



# **HT32F52231/HT32F52241 HT32F52331/HT32F52341 Datasheet**

**32-Bit ARM® Cortex™-M0+ Microcontroller,  
up to 64 KB Flash and 8 KB SRAM with 1 MSPS ADC,  
USART, UART, SPI, I<sup>2</sup>C, MCTM, GPTM, SCTM, BFTM,  
SCI, CRC, RTC, WDT, and USB2.0 FS**

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**Note that 24-pin and 28-pin package types are not marketed in the following countries: USA, UK, Germany, The Netherlands, France and Italy.**

# 1 General Description

The HOLTEK HT32F522x1/523x1 devices are high performance, low power consumption 32-bit microcontrollers based around an ARM® Cortex™-M0+ processor core. The Cortex™-M0+ is a next-generation processor core which is tightly coupled with Nested Vectored Interrupt Controller (NVIC), SysTick timer, and including advanced debug support.

The devices operate at a frequency of up to 40MHz for HT32F52231/52241 and 48MHz for HT32F52331/52341 with a Flash accelerator to obtain maximum efficiency. It provides up to 64KB of embedded Flash memory for code/data storage and 8 KB of embedded SRAM memory for system operation and application program usage. A variety of peripherals, such as ADC, I<sup>2</sup>C, USART, UART, SPI, MCTM, GPTM, SCTM, CRC-16/32, RTC, WDT, SCI, USB2.0 FS, SW-DP (Serial Wire Debug Port), etc., are also implemented in the device series. Several power saving modes provide the flexibility for maximum optimization between wakeup latency and power consumption, an especially important consideration in low power applications.

The above features ensure that the devices are suitable for use in a wide range of applications, especially in areas such as white goods application control, power monitors, alarm systems, consumer products, handheld equipment, data logging applications, motor control and so on.



## 2 Features

### Core

- 32-bit ARM® Cortex™-M0+ processor core
- Up to 40MHz operating frequency for HT32F52231/52241 or 48MHz for HT32F52331/52341
- 0.93 DMIPS/MHz (Dhrystone v2.1)
- Single-cycle multiplication
- Integrated Nested Vectored Interrupt Controller (NVIC)
- 24-bit SysTick timer

The Cortex-M0+ processor is a very low gate count, highly energy efficient processor that is intended for microcontroller and deeply embedded applications that require an area optimized, low-power processor. The processor is based on the ARMv6-M architecture and supports Thumb® instruction sets; single-cycle I/O port; hardware multiplier and low latency interrupt respond time.

### On-chip Memory

- Up to 64 KB on-chip Flash memory for instruction/data and options storage
- 8 KB on-chip SRAM
- Supports multiple boot modes

The ARM® Cortex™-M0+ processor accesses and debug accesses share the single external interface to external AHB peripheral. The processor accesses take priority over debug accesses. The maximum address range of the Cortex™-M0+ is 4 GB since it has a 32-bit bus address width. Additionally, a pre-defined memory map is provided by the Cortex™-M0+ processor to reduce the software complexity of repeated implementation by different device vendors. However, some regions are used by the ARM® Cortex™-M0+ system peripherals. Refer to the ARM® Cortex™-M0+ Technical Reference Manual for more information. Figure 2 shows the memory map of the HT32F52231/52241 and HT32F52331/52341 series of devices, including code, SRAM, peripheral, and other pre-defined regions.

### Flash Memory Controller – FMC

- Flash accelerator for maximum efficiency
- 32-bit word programming with In System Programming Interface (ISP) and In Application Programming (IAP)
- Flash protection capability to prevent illegal access

The Flash Memory Controller, FMC, provides all the necessary functions and pre-fetch buffer for the embedded on-chip Flash Memory. Since the access speed of the Flash Memory is slower than the CPU, a wide access interface with a pre-fetch buffer and cache are provided for the Flash Memory in order to reduce the CPU waiting time which will cause CPU instruction execution delays. Flash Memory word program/page erase functions are also provided.

## Reset Control Unit – RSTCU

- Supply supervisor:
  - Power On Reset / Power Down Reset – POR/PDR
  - Brown-out Detector – BOD
  - Programmable Low Voltage Detector – LVD

The Reset Control Unit, RSTCU, has three kinds of reset, a power on reset, a system reset and an APB unit reset. The power on reset, known as a cold reset, resets the full system during power up. A system reset resets the processor core and peripheral IP components with the exception of the SW-DP controller. The resets can be triggered by an external signal, internal events and the reset generators.

## Clock Control Unit – CKCU

- External 4 to 16MHz crystal oscillator
- External 32,768 Hz crystal oscillator
- Internal 8MHz RC oscillator trimmed to  $\pm 2\%$  accuracy at 3.3V operating voltage and 25°C operating temperature
- Internal 32 kHz RC oscillator
- Integrated system clock PLL
- Independent clock divider and gating bits for peripheral clock sources

The Clock Control unit, CKCU, provides a range of oscillator and clock functions. These include a High Speed Internal RC oscillator (HSI), a High Speed External crystal oscillator (HSE), a Low Speed Internal RC oscillator (LSI), a Low Speed External crystal oscillator (LSE), a Phase Lock Loop (PLL), a HSE clock monitor, clock prescalers, clock multiplexers, APB clock divider and gating circuitry. The AHB, APB and Cortex™-M0+ clocks are derived from the system clock (CK\_SYS) which can come from the HSI, HSE or PLL. The Watchdog Timer and Real Time Clock (RTC) use either the LSI or LSE as their clock source.

## Power Management – PWRCU

- Single  $V_{DD}$  power supply: 2.0V to 3.6V
- Integrated 1.5V LDO regulator for CPU core, peripherals and memories power supply
- $V_{DD}$  power supply for RTC.
- Two power domains:  $V_{DD}$ , 1.5 V
- Four power saving modes: Sleep, Deep-Sleep1, Deep-Sleep2, Power-Down

Power consumption can be regarded as one of the most important issues for many embedded system applications. Accordingly the Power Control Unit, PWRCU, in these devices provides many types of power saving modes such as Sleep, Deep-Sleep1, Deep-Sleep2 and Power-Down mode. These operating modes reduce the power consumption and allow the application to achieve the best trade-off between the conflicting demands of CPU operating time, speed and power consumption.

## External Interrupt/Event Controller – EXTI

- Up to 16 EXTI lines with configurable trigger source and type
- All GPIO pins can be selected as EXTI trigger source
- Source trigger type includes high level, low level, negative edge, positive edge, or both edge
- Individual interrupt enable, wakeup enable and status bits for each EXTI line
- Software interrupt trigger mode for each EXTI line
- Integrated deglitch filter for short pulse blocking

The External Interrupt/Event Controller, EXTI, comprises 16 edge detectors which can generate a wake-up event or interrupt requests independently. Each EXTI line can also be masked independently.

## Analog to Digital Converter – ADC

- 12-bit SAR ADC engine
- Up to 1 Msps conversion rate
- Up to 12 external analog input channels

A 12-bit multi-channel ADC is integrated in the device. There are multiplexed channels, which include 12 external analog signal channels and 2 internal channels which can be measured. If the input voltage is required to remain within a specific threshold window, an Analog Watchdog function will monitor and detect these signals. An interrupt will then be generated to inform the device that the input voltage is not within the preset threshold levels. There are three conversion modes to convert an analog signal to digital data. The ADC can be operated in one shot, continuous and discontinuous conversion modes.

## I/O Ports – GPIO

- Up to 40 GPIOs
- Port A, B, C are mapped as 16 external interrupts – EXTI
- Almost all I/O pins have a configurable output driving current.

There are up to 40 General Purpose I/O pins, GPIO, named from PA0 ~ PA15 to PC0 ~ PC7 for the implementation of logic input/output functions. Each of the GPIO ports has a series of related control and configuration registers to maximize flexibility and to meet the requirements of a wide range of applications.

The GPIO ports are pin-shared with other alternative functions to obtain maximum functional flexibility on the package pins. The GPIO pins can be used as alternative functional pins by configuring the corresponding registers regardless of the input or output pins. The external interrupts on the GPIO pins of the device have related control and configuration registers in the External Interrupt Control Unit, EXTI.

## Motor Control Timer – MCTM

- One 16-bit up, down, up/down auto-reload counter
- 16-bit programmable prescaler allowing counter clock frequency division by any factor between 1 and 65536
- Input Capture function
- Compare Match Output
- PWM waveform generation with Edge-aligned and Center-aligned Counting Modes
- Single Pulse Mode Output
- Complementary Outputs with programmable dead-time insertion
- Supports 3-phase motor control and hall sensor interface
- Break input to force the timer's output signals into a reset or fixed condition

The Motor Control Timer consists of a single 16-bit up/down counter, four 16-bit CCRs (Capture/Compare Registers), single one 16-bit counter-reload register (CRR), single 8-bit repetition counter and several control/status registers. It can be used for a variety of purposes including measuring the pulse widths of input signals or generating output waveforms such as compare match outputs, PWM outputs or complementary PWM outputs with dead-time insertion. The MCTM is capable of offering full functional support for motor control, hall sensor interfacing and brake input.

## PWM Generation and Capture Timers – GPTM

- One 16-bit up, down, up/down auto-reload counter
- 16-bit programmable prescaler allowing counter clock frequency division by any factor between 1 and 65536
- Input Capture function
- Compare Match Output
- PWM waveform generation with Edge-aligned and Center-aligned Counting Modes
- Single Pulse Mode Output
- Encoder interface controller with two inputs using quadrature decoder

The General Purpose Timer consists of one 16-bit up/down-counter, four 16-bit Capture/Compare Registers (CCRs), one 16-bit Counter Reload Register (CRR) and several control/status registers. They can be used for a variety of purposes including general time measurement, input signal pulse width measurement, output waveform generation such as single pulse generation, or PWM output generation. The GPTM supports an Encoder Interface using a decoder with two inputs.

## Single Channel Generation and Capture Timers – SCTM

- One 16-bit up and auto-reload counter
- One channel for each timer
- 16-bit programmable prescaler allowing counter clock frequency division by any factor between 1 and 65536
- Input Capture function
- Compare Match Output
- PWM waveform generation with Edge-aligned
- Single Pulse Mode Output

The Single-Channel Timer consists of one 16-bit up-counter, one 16-bit Capture/Compare Register (CCR), one 16-bit Counter-Reload Register (CRR) and several control/status registers. It can be used for a variety of purposes including general timer, input signal pulse width measurement or output waveform generation such as single pulse generation or PWM output.

## Basic Function Timer – BFTM

- One 32-bit compare/match count-up counter - no I/O control features
- One shot mode - counting stops after a match condition
- Repetitive mode - restart counter after a match condition

The Basic Function Timer is a simple count-up 32-bit counter designed to measure time intervals and generate a one shot or repetitive interrupts. The BFTM operates in two functional modes, repetitive or one shot mode. In the repetitive mode the BFTM restarts the counter when a compare match event occurs. The BFTM also supports a one shot mode which forces the counter to stop counting when a compare match event occurs.

## Watchdog Timer – WDT

- 12-bit down counter with 3-bit prescaler
- Reset event for the system
- Programmable watchdog timer window function
- Register write protection function

The Watchdog Timer is a hardware timing circuit that can be used to detect system failures due to software malfunctions. It includes a 12-bit count-down counter, a prescaler, a WDT delta value register, WDT operation control circuitry and a WDT protection mechanism. If the software does not reload the counter value before a Watchdog Timer underflow occurs, a reset will be generated when the counter underflows. In addition, a reset is also generated if the software reloads the counter when the counter value is greater than the WDT delta value. This means the counter must be reloaded within a limited timing window using a specific method. The Watchdog Timer counter can be stopped while the processor is in the debug mode. There is a register write protect function which can be enabled to prevent it from changing the Watchdog Timer configuration unexpectedly.

## Real Time Clock – RTC

- 24-bit up-counter with a programmable prescaler
- Alarm function
- Interrupt and Wake-up event

The Real Time Clock, RTC, includes an APB interface, a 24-bit count-up counter, a control register, a prescaler, a compare register and a status register. Most of the RTC circuits are located in the Backup Domain except for the APB interface. The APB interface is located in the V<sub>DD15</sub> power domain. Therefore, it is necessary to be isolated from the ISO signal that comes from the power control unit when the V<sub>DD15</sub> power domain is powered off, that is when the device enters the Power-Down mode. The RTC counter is used as a wakeup timer to generate a system resume signal from the Power-Down mode.

