})</td>
<td>EXMC_NEx low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(NADV)}})</td>
<td>EXMC_NADV low time</td>
<td>7.3</td>
<td>9.3</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(AD,NADV)}})</td>
<td>EXMC_AD(address) valid hold time after</td>
<td>15.6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(A,NWE)}})</td>
<td>Address hold time after EXMC_NWE high</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(BL,NWE)}})</td>
<td>EXMC_BL hold time after EXMC_NWE high</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{H(BL,NE)}})</td>
<td>EXMC_NEx low to EXMC_BL valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(DATA,NADV)}})</td>
<td>EXMC_NADV high to DATA valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{W(DATA,NWE)}})</td>
<td>Data hold time after EXMC_NWE high</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) \(C_L = 30\) pF.
\(^{(2)}\) Guaranteed by design, not tested in production.
\(^{(3)}\) Based on configure: \(f_{\text{HCLK}} = 120\) MHz, AddressSetupTime = 0, AddressHoldTime = 1, DataSetupTime = 1.
### Table 4-37. Asynchronous multiplexed PSRAM/NOR read timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{(\text{NE})})</td>
<td>EXMC_NE low time</td>
<td>57.1</td>
<td>59.1</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{V(\text{NOE,NE})})</td>
<td>EXMC_NEx low to EXMC_NOE low</td>
<td>23.9</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{NOE})})</td>
<td>EXMC_NOE low time</td>
<td>32.2</td>
<td>34.2</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{NE,NOE})})</td>
<td>EXMC_NOE high to EXMC_NE high hold time</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{A,NE})})</td>
<td>EXMC_NEx low to EXMC_A valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{A,NOE})})</td>
<td>Address hold time after EXMC_NOE high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{BL,NE})})</td>
<td>EXMC_NEx low to EXMC_BL valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{BL,NOE})})</td>
<td>EXMC_BL hold time after EXMC_NOE high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{su(data,NE)}})</td>
<td>Data to EXMC_NEx high setup time</td>
<td>33.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{\text{su(data,NOE)}})</td>
<td>Data to EXMC_NOEx high setup time</td>
<td>33.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{data,NOE})})</td>
<td>Data hold time after EXMC_NOE high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{V(NOADV,NE)}})</td>
<td>EXMC_NEx low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{w(NADV)}})</td>
<td>EXMC_NADV low time</td>
<td>7.3</td>
<td>9.3</td>
<td>ns</td>
</tr>
<tr>
<td>(T_{(\text{AX,ADV)}})</td>
<td>EXMC_AD(address) valid hold time after EXMC_NADV high</td>
<td>7.3</td>
<td>9.3</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) \(C_L = 30 \text{ pF}\).  
\(^{(2)}\) Guaranteed by design, not tested in production.  
\(^{(3)}\) Based on configure: \(f_{\text{CLK}} = 120 \text{ MHz}\), AddressSetupTime = 0, AddressHoldTime = 1, DataSetupTime = 1.