## Inter-integrated Circuit – I<sup>2</sup>C

- Supports both master and slave modes with a frequency of up to 1MHz
- Provide an arbitration function and clock synchronization
- Supports 7-bit and 10-bit addressing modes and general call addressing
- Supports slave multi-addressing mode with maskable address

The I<sup>2</sup>C is an internal circuit allowing communication with an external I<sup>2</sup>C 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 I<sup>2</sup>C module provides three data transfer rates: (1) 100kHz in the Standard mode, (2) 400kHz in the Fast mode and (3) 1MHz in the Fast plus mode. The SCL period generation register is used to setup different kinds of duty cycle implementations for the SCL pulse.

The SDA line which is connected directly to the I<sup>2</sup>C bus is a bi-directional data line between the master and slave devices and is used for data transmission and reception. The I<sup>2</sup>C also has an arbitration detect function and clock synchronization to prevent situations where more than one master attempts to transmit data to the I<sup>2</sup>C bus at the same time.

## Serial Peripheral Interface – SPI

- Supports both master and slave mode
- Frequency of up to (f<sub>CLK</sub>/2)MHz for the master mode and (f<sub>CLK</sub>/3)MHz for the slave mode
- FIFO Depth: 8 levels
- Multi-master and multi-slave operation

The Serial Peripheral Interface, SPI, provides an SPI protocol data transmit and receive function in both master and slave mode. The SPI interface uses 4 pins, which are the serial data input and output lines MISO and MOSI, the clock line, SCK, and the slave select line, SEL. One SPI device acts as a master device which controls the data flow using the SEL and SCK signals to indicate the start of data communication and the data sampling rate. To receive a data byte, the streamed data bits are latched on a specific clock edge and stored in the data register or in the RX FIFO. Data transmission is carried out in a similar way but in a reverse sequence. The mode fault detection provides a capability for multi-master applications.

## Universal Synchronous Asynchronous Receiver Transmitter – USART

- Supports both asynchronous and clocked synchronous serial communication modes
- Asynchronous operating baud rate up to ( $f_{PCLK}/16$ )MHz and synchronous operating rate up to ( $f_{PCLK}/8$ )MHz
- Full duplex communication
- Fully programmable serial communication characteristics including:
  - Word length: 7, 8, or 9-bit character
  - Parity: Even, odd, or no-parity bit generation and detection
  - Stop bit: 1 or 2 stop bit generation
  - Bit order: LSB-first or MSB-first transfer
- Error detection: Parity, overrun, and frame error
- Auto hardware flow control mode – RTS, CTS
- IrDA SIR encoder and decoder
- RS485 mode with output enable control
- FIFO Depth: 8×9 bits for both receiver and transmitter

The Universal Synchronous Asynchronous Receiver Transceiver, USART, provides a flexible full duplex data exchange using synchronous or asynchronous data transfer. The USART is used to translate data between parallel and serial interfaces, and is commonly used for RS232 standard communication. The USART peripheral function supports four types of interrupt including Line Status Interrupt, Transmitter FIFO Empty Interrupt, Receiver Threshold Level Reaching Interrupt and Time Out Interrupt. The USART module includes a transmitter FIFO, (TX\_FIFO) and receiver FIFO (RX\_FIFO). The software can detect a USART error status by reading the Line Status Register, LSR. The status includes the type and the condition of transfer operations as well as several error conditions resulting from Parity, Overrun, Framing and Break events.

## Universal Asynchronous Receiver Transmitter – UART

- Asynchronous serial communication operating baud-rate up to  $f_{PCLK}/16$ MHz
- Full duplex communication
- Fully programmable serial communication characteristics including:
  - Word length: 7, 8, or 9-bit character
  - Parity: Even, odd, or no-parity bit generation and detection
  - Stop bit: 1 or 2 stop bit generation
  - Bit order: LSB-first or MSB-first transfer
- Error detection: Parity, overrun, and frame error

The Universal Asynchronous Receiver Transceiver, UART, provides a flexible full duplex data exchange using asynchronous transfer. The UART is used to translate data between parallel and serial interfaces, and is commonly used for RS232 standard communication. The UART peripheral function supports Line Status Interrupt. The software can detect a UART error status by reading the Line Status Register, LSR. The status includes the type and the condition of transfer operations as well as several error conditions resulting from Parity, Overrun, Framing and Break events.

## Smart Card Interface – SCI (HT32F52331/52341 only)

- Supports ISO 7816-3 standard
- Character mode
- Single transmit buffer and single receive buffer
- 11-bit ETU (elementary time unit) counter
- 9-bit guard time counter
- 24-bit general purpose waiting time counter
- Parity generation and checking
- Automatic character retry on parity error detection in transmission and reception modes

The Smart Card Interface is compatible with the ISO 7816-3 standard. This interface includes Card Insertion/Removal detection, SCI data transfer control logic and data buffers, internal Timer Counters and corresponding control logic circuits to perform all the necessary Smart Card operations. The Smart Card interface acts as a Smart Card Reader to facilitate communication with the external Smart Card. The overall functions of the Smart Card interface are controlled by a series of registers including control and status registers together with several corresponding interrupts which are generated to get the attention of the microcontroller for SCI transfer status.

## Cyclic Redundancy Check – CRC

- Support CRC16 polynomial: 0x8005,  
 $X^{16}+X^{15}+X^2+1$
- Support CCITT CRC16 polynomial: 0x1021,  
 $X^{16}+X^{12}+X^5+1$
- Support IEEE-802.3 CRC32 polynomial: 0x04C11DB7,  
 $X^{32}+X^{26}+X^{23}+X^{22}+X^{16}+X^{12}+X^{11}+X^{10}+X^8+X^7+X^5+X^4+X^2+X+1$
- Supports 1's complement, byte reverse & bit reverse operation on data and checksum
- Supports byte, half-word & word data size
- Programmable CRC initial seed value
- CRC computation executed in 1 AHB clock cycle for 8-bit data and 4 AHB clock cycles for 32-bit data
- Supports PDMA to complete a CRC computation of a block of memory

The CRC calculation unit is an error detection technique test algorithm which is used to verify data transmission or storage data correctness. A CRC calculation takes a data stream or a block of data as its input and generates a 16- or 32-bit output remainder. Ordinarily, a data stream is suffixed by a CRC code and used as a checksum when being sent or stored. Therefore, the received or restored data stream is calculated by the same generator polynomial as described above. If the new CRC code result does not match the one calculated earlier, then this means that the data stream contains a data error.

## Universal Serial Bus Device Controller – USB (HT32F52331/52341 only)

- Complies with USB 2.0 full-speed (12 Mbps) specification
- On-chip USB full-speed transceiver
- 1 control endpoint (EP0) for control transfer
- 3 single-buffered endpoints for bulk and interrupt transfer
- 4 double-buffered endpoints for bulk, interrupt and isochronous transfer
- 1,024 bytes EP-SRAM used as the endpoint data buffers

The USB device controller is compliant with the USB 2.0 full-speed specification. There is one control endpoint known as Endpoint 0 and seven configurable endpoints. A 1024-byte SRAM is used as the endpoint buffer. Each endpoint buffer size is programmable using corresponding registers, which provides maximum flexibility for various applications. The integrated USB full-speed transceiver helps to minimize the overall system complexity and cost. The USB functional block also contains the resume and suspend feature to meet the requirements of low-power consumption.

## Debug Support

- Serial Wire Debug Port – SW-DP
- 4 comparators for hardware breakpoint or code / literal patch
- 2 comparators for hardware watchpoints

## Package and Operation Temperature

- 24/28-pin SSOP, 33-pin QFN, 48-pin LQFP for HT32F52231/52241
- 33-pin QFN, 48-pin LQFP package for HT32F52331/52341
- Operation temperature range: -40°C to +85°C

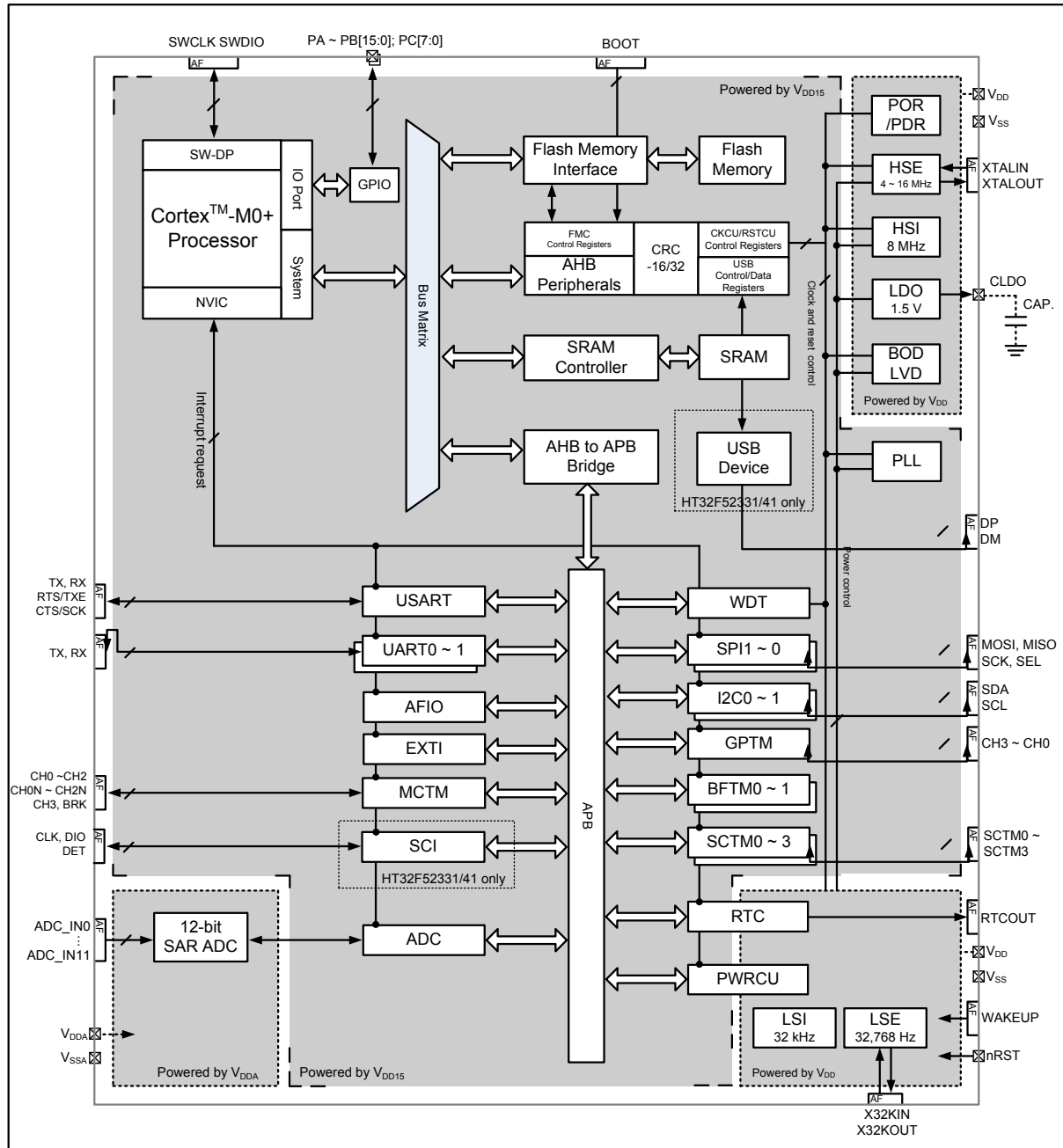
# 3 Overview

## Device Information

**Table 1 Features and Peripheral List**

| Peripherals             |                  | HT32F52231                                | HT32F52241 | HT32F52331              | HT32F52341 |
|-------------------------|------------------|-------------------------------------------|------------|-------------------------|------------|
| Main Flash (KB)         |                  | 32                                        | 63         | 32                      | 63         |
| Option Bytes Flash (KB) |                  | 1                                         | 1          | 1                       | 1          |
| SRAM (KB)               |                  | 4                                         | 8          | 4                       | 8          |
| Timers                  | MCTM             | 1                                         |            |                         |            |
|                         | GPTM             | 1                                         |            |                         |            |
|                         | SCTM             | 4                                         |            |                         |            |
|                         | BFTM             | 2                                         |            |                         |            |
|                         | RTC              | 1                                         |            |                         |            |
|                         | WDT              | 1                                         |            |                         |            |
| Communication           | USB              | —                                         |            | 1                       |            |
|                         | SPI              | 2                                         |            |                         |            |
|                         | USART            | 1                                         |            |                         |            |
|                         | UART             | 2                                         |            |                         |            |
|                         | I <sup>2</sup> C | 2                                         |            |                         |            |
|                         | SCI (ISO7816-3)  | —                                         |            | 1                       |            |
| CRC-16/32               |                  | 1                                         |            |                         |            |
| EXTI                    |                  | 16                                        |            |                         |            |
| 12-bit ADC              |                  | 1                                         |            |                         |            |
| Number of channels      |                  | 12 Channels                               |            |                         |            |
| GPIO                    |                  | Up to 40                                  |            | Up to 38                |            |
| CPU frequency           |                  | Up to 40MHz                               |            | Up to 48MHz             |            |
| Operating voltage       |                  | 2.0 V ~ 3.6 V                             |            |                         |            |
| Operating temperature   |                  | -40° C ~ +85° C                           |            |                         |            |
| Package                 |                  | 24/28-pin SSOP<br>33-pin QFN, 48-pin LQFP |            | 33-pin QFN, 48-pin LQFP |            |