### Table 4-38. Asynchronous multiplexed PSRAM/NOR write timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{(\text{NE})})</td>
<td>EXMC_NE low time</td>
<td>40.5</td>
<td>42.5</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{V(\text{NWE,NE})})</td>
<td>EXMC_NEx low to EXMC_NWE low</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{NWE})})</td>
<td>EXMC_NWE low time</td>
<td>23.9</td>
<td>25.9</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{V(\text{NE,NWE})})</td>
<td>EXMC_NWE high to EXMC_NE high hold time</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{A,NE})})</td>
<td>EXMC_NEx low to EXMC_A valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{V(\text{NADV,NE})})</td>
<td>EXMC_NEx low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{w(NADV)}})</td>
<td>EXMC_NADV low time</td>
<td>7.3</td>
<td>9.3</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{AX,NADV)}})</td>
<td>EXMC_AD(address) valid hold time after EXMC_NADV high</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{AX,NE})})</td>
<td>Address hold time after EXMC_NWE high</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{BL,NWE})})</td>
<td>EXMC_BL hold time after EXMC_NWE high</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{BL,NE})})</td>
<td>EXMC_NEx low to EXMC_BL valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{DATA,NADV)}})</td>
<td>EXMC_NADV high to DATA valid</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>(t_{(\text{DATA,NE})})</td>
<td>Data hold time after EXMC_NWE high</td>
<td>7.3</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) \(C_L = 30 \text{ pF}\).  
\(^{(2)}\) Guaranteed by design, not tested in production.  
\(^{(3)}\) Based on configure: \(f_{\text{CLK}} = 120 \text{ MHz}\), AddressSetupTime = 0, AddressHoldTime = 1, DataSetupTime =1.
Table 4-39. Synchronous multiplexed PSRAM/NOR read timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_{w(CLK)} )</td>
<td>EXMC_CLK period</td>
<td>33.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NExL)} )</td>
<td>EXMC_CLK low to EXMC_NEx low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKH-NExH)} )</td>
<td>EXMC_CLK high to EXMC_NEx high</td>
<td>15.6</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NADVL)} )</td>
<td>EXMC_CLK low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NADVH)} )</td>
<td>EXMC_CLK low to EXMC_NADV high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-ADV)} )</td>
<td>EXMC_CLK high to EXMC_Ax valid</td>
<td>15.6</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-ADIV)} )</td>
<td>EXMC_CLK low to EXMC_AD valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-ADVH)} )</td>
<td>EXMC_CLK high to EXMC_AD invalid</td>
<td>15.6</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-ADVH)} )</td>
<td>EXMC_CLK low to EXMC_AD invalid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) \( C_L = 30 \text{ pF.} \)
\(^{(2)}\) Guaranteed by design, not tested in production.
\(^{(3)}\) Based on configure: \( f_{HCLK} = 120 \text{ MHz}, \text{ BurstAccessMode} = \text{ Enable; Memory Type} = \text{ PSRAM; WriteBurst} = \text{ Enable; CLKDivision = 3 (EXMC_CLK is 4 divided by HCLK); DataLatency = 1.} \)

Table 4-40. Synchronous multiplexed PSRAM write timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_{w(CLK)} )</td>
<td>EXMC_CLK period</td>
<td>33.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NExL)} )</td>
<td>EXMC_CLK low to EXMC_NEx low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKH-NExH)} )</td>
<td>EXMC_CLK high to EXMC_NEx high</td>
<td>15.6</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NADVL)} )</td>
<td>EXMC_CLK low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NADVH)} )</td>
<td>EXMC_CLK low to EXMC_NADV high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-ADV)} )</td>
<td>EXMC_CLK high to EXMC_Ax valid</td>
<td>15.6</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-ADIV)} )</td>
<td>EXMC_CLK low to EXMC_Ax invalid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NWE)} )</td>
<td>EXMC_CLK low to EXMC_NWE low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKH-NWEH)} )</td>
<td>EXMC_CLK high to EXMC_NWE high</td>
<td>15.6</td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-ADV)} )</td>
<td>EXMC_CLK low to EXMC_AD invalid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>( t_{d(CLKL-NBLH)} )</td>
<td>EXMC_A/D valid data after EXMC_CLK low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) \( C_L = 30 \text{ pF.} \)
\(^{(2)}\) Guaranteed by design, not tested in production.
\(^{(3)}\) Based on configure: \( f_{HCLK} = 120 \text{ MHz}, \text{ BurstAccessMode} = \text{ Enable; Memory Type} = \text{ PSRAM; WriteBurst} = \text{ Enable; CLKDivision = 3 (EXMC_CLK is 4 divided by HCLK); DataLatency = 1.} \)
### Table 4-41. Synchronous non-multiplexed PSRAM/NOR read timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(_{w}(\text{CLK}))</td>
<td>EXMC_CLK period</td>
<td>33.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NExL}))</td>
<td>EXMC_CLK low to EXMC_NEx low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKH-NExH}))</td>
<td>EXMC_CLK high to EXMC_NEx high</td>
<td>15.6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NADVL}))</td>
<td>EXMC_CLK low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NADVH}))</td>
<td>EXMC_CLK low to EXMC_NADV high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-AV}))</td>
<td>EXMC_CLK low to EXMC_Ax valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKH-AV}))</td>
<td>EXMC_CLK high to EXMC_Ax invalid</td>
<td>15.6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NOEL}))</td>
<td>EXMC_CLK low to EXMC_NOE low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKH-NOEH}))</td>
<td>EXMC_CLK high to EXMC_NOE high</td>
<td>15.6</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) C\(_L\) = 30 pF.  
\(^{(2)}\) Guaranteed by design, not tested in production.  
\(^{(3)}\) Based on configure: HCLK = 120 MHz, BurstAccessMode = Enable; MemoryType = PSRAM; WriteBurst = Enable; CLKDivision = 3 (EXMC\_CLK is 4 divided by HCLK); DataLatency = 1.

### Table 4-42. Synchronous non-multiplexed PSRAM write timings\(^{(1)(2)(3)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>t(_{w}(\text{CLK}))</td>
<td>EXMC_CLK period</td>
<td>33.2</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NExL}))</td>
<td>EXMC_CLK low to EXMC_NEx low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKH-NExH}))</td>
<td>EXMC_CLK high to EXMC_NEx high</td>
<td>15.6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NADVL}))</td>
<td>EXMC_CLK low to EXMC_NADV low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NADVH}))</td>
<td>EXMC_CLK low to EXMC_NADV high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-AV}))</td>
<td>EXMC_CLK low to EXMC_Ax valid</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKH-AV}))</td>
<td>EXMC_CLK high to EXMC_Ax invalid</td>
<td>15.6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NWE}))</td>
<td>EXMC_CLK low to EXMC_NWE low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKH-NWE}))</td>
<td>EXMC_CLK high to EXMC_NWE high</td>
<td>15.6</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-DATA}))</td>
<td>EXMC_A/D valid data after EXMC_CLK low</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
<tr>
<td>t(_{d}(\text{CLKL-NBL}))</td>
<td>EXMC_CLK low to EXMC_NBL high</td>
<td>0</td>
<td>—</td>
<td>ns</td>
</tr>
</tbody>
</table>

\(^{(1)}\) C\(_L\) = 30 pF.  
\(^{(2)}\) Guaranteed by design, not tested in production.  
\(^{(3)}\) Based on configure: HCLK = 120 MHz, BurstAccessMode = Enable; MemoryType = PSRAM; WriteBurst = Enable; CLKDivision = 3 (EXMC\_CLK is 4 divided by HCLK); DataLatency = 1.
4.24. **TIMER characteristics**

Table 4-43. TIMER characteristics\(^{(1)}\)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{\text{res}})</td>
<td>Timer resolution time</td>
<td>(-)</td>
<td>1</td>
<td>(t_{\text{TIMERxCLK}})</td>
<td>ns</td>
</tr>
<tr>
<td>(f_{\text{EXT}})</td>
<td>Timer external clock frequency</td>
<td>(-)</td>
<td>0</td>
<td>(f_{\text{TIMERxCLK}}/2)</td>
<td>MHz</td>
</tr>
<tr>
<td>RES</td>
<td>Timer resolution</td>
<td>(-)</td>
<td>(-)</td>
<td>16</td>
<td>bit</td>
</tr>
<tr>
<td>(t_{\text{COUNTER}})</td>
<td>16-bit counter clock period when internal clock is selected</td>
<td>(-)</td>
<td>1</td>
<td>(0.0084)</td>
<td>(t_{\text{TIMERxCLK}})</td>
</tr>
<tr>
<td>(t_{\text{MAX_COUNT}})</td>
<td>Maximum possible count</td>
<td>(-)</td>
<td>(-)</td>
<td>65536x65536</td>
<td>(t_{\text{TIMERxCLK}})</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Guaranteed by design, not tested in production.