## Block Diagram



Power supply: .....  
Bus: <=>  
Control signal: <-△->  
Alternate function: <-□->

**Figure 1 Block Diagram**

## Memory Map

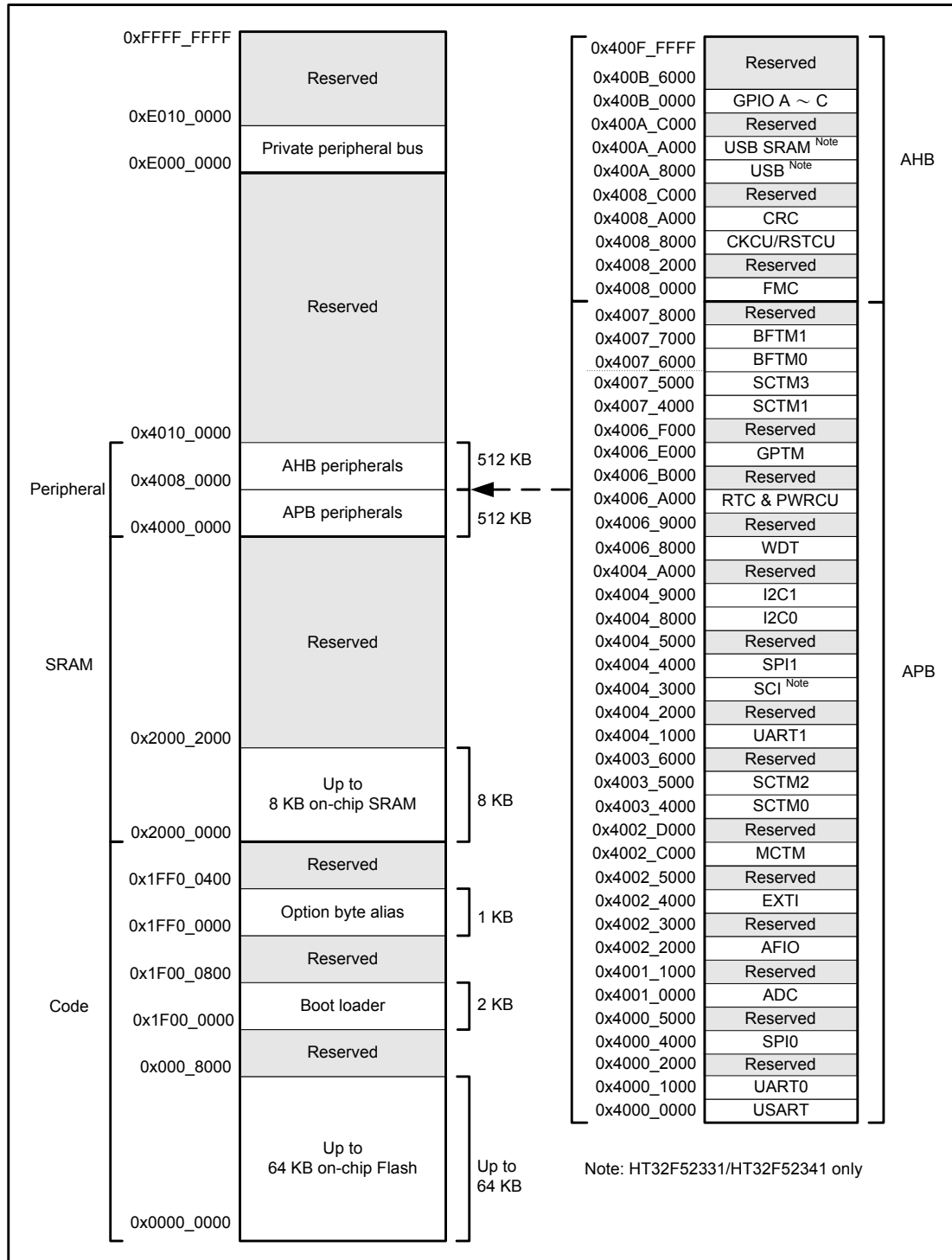


Figure 2 Memory Map

**Table 2 Register Map**

| Start Address | End Address | Peripheral          | Bus |
|---------------|-------------|---------------------|-----|
| 0x4000_0000   | 0x4000_0FFF | USART0              | APB |
| 0x4000_1000   | 0x4000_1FFF | UART0               |     |
| 0x4000_2000   | 0x4000_3FFF | Reserved            |     |
| 0x4000_4000   | 0x4000_4FFF | SPI0                |     |
| 0x4000_5000   | 0x4001_9FFF | Reserved            |     |
| 0x4001_0000   | 0x4001_0FFF | ADC                 |     |
| 0x4001_1000   | 0x4002_1FFF | Reserved            |     |
| 0x4002_2000   | 0x4002_2FFF | AFIO                |     |
| 0x4002_3000   | 0x4002_3FFF | Reserved            |     |
| 0x4002_4000   | 0x4002_4FFF | EXTI                |     |
| 0x4002_5000   | 0x4002_BFFF | Reserved            |     |
| 0x4002_C000   | 0x4002_CFFF | MCTM                |     |
| 0x4002_D000   | 0x4003_3FFF | Reserved            |     |
| 0x4003_4000   | 0x4003_4FFF | SCTM0               |     |
| 0x4003_5000   | 0x4003_5FFF | SCTM2               |     |
| 0x4003_6000   | 0x4004_0FFF | Reserved            |     |
| 0x4004_1000   | 0x4004_1FFF | UART1               |     |
| 0x4004_2000   | 0x4004_2FFF | Reserved            |     |
| 0x4004_3000   | 0x4004_3FFF | SCI <sup>Note</sup> |     |
| 0x4004_4000   | 0x4004_4FFF | SPI1                |     |
| 0x4004_5000   | 0x4004_7FFF | Reserved            |     |
| 0x4004_8000   | 0x4004_8FFF | I2C0                |     |
| 0x4004_9000   | 0x4004_9FFF | I2C1                |     |
| 0x4004_A000   | 0x4006_7FFF | Reserved            |     |
| 0x4006_8000   | 0x4006_8FFF | WDT                 |     |
| 0x4006_9000   | 0x4006_9FFF | Reserved            |     |
| 0x4006_A000   | 0x4006_AFFF | RTC/PWRCU           |     |
| 0x4006_B000   | 0x4006_DFFF | Reserved            |     |
| 0x4006_E000   | 0x4006_EFFF | GPTM                |     |
| 0x4006_F000   | 0x4007_3FFF | Reserved            |     |
| 0x4007_4000   | 0x4007_4FFF | SCTM1               |     |
| 0x4007_5000   | 0x4007_5FFF | SCTM3               |     |
| 0x4007_6000   | 0x4007_6FFF | BFTM0               |     |
| 0x4007_7000   | 0x4007_7FFF | BFTM1               |     |
| 0x4007_8000   | 0x4007_FFFF | Reserved            |     |

| Start Address | End Address | Peripheral          | Bus |
|---------------|-------------|---------------------|-----|
| 0x4008_0000   | 0x4008_1FFF | FMC                 | AHB |
| 0x4008_2000   | 0x4008_7FFF | Reserved            |     |
| 0x4008_8000   | 0x4008_9FFF | CKCU/RSTCU          |     |
| 0x4008_A000   | 0x4008_BFFF | CRC                 |     |
| 0x4008_C000   | 0x400A_7FFF | Reserved            |     |
| 0x400A_8000   | 0x400A_BFFF | USB <sup>Note</sup> |     |
| 0x400A_C000   | 0x400A_FFFF | Reserved            |     |
| 0x400B_0000   | 0x400B_1FFF | GPIOA               |     |
| 0x400B_2000   | 0x400B_3FFF | GPIOB               |     |
| 0x400B_4000   | 0x400B_5FFF | GPIOC               |     |
| 0x400B_6000   | 0x400F_FFFF | Reserved            |     |

Note: HT32F52331/HT32F52341 only.

## Clock Structure

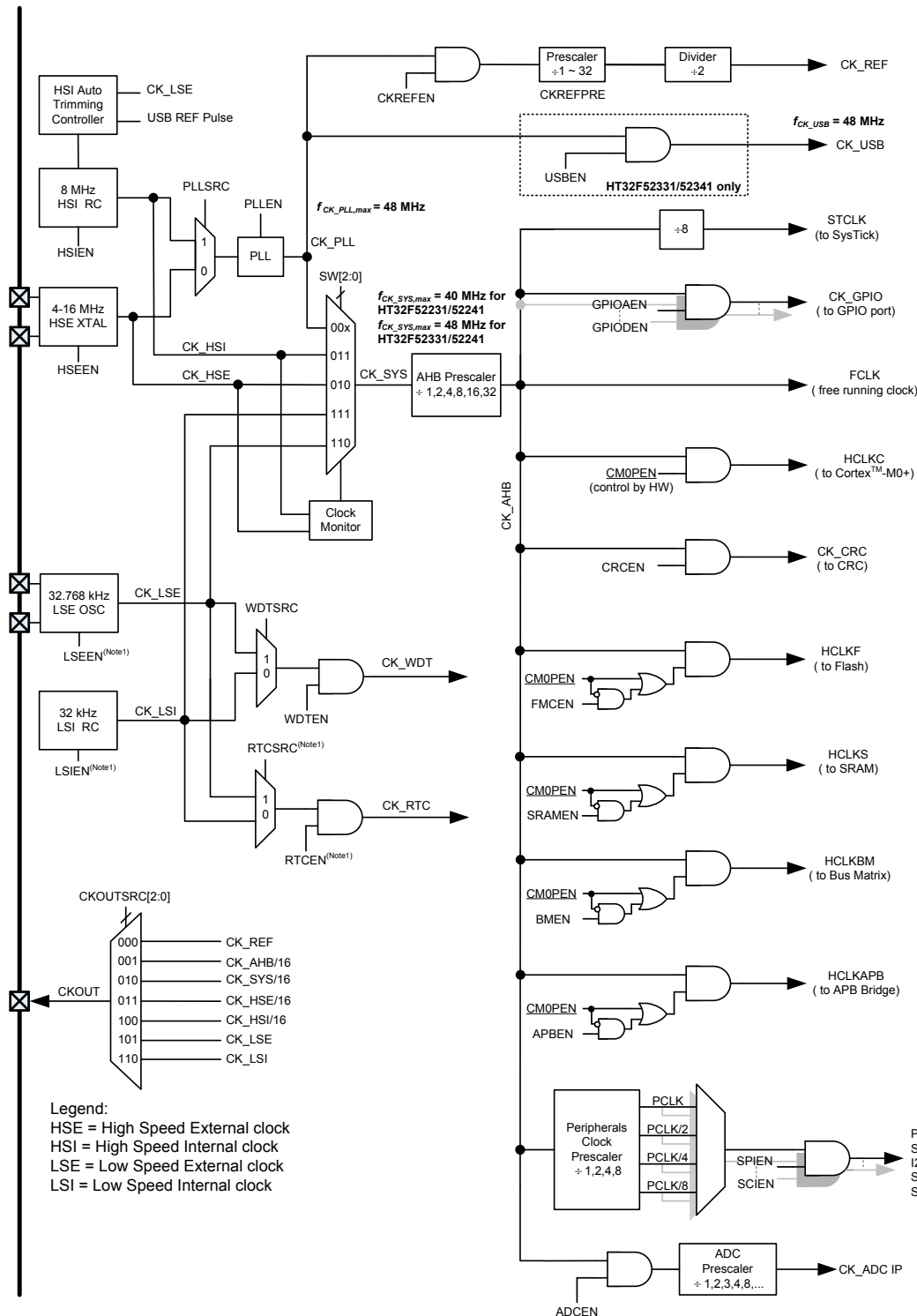
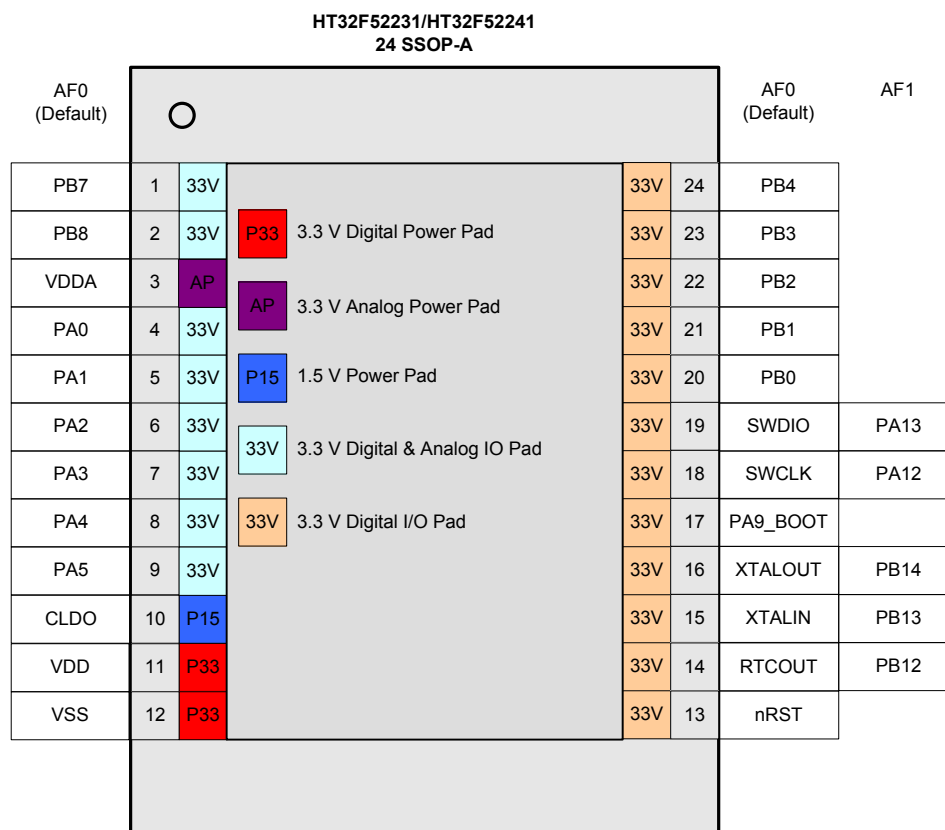
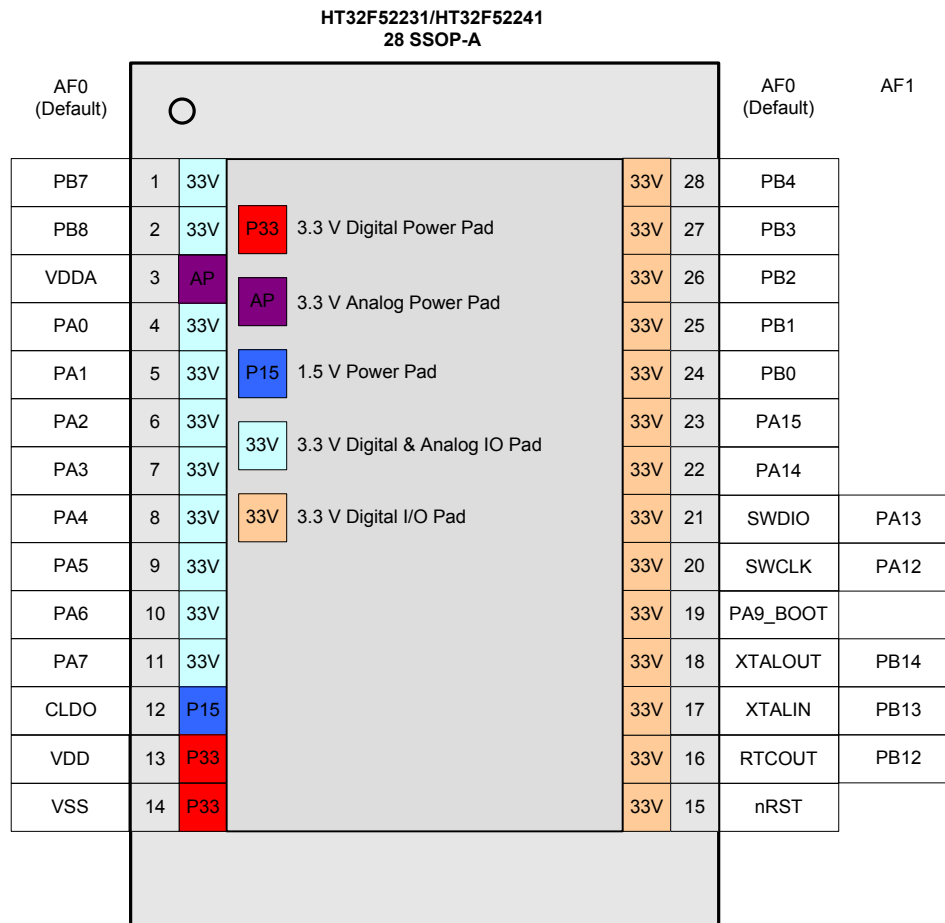


Figure 3 Clock Structure

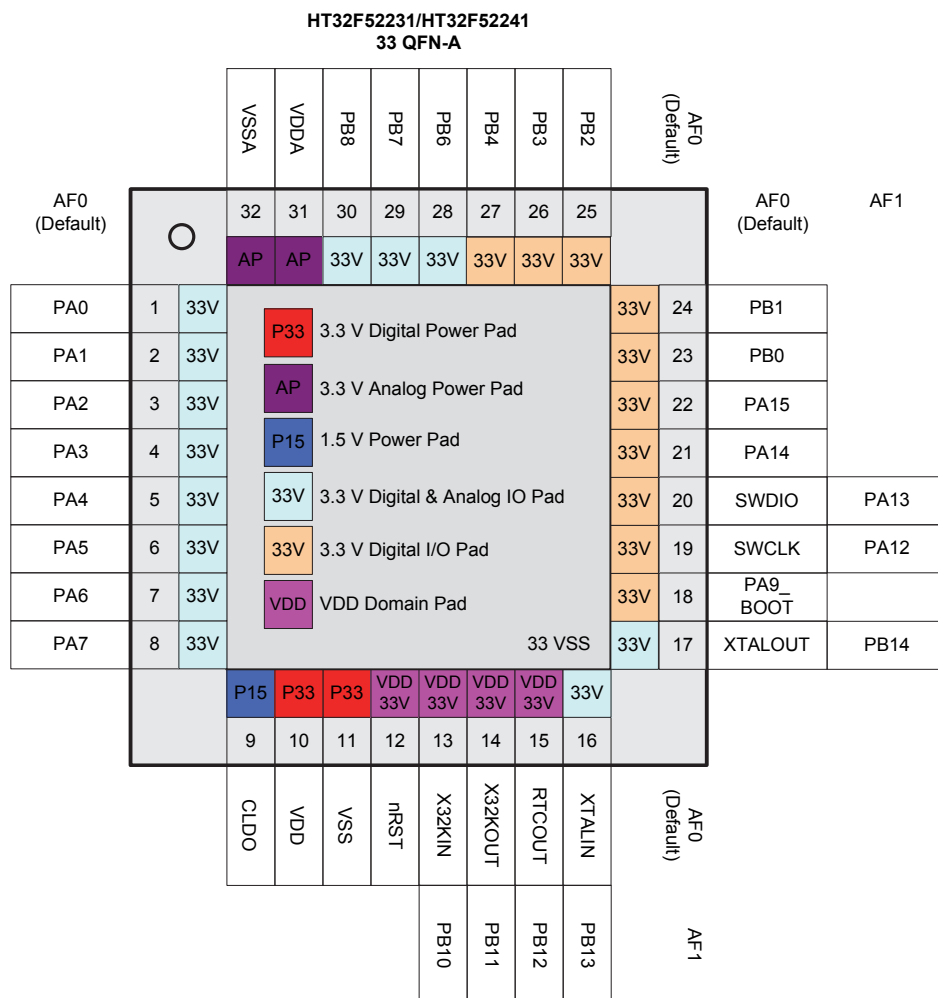
## 4 Pin Assignment



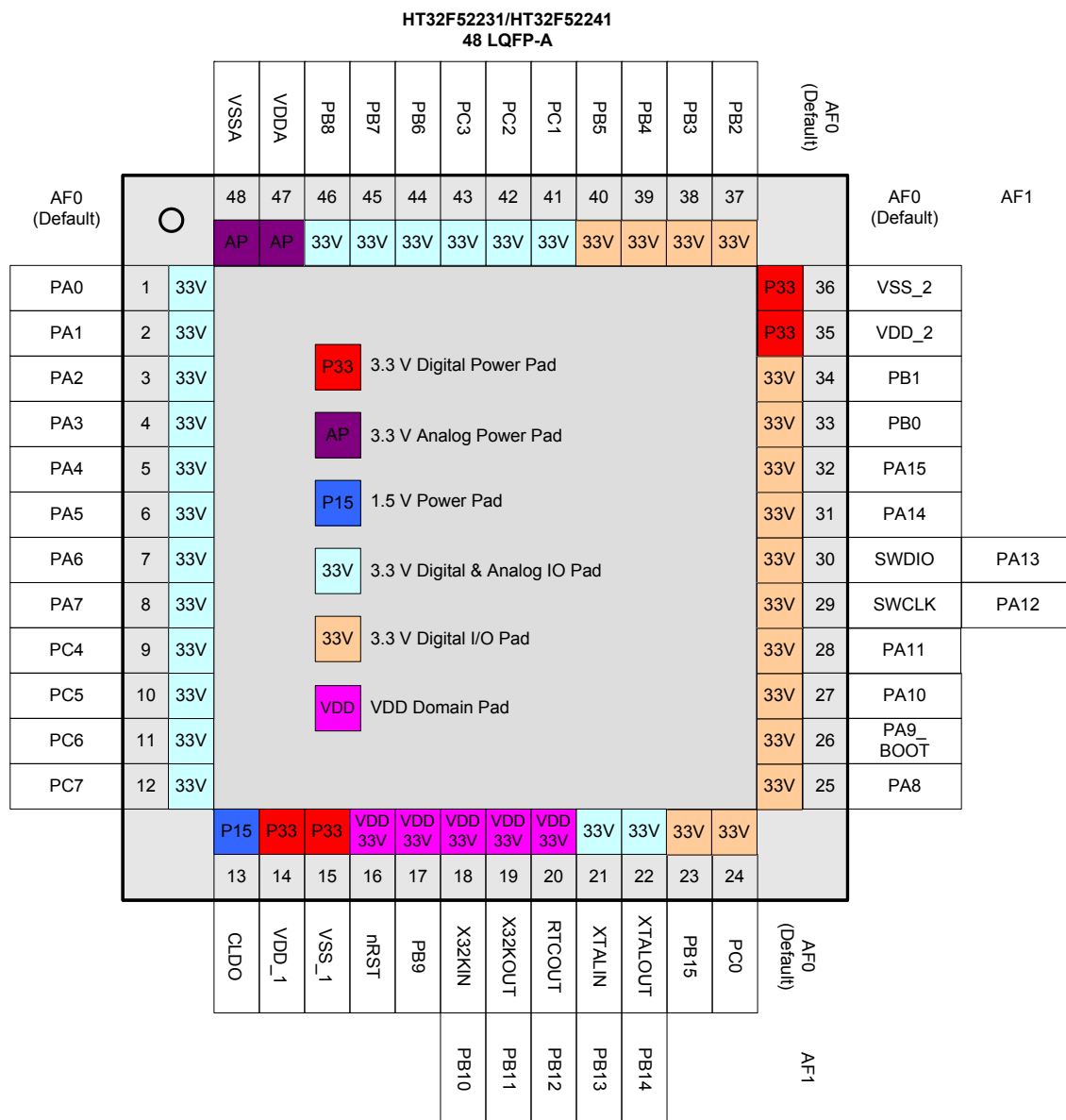
**Figure 4 HT32F52231/52241 24-pin SSOP Pin Assignment**