4.25. **WDGT characteristics**

Table 4-44. FWDGT min/max timeout period at 40 kHz (IRC40K) \(^{(1)}\)

<table>
<thead>
<tr>
<th>Prescaler divider</th>
<th>PSC[2:0] bits</th>
<th>Min timeout RLD[11:0] = 0x000</th>
<th>Max timeout RLD[11:0] = 0xFFF</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>000</td>
<td>0.025</td>
<td>409.525</td>
<td>ms</td>
</tr>
<tr>
<td>1/8</td>
<td>001</td>
<td>0.025</td>
<td>819.025</td>
<td></td>
</tr>
<tr>
<td>1/16</td>
<td>010</td>
<td>0.025</td>
<td>1638.025</td>
<td></td>
</tr>
<tr>
<td>1/32</td>
<td>011</td>
<td>0.025</td>
<td>3276.025</td>
<td></td>
</tr>
<tr>
<td>1/64</td>
<td>100</td>
<td>0.025</td>
<td>6552.025</td>
<td></td>
</tr>
<tr>
<td>1/128</td>
<td>101</td>
<td>0.025</td>
<td>13104.025</td>
<td></td>
</tr>
<tr>
<td>1/256</td>
<td>110 or 111</td>
<td>0.025</td>
<td>26208.025</td>
<td></td>
</tr>
</tbody>
</table>

\(^{(1)}\) Guaranteed by design, not tested in production.

Table 4-45. WWDGT min-max timeout value at 60 MHz (\(f_{\text{PCLK1}}\)) \(^{(1)}\)

<table>
<thead>
<tr>
<th>Prescaler divider</th>
<th>PSC[1:0]</th>
<th>Min timeout value CNT[6:0] = 0x40</th>
<th>Unit</th>
<th>Max timeout value CNT[6:0] = 0x7F</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1</td>
<td>00</td>
<td>68.2</td>
<td>(\mu)s</td>
<td>4.3</td>
<td>ms</td>
</tr>
<tr>
<td>1/2</td>
<td>01</td>
<td>136.4</td>
<td>(\mu)s</td>
<td>8.6</td>
<td></td>
</tr>
<tr>
<td>1/4</td>
<td>10</td>
<td>272.8</td>
<td>(\mu)s</td>
<td>17.2</td>
<td></td>
</tr>
<tr>
<td>1/8</td>
<td>11</td>
<td>545.6</td>
<td>(\mu)s</td>
<td>34.4</td>
<td></td>
</tr>
</tbody>
</table>

\(^{(1)}\) Guaranteed by design, not tested in production.

4.26. **Parameter conditions**

Unless otherwise specified, all values given for \(V_{DD} = V_{DDA} = 3.3\) V, \(T_A = 25\) °C.
5. Package information

5.1. LQFP144 package outline dimensions

Table 5-1. LQFP144 package dimensions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>—</td>
<td>—</td>
<td>1.60</td>
</tr>
<tr>
<td>A1</td>
<td>0.05</td>
<td>—</td>
<td>0.15</td>
</tr>
<tr>
<td>A2</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
</tr>
<tr>
<td>A3</td>
<td>0.59</td>
<td>0.64</td>
<td>0.69</td>
</tr>
<tr>
<td>b</td>
<td>0.18</td>
<td>—</td>
<td>0.26</td>
</tr>
<tr>
<td>b1</td>
<td>0.17</td>
<td>0.20</td>
<td>0.23</td>
</tr>
<tr>
<td>c</td>
<td>0.13</td>
<td>—</td>
<td>0.17</td>
</tr>
<tr>
<td>c1</td>
<td>0.12</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>D</td>
<td>21.80</td>
<td>22.00</td>
<td>22.20</td>
</tr>
<tr>
<td>D1</td>
<td>19.90</td>
<td>20.00</td>
<td>20.10</td>
</tr>
<tr>
<td>E</td>
<td>21.80</td>
<td>22.00</td>
<td>22.20</td>
</tr>
<tr>
<td>E1</td>
<td>19.90</td>
<td>20.00</td>
<td>20.10</td>
</tr>
<tr>
<td>e</td>
<td>—</td>
<td>0.50</td>
<td>—</td>
</tr>
<tr>
<td>L</td>
<td>0.45</td>
<td>—</td>
<td>0.75</td>
</tr>
<tr>
<td>L1</td>
<td>—</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>θ</td>
<td>0°</td>
<td>—</td>
<td>7°</td>
</tr>
</tbody>
</table>