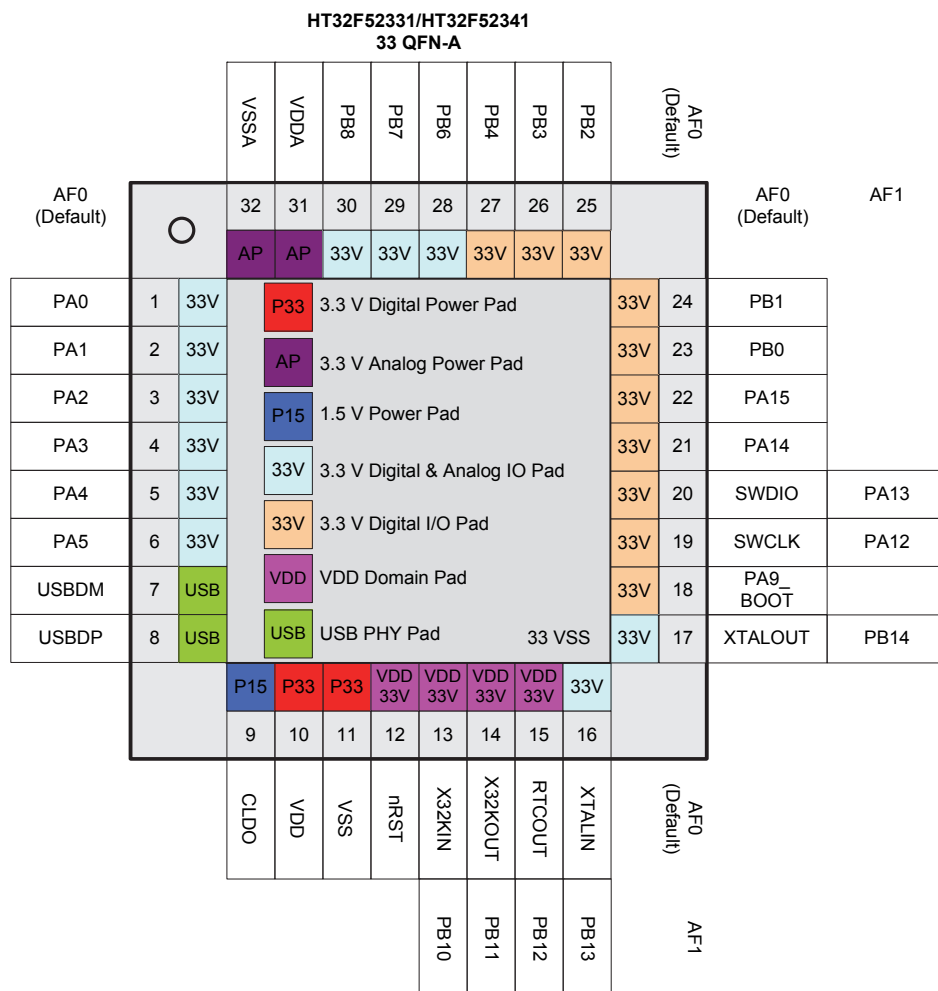
**Figure 5 HT32F52231/52241 28-pin SSOP Pin Assignment**



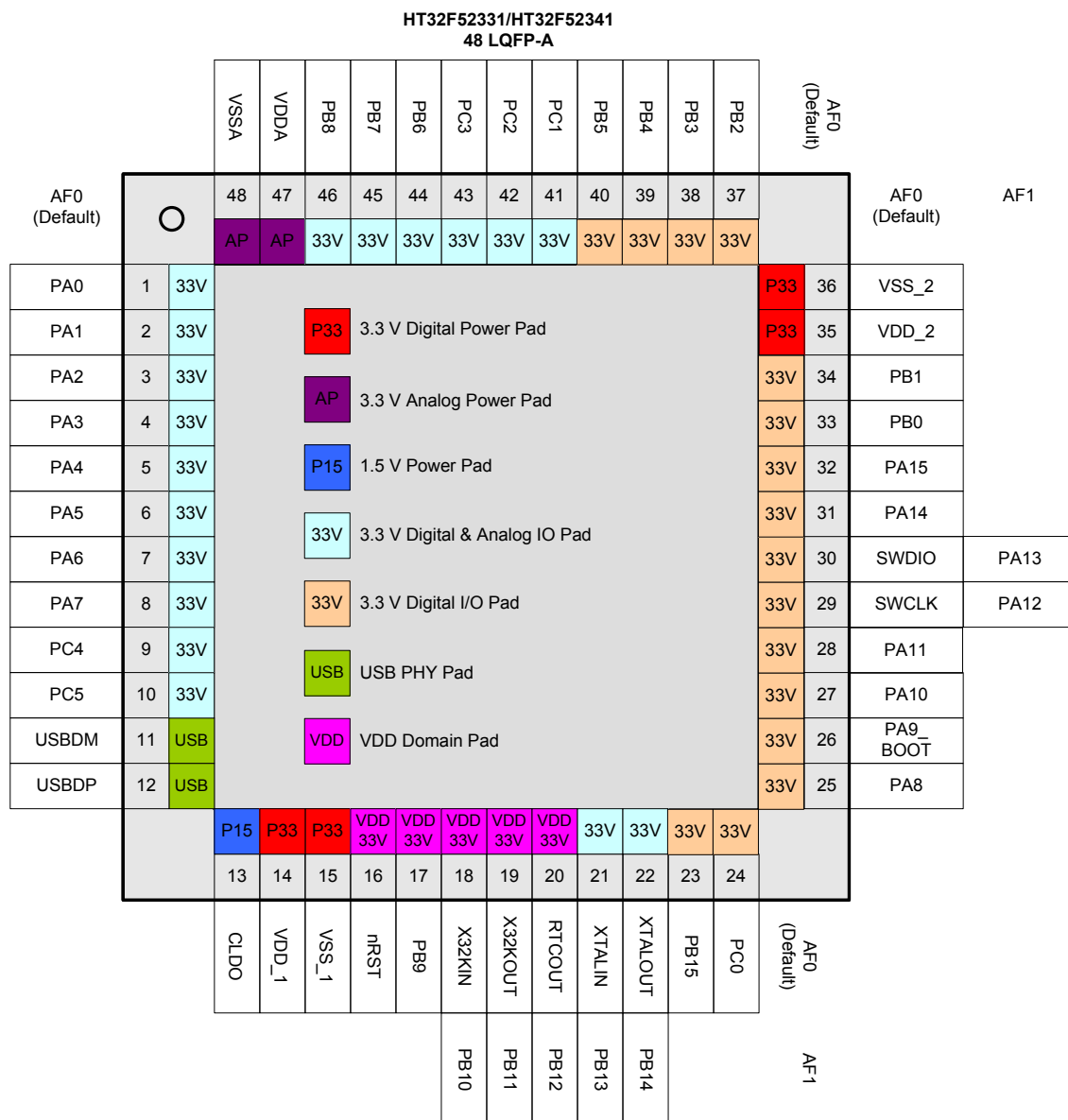
**Figure 6 HT32F52231/52241 33-pin QFN Pin Assignment**



**Figure 7 HT32F52231/52241 48-pin LQFP Pin Assignment**



**Figure 8 HT32F52331/52341 33-pin QFN Pin Assignment**



**Figure 9 HT32F52331/52341 48-pin LQFP Pin Assignment**

**Table 3 HT32F52231/52241 Series Pin Assignment for 24/28SSOP, 33QFN, 48LQFP Package**

| Package |        |         |         | HT32F52231/52241 Alternate Function Mapping |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
|---------|--------|---------|---------|---------------------------------------------|-------------|------------|------------|----------------------|------------|-----------------------|-------------------------|------------|------------|-------------|-------------|-------------|--------------|-------------|-------------------------|
| 48 LQFP | 33 QFN | 28 SSOP | 24 SSOP | AF0<br>System<br>Default                    | AF1<br>GPIO | AF2<br>ADC | AF3<br>N/A | AF4<br>GPTM<br>/MCTM | AF5<br>SPI | AF6<br>USART<br>/UART | AF7<br>I <sup>2</sup> C | AF8<br>N/A | AF9<br>N/A | AF10<br>N/A | AF11<br>N/A | AF12<br>N/A | AF13<br>SCTM | AF14<br>N/A | AF15<br>System<br>Other |
| 1       | 1      | 4       | 4       | PA0                                         |             | ADC_IN2    |            | GT_CH0               | SPI1_SCK   | USR_RTS               | I2C1_SCL                |            |            |             |             |             |              |             |                         |
| 2       | 2      | 5       | 5       | PA1                                         |             | ADC_IN3    |            | GT_CH1               | SPI1_MOSI  | USR_CTS               | I2C1_SDA                |            |            |             |             |             |              |             |                         |
| 3       | 3      | 6       | 6       | PA2                                         |             | ADC_IN4    |            | GT_CH2               | SPI1_MISO  | USR_TX                |                         |            |            |             |             |             |              |             |                         |
| 4       | 4      | 7       | 7       | PA3                                         |             | ADC_IN5    |            | GT_CH3               | SPI1_SEL   | USR_RX                |                         |            |            |             |             |             |              |             |                         |
| 5       | 5      | 8       | 8       | PA4                                         |             | ADC_IN6    |            | GT_CH0               | SPI0_SCK   | UR1_TX                | I2C0_SCL                |            |            |             |             |             |              |             |                         |
| 6       | 6      | 9       | 9       | PA5                                         |             | ADC_IN7    |            | GT_CH1               | SPI0_MOSI  | UR1_RX                | I2C0_SDA                |            |            |             |             |             |              |             |                         |
| 7       | 7      | 10      |         | PA6                                         |             | ADC_IN8    |            | GT_CH2               | SPI0_MISO  |                       |                         |            |            |             |             |             |              |             |                         |
| 8       | 8      | 11      |         | PA7                                         |             | ADC_IN9    |            | GT_CH3               | SPI0_SEL   |                       |                         |            |            |             |             |             |              |             |                         |
| 9       |        |         |         | PC4                                         |             | ADC_IN10   |            |                      |            | USR_TX                |                         |            |            |             |             |             | SCTM0        |             |                         |
| 10      |        |         |         | PC5                                         |             | ADC_IN11   |            |                      |            | USR_RX                |                         |            |            |             |             |             | SCTM1        |             |                         |
| 11      |        |         |         | PC6                                         |             |            |            | MT_CH2               |            | UR0_TX                | I2C0_SCL                |            |            |             |             |             |              |             |                         |
| 12      |        |         |         | PC7                                         |             |            |            | MT_CH2N              |            | UR0_RX                | I2C0_SDA                |            |            |             |             |             |              |             |                         |
| 13      | 9      | 12      | 10      | CLDO                                        |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 14      | 10     | 13      | 11      | VDD_1                                       |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 15      | 11     | 14      | 12      | VSS_1                                       |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 16      | 12     | 15      | 13      | nRST                                        |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 17      |        |         |         | PB9                                         |             |            |            | MT_CH3               |            |                       |                         |            |            |             |             |             |              |             |                         |
| 18      | 13     |         |         | X32KIN                                      | PB10        |            |            | GT_CH0               | SPI1_SEL   | USR_TX                |                         |            |            |             |             |             | SCTM2        |             |                         |
| 19      | 14     |         |         | X32KOUT                                     | PB11        |            |            | GT_CH1               | SPI1_SCK   | USR_RX                |                         |            |            |             |             |             | SCTM3        |             |                         |
| 20      | 15     | 16      | 14      | RTCOU                                       | PB12        |            |            |                      | SPI0_MISO  | UR0_RX                |                         |            |            |             |             |             | SCTM0        |             | WAKEUP                  |
| 21      | 16     | 17      | 15      | XTALIN                                      | PB13        |            |            |                      |            | UR0_TX                | I2C0_SCL                |            |            |             |             |             |              |             |                         |
| 22      | 17     | 18      | 16      | XTALOUT                                     | PB14        |            |            |                      |            | UR0_RX                | I2C0_SDA                |            |            |             |             |             |              |             |                         |
| 23      |        |         |         | PB15                                        |             |            |            | MT_CH0               | SPI0_SEL   |                       | I2C1_SCL                |            |            |             |             |             |              |             |                         |
| 24      |        |         |         | PC0                                         |             |            |            | MT_CH0N              | SPI0_SCK   |                       | I2C1_SDA                |            |            |             |             |             | SCTM3        |             |                         |
| 25      |        |         |         | PA8                                         |             |            |            |                      |            | USR_TX                |                         |            |            |             |             |             | SCTM2        |             |                         |
| 26      | 18     | 19      | 17      | PA9_BOOT                                    |             |            |            |                      | SPI0_MOSI  |                       |                         |            |            |             |             |             | SCTM3        |             | CKOUT                   |
| 27      |        |         |         | PA10                                        |             |            |            | MT_CH1               | SPI0_MOSI  | USR_RX                |                         |            |            |             |             |             |              |             |                         |
| 28      |        |         |         | PA11                                        |             |            |            | MT_CH1N              | SPI0_MISO  |                       |                         |            |            |             |             |             | SCTM0        |             |                         |
| 29      | 19     | 20      | 18      | SWCLK                                       | PA12        |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 30      | 20     | 21      | 19      | SWDIO                                       | PA13        |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 31      | 21     | 22      |         | PA14                                        |             |            |            | MT_CH0               | SPI1_SEL   | USR_RTS               | I2C1_SCL                |            |            |             |             |             |              |             |                         |
| 32      | 22     | 23      |         | PA15                                        |             |            |            | MT_CH0N              | SPI1_SCK   | USR_CTS               | I2C1_SDA                |            |            |             |             |             | SCTM1        |             |                         |
| 33      | 23     | 24      | 20      | PB0                                         |             |            |            | MT_CH1               | SPI1_MOSI  | USR_TX                | I2C0_SCL                |            |            |             |             |             |              |             |                         |
| 34      | 24     | 25      | 21      | PB1                                         |             |            |            | MT_CH1N              | SPI1_MISO  | USR_RX                | I2C0_SDA                |            |            |             |             |             | SCTM2        |             |                         |
| 35      |        |         |         | VDD_2                                       |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 36      | 33     |         |         | VSS_2                                       |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 37      | 25     | 26      | 22      | PB2                                         |             |            |            | MT_CH2               | SPI0_SEL   | UR1_TX                |                         |            |            |             |             |             |              |             |                         |
| 38      | 26     | 27      | 23      | PB3                                         |             |            |            | MT_CH2N              | SPI0_SCK   | UR1_RX                |                         |            |            |             |             |             | SCTM1        |             |                         |
| 39      | 27     | 28      | 24      | PB4                                         |             |            |            | MT_BRK               | SPI0_MOSI  | UR1_TX                |                         |            |            |             |             |             | SCTM0        |             |                         |
| 40      | 28     |         |         | PB5                                         |             |            |            | GT_CH2               | SPI0_MISO  | UR1_RX                |                         |            |            |             |             |             |              |             |                         |
| 41      |        |         |         | PC1                                         |             |            |            | MT_CH0               | SPI1_SEL   | UR1_TX                |                         |            |            |             |             |             |              |             |                         |
| 42      |        |         |         | PC2                                         |             |            |            | MT_CH0N              | SPI1_SCK   |                       |                         |            |            |             |             |             |              |             |                         |
| 43      |        |         |         | PC3                                         |             |            |            | MT_BRK               | SPI1_MOSI  | UR1_RX                |                         |            |            |             |             |             |              |             |                         |
| 44      | 28     |         |         | PB6                                         |             |            |            | GT_CH3               | SPI1_MISO  | UR0_TX                |                         |            |            |             |             |             |              |             |                         |
| 45      | 29     | 1       | 1       | PB7                                         |             | ADC_IN0    |            | MT_CH1               | SPI0_MISO  | UR0_TX                | I2C1_SCL                |            |            |             |             |             |              |             |                         |
| 46      | 30     | 2       | 2       | PB8                                         |             | ADC_IN1    |            | MT_CH1N              | SPI0_SEL   | UR0_RX                | I2C1_SDA                |            |            |             |             |             |              |             |                         |
| 47      | 31     | 3       | 3       | VDDA                                        |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |
| 48      | 32     |         |         | VSSA                                        |             |            |            |                      |            |                       |                         |            |            |             |             |             |              |             |                         |

Note: The pin number 33 of the 33-pin QFN package is located at the bottom metal of the QFN package.

**Table 4 HT32F52331/52341 Series Pin Assignment for 33QFN, 48LQFP Package**

| Package |        | HT32F52331/52341 Alternate Function Mapping |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
|---------|--------|---------------------------------------------|-------------|------------|------------|----------------------|------------|-----------------------|------------|------------|------------|-------------|-------------|-------------|--------------|-------------|-------------------------|
| 48 LQFP | 33 QFN | AF0<br>System<br>Default                    | AF1<br>GPIO | AF2<br>ADC | AF3<br>N/A | AF4<br>GPTM<br>/MCTM | AF5<br>SPI | AF6<br>USART<br>/UART | AF7<br>I2C | AF8<br>SCI | AF9<br>N/A | AF10<br>N/A | AF11<br>N/A | AF12<br>N/A | AF13<br>SCTM | AF14<br>N/A | AF15<br>System<br>Other |
| 1       | 1      | PA0                                         |             | ADC_IN2    |            | GT_CH0               | SPI1_SCK   | USR_RTS               | I2C1_SCL   | SCI_CLK    |            |             |             |             |              |             |                         |
| 2       | 2      | PA1                                         |             | ADC_IN3    |            | GT_CH1               | SPI1_MOSI  | USR_CTS               | I2C1_SDA   | SCI_DIO    |            |             |             |             |              |             |                         |
| 3       | 3      | PA2                                         |             | ADC_IN4    |            | GT_CH2               | SPI1_MISO  | USR_TX                |            |            |            |             |             |             |              |             |                         |
| 4       | 4      | PA3                                         |             | ADC_IN5    |            | GT_CH3               | SPI1_SEL   | USR_RX                |            |            |            |             |             |             |              |             |                         |
| 5       | 5      | PA4                                         |             | ADC_IN6    |            | GT_CH0               | SPI0_SCK   | UR1_TX                | I2C0_SCL   | SCI_CLK    |            |             |             |             |              |             |                         |
| 6       | 6      | PA5                                         |             | ADC_IN7    |            | GT_CH1               | SPI0_MOSI  | UR1_RX                | I2C0_SDA   | SCI_DIO    |            |             |             |             |              |             |                         |
| 7       |        | PA6                                         |             | ADC_IN8    |            | GT_CH2               | SPI0_MISO  |                       |            | SCI_DET    |            |             |             |             |              |             |                         |
| 8       |        | PA7                                         |             | ADC_IN9    |            | GT_CH3               | SPI0_SEL   |                       |            |            |            |             |             |             |              |             |                         |
| 9       |        | PC4                                         |             | ADC_IN10   |            |                      |            | USR_TX                |            |            |            |             |             |             | SCTM0        |             |                         |
| 10      |        | PC5                                         |             | ADC_IN11   |            |                      |            | USR_RX                |            |            |            |             |             |             | SCTM1        |             |                         |
| 11      | 7      | USBDM                                       |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 12      | 8      | USBDP                                       |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 13      | 9      | CLDO                                        |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 14      | 10     | VDD_1                                       |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 15      | 11     | VSS_1                                       |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 16      | 12     | nRST                                        |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 17      |        | PB9                                         |             |            |            | MT_CH3               |            |                       |            |            |            |             |             |             |              |             |                         |
| 18      | 13     | X32KIN                                      | PB10        |            |            | GT_CH0               | SPI1_SEL   | USR_TX                |            |            |            |             |             |             | SCTM2        |             |                         |
| 19      | 14     | X32KOUT                                     | PB11        |            |            | GT_CH1               | SPI1_SCK   | USR_RX                |            |            |            |             |             |             | SCTM3        |             |                         |
| 20      | 15     | RTCOU                                       | PB12        |            |            |                      | SPI0_MISO  | UR0_RX                |            |            |            |             |             |             | SCTM0        |             | WAKEUP                  |
| 21      | 16     | XTALIN                                      | PB13        |            |            |                      |            | UR0_TX                | I2C0_SCL   |            |            |             |             |             |              |             |                         |
| 22      | 17     | XTALOUT                                     | PB14        |            |            |                      |            | UR0_RX                | I2C0_SDA   |            |            |             |             |             |              |             |                         |
| 23      |        | PB15                                        |             |            |            | MT_CH0               | SPI0_SEL   |                       | I2C1_SCL   |            |            |             |             |             |              |             |                         |
| 24      |        | PC0                                         |             |            |            | MT_CH0N              | SPI0_SCK   |                       | I2C1_SDA   |            |            |             |             |             | SCTM3        |             |                         |
| 25      |        | PA8                                         |             |            |            |                      |            | USR_TX                |            | SCI_CLK    |            |             |             |             | SCTM2        |             |                         |
| 26      | 18     | PA9_BOOT                                    |             |            |            |                      | SPI0_MOSI  |                       |            | SCI_DIO    |            |             |             |             | SCTM3        |             | CKOUT                   |
| 27      |        | PA10                                        |             |            |            | MT_CH1               | SPI0_MOSI  | USR_RX                |            | SCI_DET    |            |             |             |             |              |             |                         |
| 28      |        | PA11                                        |             |            |            | MT_CH1N              | SPI0_MISO  |                       |            | SCI_DET    |            |             |             |             | SCTM0        |             |                         |
| 29      | 19     | SWCLK                                       | PA12        |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 30      | 20     | SWDIO                                       | PA13        |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 31      | 21     | PA14                                        |             |            |            | MT_CH0               | SPI1_SEL   | USR_RTS               | I2C1_SCL   | SCI_CLK    |            |             |             |             |              |             |                         |
| 32      | 22     | PA15                                        |             |            |            | MT_CH0N              | SPI1_SCK   | USR_CTS               | I2C1_SDA   | SCI_DIO    |            |             |             |             | SCTM1        |             |                         |
| 33      | 23     | PB0                                         |             |            |            | MT_CH1               | SPI1_MOSI  | USR_TX                | I2C0_SCL   |            |            |             |             |             |              |             |                         |
| 34      | 24     | PB1                                         |             |            |            | MT_CH1N              | SPI1_MISO  | USR_RX                | I2C0_SDA   |            |            |             |             |             | SCTM2        |             |                         |
| 35      |        | VDD_2                                       |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 36      | 33     | VSS_2                                       |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 37      | 25     | PB2                                         |             |            |            | MT_CH2               | SPI0_SEL   | UR1_TX                |            |            |            |             |             |             |              |             |                         |
| 38      | 26     | PB3                                         |             |            |            | MT_CH2N              | SPI0_SCK   | UR1_RX                |            |            |            |             |             |             | SCTM1        |             |                         |
| 39      | 27     | PB4                                         |             |            |            | MT_BRK               | SPI0_MOSI  | UR1_TX                |            |            |            |             |             |             | SCTM0        |             |                         |
| 40      |        | PB5                                         |             |            |            | GT_CH2               | SPI0_MISO  | UR1_RX                |            |            |            |             |             |             |              |             |                         |
| 41      |        | PC1                                         |             |            |            | MT_CH0               | SPI1_SEL   | UR1_TX                |            |            |            |             |             |             |              |             |                         |
| 42      |        | PC2                                         |             |            |            | MT_CH0N              | SPI1_SCK   |                       |            |            |            |             |             |             |              |             |                         |
| 43      |        | PC3                                         |             |            |            | MT_BRK               | SPI1_MOSI  | UR1_RX                |            |            |            |             |             |             |              |             |                         |
| 44      | 28     | PB6                                         |             |            |            | GT_CH3               | SPI1_MISO  | UR0_TX                |            | SCI_CLK    |            |             |             |             |              |             |                         |
| 45      | 29     | PB7                                         |             | ADC_IN0    |            | MT_CH1               | SPI0_MISO  | UR0_TX                | I2C1_SCL   | SCI_DET    |            |             |             |             |              |             |                         |
| 46      | 30     | PB8                                         |             | ADC_IN1    |            | MT_CH1N              | SPI0_SEL   | UR0_RX                | I2C1_SDA   | SCI_DIO    |            |             |             |             |              |             |                         |
| 47      | 31     | VDDA                                        |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |
| 48      | 32     | VSSA                                        |             |            |            |                      |            |                       |            |            |            |             |             |             |              |             |                         |

Note: The pin number 33 of the 33-pin QFN package is located at the bottom metal of the QFN package.