(Original dimensions are in millimeters)
Figure 5-2. LQFP144 recommended footprint

(Original dimensions are in millimeters)
5.2. LQFP100 package outline dimensions

Figure 5-3. LQFP100 package outline

Table 5-2. LQFP100 package dimensions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>—</td>
<td>—</td>
<td>1.60</td>
</tr>
<tr>
<td>A1</td>
<td>0.05</td>
<td>—</td>
<td>0.15</td>
</tr>
<tr>
<td>A2</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
</tr>
<tr>
<td>A3</td>
<td>0.59</td>
<td>0.64</td>
<td>0.69</td>
</tr>
<tr>
<td>b</td>
<td>0.18</td>
<td>—</td>
<td>0.26</td>
</tr>
<tr>
<td>b1</td>
<td>0.17</td>
<td>0.20</td>
<td>0.23</td>
</tr>
<tr>
<td>c</td>
<td>0.13</td>
<td>—</td>
<td>0.17</td>
</tr>
<tr>
<td>c1</td>
<td>0.12</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>D</td>
<td>15.80</td>
<td>16.00</td>
<td>16.20</td>
</tr>
<tr>
<td>D1</td>
<td>13.90</td>
<td>14.00</td>
<td>14.10</td>
</tr>
<tr>
<td>E</td>
<td>15.80</td>
<td>16.00</td>
<td>16.20</td>
</tr>
<tr>
<td>E1</td>
<td>13.90</td>
<td>14.00</td>
<td>14.10</td>
</tr>
<tr>
<td>e</td>
<td>—</td>
<td>0.50</td>
<td>—</td>
</tr>
<tr>
<td>eB</td>
<td>15.05</td>
<td>—</td>
<td>15.35</td>
</tr>
<tr>
<td>L</td>
<td>0.45</td>
<td>—</td>
<td>0.75</td>
</tr>
<tr>
<td>L1</td>
<td>—</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>θ</td>
<td>0°</td>
<td>—</td>
<td>7°</td>
</tr>
</tbody>
</table>

(Original dimensions are in millimeters)
Figure 5-4. LQFP100 recommended footprint

(Original dimensions are in millimeters)
5.3. LQFP64 package outline dimensions

Figure 5-5. LQFP64 package outline

Table 5-3. LQFP64 package dimensions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>—</td>
<td>—</td>
<td>1.60</td>
</tr>
<tr>
<td>A1</td>
<td>0.05</td>
<td>—</td>
<td>0.15</td>
</tr>
<tr>
<td>A2</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
</tr>
<tr>
<td>A3</td>
<td>0.59</td>
<td>0.64</td>
<td>0.69</td>
</tr>
<tr>
<td>b</td>
<td>0.18</td>
<td>—</td>
<td>0.26</td>
</tr>
<tr>
<td>b1</td>
<td>0.17</td>
<td>0.20</td>
<td>0.23</td>
</tr>
<tr>
<td>c</td>
<td>0.13</td>
<td>—</td>
<td>0.17</td>
</tr>
<tr>
<td>c1</td>
<td>0.12</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>D</td>
<td>11.80</td>
<td>12.00</td>
<td>12.20</td>
</tr>
<tr>
<td>D1</td>
<td>9.90</td>
<td>10.00</td>
<td>10.10</td>
</tr>
<tr>
<td>E</td>
<td>11.80</td>
<td>12.00</td>
<td>12.20</td>
</tr>
<tr>
<td>E1</td>
<td>9.90</td>
<td>10.00</td>
<td>10.10</td>
</tr>
<tr>
<td>e</td>
<td>—</td>
<td>0.50</td>
<td>—</td>
</tr>
<tr>
<td>eB</td>
<td>11.25</td>
<td>—</td>
<td>11.45</td>
</tr>
<tr>
<td>L</td>
<td>0.45</td>
<td>—</td>
<td>0.75</td>
</tr>
<tr>
<td>L1</td>
<td>—</td>
<td>1.00</td>
<td>—</td>
</tr>
<tr>
<td>θ</td>
<td>0°</td>
<td>—</td>
<td>7°</td>
</tr>
</tbody>
</table>