**Table 5 HT32F52231/52241 Pin Description**

| Pin number |       |        |        | Pin Name               | Type (Note1)            | IO Structure (Note2) | Output Driving | Description                                                                                                                        |
|------------|-------|--------|--------|------------------------|-------------------------|----------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------|
| 48LQFP     | 33QFN | 28SSOP | 24SSOP |                        |                         |                      |                | Default function (AF0)                                                                                                             |
| 1          | 1     | 4      | 4      | PA0                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA0                                                                                                                                |
| 2          | 2     | 5      | 5      | PA1                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA1                                                                                                                                |
| 3          | 3     | 6      | 6      | PA2                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA2                                                                                                                                |
| 4          | 4     | 7      | 7      | PA3                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA3                                                                                                                                |
| 5          | 5     | 8      | 8      | PA4                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA4                                                                                                                                |
| 6          | 6     | 9      | 9      | PA5                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA5                                                                                                                                |
| 7          |       | 10     |        | PA6                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA6                                                                                                                                |
| 8          |       | 11     |        | PA7                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PA7                                                                                                                                |
| 9          |       |        |        | PC4                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PC4                                                                                                                                |
| 10         |       |        |        | PC5                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PC5                                                                                                                                |
| 11         | 7     |        |        | PC6                    | AI/O                    | —                    | —              | PC6                                                                                                                                |
| 12         | 8     |        |        | PC7                    | AI/O                    | —                    | —              | PC7                                                                                                                                |
| 13         | 9     | 12     | 10     | CLDO                   | P                       | —                    | —              | Core power LDO 1.5 V output<br>It is recommended to connect a 1 $\mu$ F capacitor as close as possible between this pin and VSS_1. |
| 14         | 10    | 13     | 11     | VDD_1                  | P                       | —                    | —              | Voltage for digital I/O                                                                                                            |
| 15         | 11    | 14     | 12     | VSS_1                  | P                       | —                    | —              | Ground reference for digital I/O                                                                                                   |
| 16         | 12    | 15     | 13     | nRST <sup>Note 3</sup> | I                       | 33V_PU               | —              | External reset pin and external wakeup pin in the Power-Down mode                                                                  |
| 17         |       |        |        | PB9 <sup>Note 3</sup>  | I/O (V <sub>DD</sub> )  | 33V                  | 4/8/12/16 mA   | PB9                                                                                                                                |
| 18         | 13    |        |        | PB10 <sup>Note 3</sup> | AI/O (V <sub>DD</sub> ) | 33V                  | 4/8/12/16 mA   | X32KIN                                                                                                                             |
| 19         | 14    |        |        | PB11 <sup>Note 3</sup> | AI/O (V <sub>DD</sub> ) | 33V                  | 4/8/12/16 mA   | X32KOUT                                                                                                                            |
| 20         | 15    | 16     | 14     | PB12 <sup>Note 3</sup> | I/O (V <sub>DD</sub> )  | 33V                  | 4/8/12/16 mA   | RTCOUT                                                                                                                             |
| 21         | 16    | 17     | 15     | PB13                   | AI/O                    | 33V                  | 4/8/12/16 mA   | XTALIN                                                                                                                             |
| 22         | 17    | 18     | 16     | PB14                   | AI/O                    | 33V                  | 4/8/12/16 mA   | XTALOUT                                                                                                                            |
| 23         |       |        |        | PB15                   | I/O                     | 33V                  | 4/8/12/16 mA   | PB15                                                                                                                               |
| 24         |       |        |        | PC0                    | I/O                     | 33V                  | 4/8/12/16 mA   | PC0                                                                                                                                |
| 25         |       |        |        | PA8                    | I/O                     | 33V                  | 4/8/12/16 mA   | PA8                                                                                                                                |
| 26         | 18    | 19     | 17     | PA9                    | I/O                     | 33V_PU               | 4/8/12/16 mA   | PA9_BOOT                                                                                                                           |
| 27         |       |        |        | PA10                   | I/O                     | 33V                  | 4/8/12/16 mA   | PA10                                                                                                                               |
| 28         |       |        |        | PA11                   | I/O                     | 33V                  | 4/8/12/16 mA   | PA11                                                                                                                               |
| 29         | 19    | 20     | 18     | PA12                   | I/O                     | 33V_PU               | 4/8/12/16 mA   | SWCLK                                                                                                                              |
| 30         | 20    | 21     | 19     | PA13                   | I/O                     | 33V_PU               | 4/8/12/16 mA   | SWDIO                                                                                                                              |
| 31         | 21    | 22     |        | PA14                   | I/O                     | 33V                  | 4/8/12/16 mA   | PA14                                                                                                                               |
| 32         | 22    | 23     |        | PA15                   | I/O                     | 33V                  | 4/8/12/16 mA   | PA15                                                                                                                               |
| 33         | 23    | 24     | 20     | PB0                    | I/O                     | 33V                  | 4/8/12/16 mA   | PB0                                                                                                                                |
| 34         | 24    | 25     | 21     | PB1                    | I/O                     | 33V                  | 4/8/12/16 mA   | PB1                                                                                                                                |
| 35         |       |        |        | VDD_2                  | P                       | —                    | —              | Voltage for digital I/O                                                                                                            |
| 36         | 33    |        |        | VSS_2                  | P                       | —                    | —              | Ground reference for digital I/O                                                                                                   |
| 37         | 25    | 26     | 22     | PB2                    | I/O                     | 33V                  | 4/8/12/16 mA   | PB2                                                                                                                                |
| 38         | 26    | 27     | 23     | PB3                    | I/O                     | 33V                  | 4/8/12/16 mA   | PB3                                                                                                                                |
| 39         | 27    | 28     | 24     | PB4                    | I/O                     | 33V                  | 4/8/12/16 mA   | PB4                                                                                                                                |
| 40         |       |        |        | PB5                    | I/O                     | 33V                  | 4/8/12/16 mA   | PB5                                                                                                                                |
| 41         |       |        |        | PC1                    | I/O                     | 33V                  | 4/8/12/16 mA   | PC1                                                                                                                                |
| 42         |       |        |        | PC2                    | I/O                     | 33V                  | 4/8/12/16 mA   | PC2                                                                                                                                |
| 43         |       |        |        | PC3                    | I/O                     | 33V                  | 4/8/12/16 mA   | PC3                                                                                                                                |
| 44         | 28    |        |        | PB6                    | I/O                     | 33V                  | 4/8/12/16 mA   | PB6                                                                                                                                |
| 45         | 29    | 1      | 1      | PB7                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PB7                                                                                                                                |
| 46         | 30    | 2      | 2      | PB8                    | AI/O                    | 33V                  | 4/8/12/16 mA   | PB8                                                                                                                                |
| 47         | 31    | 3      | 3      | VDDA                   | P                       | —                    | —              | Analog voltage for ADC and Comparator                                                                                              |
| 48         | 32    |        |        | VSSA                   | P                       | —                    | —              | Ground reference for the ADC and Comparator                                                                                        |

Note: 1. I = input, O = output, A = Analog port, P = power supply, PU = pull-up, V<sub>DD</sub> = V<sub>DD</sub> Power  
2. 33V = 3.3V tolerant.  
3. These pins are located at the V<sub>DD</sub> power domain.

**Table 6 HT32F52331/52341 Pin Description**

| Pin number |       | Pin Name               | Type<br>(Note1)         | IO Structure<br>(Note2) | Output<br>Driving | Description                                                                                                                        |
|------------|-------|------------------------|-------------------------|-------------------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 48LQFP     | 33QFN |                        |                         |                         |                   | Default function (AF0)                                                                                                             |
| 1          | 1     | PA0                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA0                                                                                                                                |
| 2          | 2     | PA1                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA1                                                                                                                                |
| 3          | 3     | PA2                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA2                                                                                                                                |
| 4          | 4     | PA3                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA3                                                                                                                                |
| 5          | 5     | PA4                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA4                                                                                                                                |
| 6          | 6     | PA5                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA5                                                                                                                                |
| 7          |       | PA6                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA6                                                                                                                                |
| 8          |       | PA7                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PA7                                                                                                                                |
| 9          |       | PC4                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PC4                                                                                                                                |
| 10         |       | PC5                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PC5                                                                                                                                |
| 11         | 7     | USBDM                  | AI/O                    | —                       | —                 | USB Differential data bus conforming to the Universal Serial Bus standard.                                                         |
| 12         | 8     | USBDP                  | AI/O                    | —                       | —                 | USB Differential data bus conforming to the Universal Serial Bus standard.                                                         |
| 13         | 9     | CLDO                   | P                       | —                       | —                 | Core power LDO 1.5 V output<br>It is recommended to connect a 1 $\mu$ F capacitor as close as possible between this pin and VSS_1. |
| 14         | 10    | VDD_1                  | P                       | —                       | —                 | Voltage for digital I/O                                                                                                            |
| 15         | 11    | VSS_1                  | P                       | —                       | —                 | Ground reference for digital I/O                                                                                                   |
| 16         | 12    | nRST <sup>Note 3</sup> | I                       | 33V_PU                  | --                | External reset pin and external wakeup pin in the Power-Down mode                                                                  |
| 17         |       | PB9 <sup>Note 3</sup>  | I/O (V <sub>DD</sub> )  | 33V                     | 4/8/12/16 mA      | PB9                                                                                                                                |
| 18         | 13    | PB10 <sup>Note 3</sup> | AI/O (V <sub>DD</sub> ) | 33V                     | 4/8/12/16 mA      | X32KIN                                                                                                                             |
| 19         | 14    | PB11 <sup>Note 3</sup> | AI/O (V <sub>DD</sub> ) | 33V                     | 4/8/12/16 mA      | X32KOUT                                                                                                                            |
| 20         | 15    | PB12 <sup>Note 3</sup> | I/O (V <sub>DD</sub> )  | 33V                     | 4/8/12/16 mA      | RTCOUT                                                                                                                             |
| 21         | 16    | PB13                   | AI/O                    | 33V                     | 4/8/12/16 mA      | XTALIN                                                                                                                             |
| 22         | 17    | PB14                   | AI/O                    | 33V                     | 4/8/12/16 mA      | XTALOUT                                                                                                                            |
| 23         |       | PB15                   | I/O                     | 33V                     | 4/8/12/16 mA      | PB15                                                                                                                               |
| 24         |       | PC0                    | I/O                     | 33V                     | 4/8/12/16 mA      | PC0                                                                                                                                |
| 25         |       | PA8                    | I/O                     | 33V                     | 4/8/12/16 mA      | PA8                                                                                                                                |
| 26         | 18    | PA9                    | I/O                     | 33V_PU                  | 4/8/12/16 mA      | PA9_BOOT                                                                                                                           |
| 27         |       | PA10                   | I/O                     | 33V                     | 4/8/12/16 mA      | PA10                                                                                                                               |
| 28         |       | PA11                   | I/O                     | 33V                     | 4/8/12/16 mA      | PA11                                                                                                                               |
| 29         | 19    | PA12                   | I/O                     | 33V_PU                  | 4/8/12/16 mA      | SWCLK                                                                                                                              |
| 30         | 20    | PA13                   | I/O                     | 33V_PU                  | 4/8/12/16 mA      | SWDIO                                                                                                                              |
| 31         | 21    | PA14                   | I/O                     | 33V                     | 4/8/12/16 mA      | PA14                                                                                                                               |
| 32         | 22    | PA15                   | I/O                     | 33V                     | 4/8/12/16 mA      | PA15                                                                                                                               |
| 33         | 23    | PB0                    | I/O                     | 33V                     | 4/8/12/16 mA      | PB0                                                                                                                                |
| 34         | 24    | PB1                    | I/O                     | 33V                     | 4/8/12/16 mA      | PB1                                                                                                                                |
| 35         |       | VDD_2                  | P                       | —                       | —                 | Voltage for digital I/O                                                                                                            |
| 36         | 33    | VSS_2                  | P                       | —                       | —                 | Ground reference for digital I/O                                                                                                   |
| 37         | 25    | PB2                    | I/O                     | 33V                     | 4/8/12/16 mA      | PB2                                                                                                                                |
| 38         | 26    | PB3                    | I/O                     | 33V                     | 4/8/12/16 mA      | PB3                                                                                                                                |
| 39         | 27    | PB4                    | I/O                     | 33V                     | 4/8/12/16 mA      | PB4                                                                                                                                |
| 40         |       | PB5                    | I/O                     | 33V                     | 4/8/12/16 mA      | PB5                                                                                                                                |
| 41         |       | PC1                    | I/O                     | 33V                     | 4/8/12/16 mA      | PC1                                                                                                                                |
| 42         |       | PC2                    | I/O                     | 33V                     | 4/8/12/16 mA      | PC2                                                                                                                                |
| 43         |       | PC3                    | I/O                     | 33V                     | 4/8/12/16 mA      | PC3                                                                                                                                |
| 44         | 28    | PB6                    | I/O                     | 33V                     | 4/8/12/16 mA      | PB6                                                                                                                                |
| 45         | 29    | PB7                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PB7                                                                                                                                |
| 46         | 30    | PB8                    | AI/O                    | 33V                     | 4/8/12/16 mA      | PB8                                                                                                                                |
| 47         | 31    | VDDA                   | P                       | —                       | —                 | Analog voltage for ADC and Comparator                                                                                              |
| 48         | 32    | VSSA                   | P                       | —                       | —                 | Ground reference for the ADC and Comparator                                                                                        |