(Original dimensions are in millimeters)
Figure 5-6. LQFP64 recommended footprint

(Original dimensions are in millimeters)
5.4. **Thermal characteristics**

Thermal resistance is used to characterize the thermal performance of the package device, which is represented by the Greek letter “$\theta$”. For semiconductor devices, thermal resistance represents the steady-state temperature rise of the chip junction due to the heat dissipated on the chip surface.

$\theta_{JA}$: Thermal resistance, junction-to-ambient.

$\theta_{JB}$: Thermal resistance, junction-to-board.

$\theta_{JC}$: Thermal resistance, junction-to-case.

$\psi_{JB}$: Thermal characterization parameter, junction-to-board.

$\psi_{JT}$: Thermal characterization parameter, junction-to-top center.

$\theta_{JA} = (T_J - T_A)/P_D$  \hspace{1cm} (5-1)

$\theta_{JB} = (T_J - T_B)/P_D$  \hspace{1cm} (5-2)

$\theta_{JC} = (T_J - T_C)/P_D$  \hspace{1cm} (5-3)

Where, $T_J =$ Junction temperature.

$T_A =$ Ambient temperature

$T_B =$ Board temperature

$T_C =$ Case temperature which is monitoring on package surface

$P_D =$ Total power dissipation

$\theta_{JA}$ represents the resistance of the heat flows from the heating junction to ambient air. It is an indicator of package heat dissipation capability. Lower $\theta_{JA}$ can be considerate as better overall thermal performance. $\theta_{JA}$ is generally used to estimate junction temperature.

$\theta_{JB}$ is used to measure the heat flow resistance between the chip surface and the PCB board.

$\theta_{JC}$ represents the thermal resistance between the chip surface and the package top case. $\theta_{JC}$ is mainly used to estimate the heat dissipation of the system (using heat sink or other heat dissipation methods outside the device package).

**Table 5-4. Package thermal characteristics**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Condition</th>
<th>Package</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{JA}$</td>
<td>Natural convection, 2S2P PCB</td>
<td>LQFP144</td>
<td>48.76</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP100</td>
<td>57.42</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP64</td>
<td>61.80</td>
<td>°C/W</td>
</tr>
<tr>
<td>$\theta_{JB}$</td>
<td>Cold plate, 2S2P PCB</td>
<td>LQFP144</td>
<td>35.00</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP100</td>
<td>31.68</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP64</td>
<td>42.83</td>
<td>°C/W</td>
</tr>
<tr>
<td>$\theta_{JC}$</td>
<td>Cold plate, 2S2P PCB</td>
<td>LQFP144</td>
<td>12.03</td>
<td>°C/W</td>
</tr>
<tr>
<td>Symbol</td>
<td>Condition</td>
<td>Package</td>
<td>Value</td>
<td>Unit</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>---------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>$\psi_{JE}$</td>
<td>Natural convection, 2S2P PCB</td>
<td>LQFP144</td>
<td>35.32</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP100</td>
<td>41.28</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP64</td>
<td>43.05</td>
<td></td>
</tr>
<tr>
<td>$\psi_{JT}$</td>
<td>Natural convection, 2S2P PCB</td>
<td>LQFP144</td>
<td>1.86</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP100</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LQFP64</td>
<td>1.58</td>
<td></td>
</tr>
</tbody>
</table>

(1) Thermal characteristics are based on simulation, and meet JEDEC specification.
## 6. Ordering information

Table 6-1. Part ordering code for GD32F205xx devices

<table>
<thead>
<tr>
<th>Ordering code</th>
<th>Flash (KB)</th>
<th>Package</th>
<th>Package type</th>
<th>Temperature operating range</th>
</tr>
</thead>
<tbody>
<tr>
<td>GD32F205ZKT6</td>
<td>3072</td>
<td>LQFP144</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205ZGT6</td>
<td>1024</td>
<td>LQFP144</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205ZET6</td>
<td>512</td>
<td>LQFP144</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205ZCT6</td>
<td>256</td>
<td>LQFP144</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205VK6</td>
<td>3072</td>
<td>LQFP100</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205VG6</td>
<td>1024</td>
<td>LQFP100</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205VE6</td>
<td>512</td>
<td>LQFP100</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205VC6</td>
<td>256</td>
<td>LQFP100</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205RK6</td>
<td>3072</td>
<td>LQFP64</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205RG6</td>
<td>1024</td>
<td>LQFP64</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205RE6</td>
<td>512</td>
<td>LQFP64</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
<tr>
<td>GD32F205RC6</td>
<td>256</td>
<td>LQFP64</td>
<td>Green</td>
<td>Industrial -40°C to +85°C</td>
</tr>
</tbody>
</table>
## 7. Revision history

**Table 7-1. Revision history**

<table>
<thead>
<tr>
<th>Revision No.</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Initial Release</td>
<td>Jul. 10, 2015</td>
</tr>
<tr>
<td>2.0</td>
<td>Adapt To New Name Convention</td>
<td>Jan. 24, 2018</td>
</tr>
<tr>
<td>2.1</td>
<td>Change pin definitions</td>
<td>Dec. 7, 2018</td>
</tr>
<tr>
<td>2.2</td>
<td>Modify the clock tree</td>
<td>Nov. 30, 2019</td>
</tr>
<tr>
<td>2.3</td>
<td>1. Modify the HXTAL frequency range of the clock tree to 4-32MHz.</td>
<td>Mar. 13, 2020</td>
</tr>
<tr>
<td></td>
<td>2. The ADC2 mapping function corresponding to PF3, PF4 and PF5 pins is modified to multiplexing function.</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>1. Modify the <strong>Table 4.3, Power consumption characteristics.</strong> Add test conditions and parameters in Deep-Sleep and Standby mode</td>
<td>Jun. 1, 2021</td>
</tr>
<tr>
<td>2.5</td>
<td>1. Modified the description of zero wait in Code Flash, refer to <strong>ARM® Cortex®-M3 core.</strong></td>
<td>Jul. 18, 2022</td>
</tr>
<tr>
<td></td>
<td>2. Update the pin names of EXMC_NL, EXMC_A16 and EXMC_A17 to EXMC_NL/EXMC_NADV, EXMC_A16/EXMC_CLE, and EXMC_A17/EXMC_ALE, refer to <strong>Pin definitions.</strong></td>
<td></td>
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<tr>
<td></td>
<td>3. Update the <strong>Electrical characteristics</strong> covering most chapter.</td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>1. Modify the cover, add version and time information.</td>
<td>Jun. 10, 2023</td>
</tr>
<tr>
<td></td>
<td>2. Change the prefix to uppercase and change VREF+ to VREFP and VREF- to VREFN, refer to <strong>Pin definitions</strong> and <strong>Figure 4.1.</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. The pin definitions table header adds chip package information.</td>
<td></td>
</tr>
</tbody>
</table>
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