Note: 1. I = input, O = output, A = Analog port, P = power supply, PU = pull-up, V<sub>DD</sub> = V<sub>DD</sub> Power

2. 33V = 3.3V tolerant.

3. These pins are located at the V<sub>DD</sub> power domain.

## 5 Electrical Characteristics

### Absolute Maximum Ratings

The following table shows the absolute maximum ratings of the device. These are stress ratings only. Stresses beyond absolute maximum ratings may cause permanent damage to 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 7 Absolute Maximum Ratings**

| Symbol           | Parameter                                         | Min                    | Max                    | Unit |
|------------------|---------------------------------------------------|------------------------|------------------------|------|
| V <sub>DD</sub>  | External Main Supply Voltage                      | V <sub>SS</sub> - 0.3  | V <sub>SS</sub> + 3.6  | V    |
| V <sub>DDA</sub> | External Analog Supply Voltage                    | V <sub>SSA</sub> - 0.3 | V <sub>SSA</sub> + 3.6 | V    |
| V <sub>IN</sub>  | Input Voltage on I/O                              | V <sub>SS</sub> - 0.3  | V <sub>SS</sub> + 0.3  | V    |
| T <sub>A</sub>   | Ambient Operating Temperature Range               | -40                    | +85                    | °C   |
| T <sub>STG</sub> | Storage Temperature Range                         | -55                    | +150                   | °C   |
| T <sub>J</sub>   | Maximum Junction Temperature                      | —                      | +125                   | °C   |
| P <sub>D</sub>   | Total Power Dissipation                           | —                      | 500                    | mW   |
| V <sub>ESD</sub> | Electrostatic Discharge Voltage - Human Body Mode | -4000                  | +4000                  | V    |

### Recommended DC Operating Conditions

**Table 8 Recommended DC Operating Conditions**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol           | Parameter                | Conditions | Min | Typ | Max | Unit |
|------------------|--------------------------|------------|-----|-----|-----|------|
| V <sub>DD</sub>  | I/O OPERating Voltage    | —          | 2.0 | 3.3 | 3.6 | V    |
| V <sub>DDA</sub> | Analog Operating Voltage | —          | 2.5 | 3.3 | 3.6 | V    |

### On-Chip LDO Voltage Regulator Characteristics

**Table 9 LDO Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol           | Parameter                                                      | Conditions                                                                                                  | Min   | Typ | Max  | Unit |
|------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------|-----|------|------|
| V <sub>LDO</sub> | Internal Regulator Output Voltage                              | V <sub>DD</sub> ≥ 2.0V Regulator input @ I <sub>LDO</sub> = 35mA and voltage variant = ±5%, After trimming. | 1.425 | 1.5 | 1.57 | V    |
| I <sub>LDO</sub> | Output Current                                                 | V <sub>DD</sub> = 2.0V Regulator input @ V <sub>LDO</sub> = 1.5V                                            | —     | 30  | 35   | mA   |
| C <sub>LDO</sub> | External Filter Capacitor Value For Internal Core Power Supply | The capacitor value is dependent on the core power current consumption                                      | —     | 1   | —    | μF   |

## Power Consumption

**Table 10 HT32F52231/52241 Power Consumption Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol          | Parameter                            | Conditions                                                                                                                             | Min | Typ | Max | Unit |
|-----------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|
| I <sub>DD</sub> | Supply Current<br>(Run Mode)         | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 40MHz,<br>f <sub>HCLK</sub> = 40MHz, f <sub>PCLK</sub> = 48MHz,<br>All peripherals enabled   | —   | 12  | —   | mA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 40MHz,<br>f <sub>HCLK</sub> = 40MHz, f <sub>PCLK</sub> = 40MHz,<br>All peripherals disabled  | —   | 7   | —   | mA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE off, PLL off, LSI on,<br>f <sub>HCLK</sub> = 32kHz, f <sub>PCLK</sub> = 32kHz,<br>All peripherals enabled  | —   | 45  | —   | μA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE off, PLL off, LSI on,<br>f <sub>HCLK</sub> = 32kHz, f <sub>PCLK</sub> = 32kHz,<br>All peripherals disabled | —   | 40  | —   | μA   |
|                 | Supply Current<br>(Sleep Mode)       | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 40MHz,<br>f <sub>HCLK</sub> = 0MHz, f <sub>PCLK</sub> = 40MHz,<br>All peripherals enabled    | —   | 7.5 | —   | mA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 40MHz,<br>f <sub>HCLK</sub> = 0MHz, f <sub>PCLK</sub> = 40MHz,<br>All peripherals disabled   | —   | 2   | —   | mA   |
|                 | Supply Current<br>(Deep-sleep1 Mode) | V <sub>DD</sub> = 3.3V, All clock off (HSE/PLL/f <sub>HCLK</sub> ),<br>LDO in low power mode, LSI on, RTC on                           | —   | 35  | —   | μA   |
|                 | Supply Current<br>(Deep-sleep2 Mode) | V <sub>DD</sub> = 3.3V, All clock off (HSE/PLL/f <sub>HCLK</sub> ),<br>LDO off DMOS on, LSI on, RTC on                                 | —   | 5   | —   | μA   |
|                 | Supply Current<br>(Power-down Mode)  | V <sub>DD</sub> = 3.3V, LDO off, DMOS off, LSE on,<br>LSI on, RTC on                                                                   | —   | —   | —   | μA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, LDO off, DMOS off, LSE off,<br>LSI on, RTC off                                                                 | —   | 1.5 | —   | μA   |

**Table 11 HT32F52331/52341 Power Consumption Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol          | Parameter                            | Conditions                                                                                                                             | Min | Typ | Max | Unit |
|-----------------|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|
| I <sub>DD</sub> | Supply Current<br>(Run Mode)         | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 48MHz,<br>f <sub>HCLK</sub> = 48MHz, f <sub>PCLK</sub> = 48MHz,<br>All peripherals enabled   | —   | 16  | —   | mA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 48MHz,<br>f <sub>HCLK</sub> = 48MHz, f <sub>PCLK</sub> = 48MHz,<br>All peripherals disabled  | —   | 8.5 | —   | mA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE off, PLL off, LSI on,<br>f <sub>HCLK</sub> = 32kHz, f <sub>PCLK</sub> = 32kHz,<br>All peripherals enabled  | —   | 45  | —   | μA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE off, PLL off, LSI on,<br>f <sub>HCLK</sub> = 32kHz, f <sub>PCLK</sub> = 32kHz,<br>All peripherals disabled | —   | 40  | —   | μA   |
|                 | Supply Current<br>(Sleep Mode)       | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 48MHz,<br>f <sub>HCLK</sub> = 0MHz, f <sub>PCLK</sub> = 48MHz,<br>All peripherals enabled    | —   | 10  | —   | mA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, HSE = 8MHz, PLL = 48MHz,<br>f <sub>HCLK</sub> = 0MHz, f <sub>PCLK</sub> = 48MHz,<br>All peripherals disabled   | —   | 2.5 | —   | mA   |
|                 | Supply Current<br>(Deep-Sleep1 Mode) | V <sub>DD</sub> = 3.3V, All clock off (HSE/PLL/f <sub>HCLK</sub> ),<br>LDO in low power mode, LSI on, RTC on                           | —   | 35  | —   | μA   |
|                 | Supply Current<br>(Deep-Sleep2 Mode) | V <sub>DD</sub> = 3.3V, All clock off (HSE/PLL/f <sub>HCLK</sub> ),<br>LDO off DMOS on, LSI on, RTC on                                 | —   | 5   | —   | μA   |
|                 | Supply Current<br>(Power-Down Mode)  | V <sub>DD</sub> = 3.3V, LDO off, DMOS off, LSE on,<br>LSI on, RTC on                                                                   | —   | —   | —   | μA   |
|                 |                                      | V <sub>DD</sub> = 3.3V, LDO off, DMOS off, LSE off,<br>LSI on, RTC off                                                                 | —   | 1.5 | —   | μA   |

Note: 1. HSE means high speed external oscillator. HSI means 8MHz high speed internal oscillator.  
2. LSE means 32.768kHz low speed external oscillator. LSI means 32kHz low speed internal oscillator.  
3. RTC means real time clock.  
4. Code = while (1) { 208 NOP } executed in Flash.

## Reset and Supply Monitor Characteristics

**Table 12 V<sub>DD</sub> Power Reset Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol               | Parameter                                                           | Conditions                     | Min  | Typ  | Max  | Unit |
|----------------------|---------------------------------------------------------------------|--------------------------------|------|------|------|------|
| V <sub>POR</sub>     | Power on Reset Threshold<br>(Rising Voltage on V <sub>DD</sub> )    | T <sub>A</sub> = -40°C ~ +85°C | 1.66 | 1.79 | 1.90 | V    |
| V <sub>PDR</sub>     | Power down Reset Threshold<br>(Falling Voltage on V <sub>DD</sub> ) |                                | 1.49 | 1.64 | 1.78 | V    |
| V <sub>PORHYST</sub> | POR Hysteresis                                                      | —                              | —    | 150  | —    | mV   |
| t <sub>POR</sub>     | Reset Delay Time                                                    | V <sub>DD</sub> = 3.3V         | —    | 0.1  | 0.2  | ms   |

- Note: 1. Data based on characterization results only, not tested in production.  
2. Guaranteed by design, not tested in production.  
3. If the LDO is turned on, the VDD POR has to be in the de-assertion condition. When the VDD POR is in the assertion state then the LDO will be turned off.

**Table 13 LVD/BOD Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol              | Parameter                          | Conditions                                                                               |            | Min  | Typ  | Max  | Unit |
|---------------------|------------------------------------|------------------------------------------------------------------------------------------|------------|------|------|------|------|
| V <sub>BOD</sub>    | Voltage of Brown Out Detection     | T <sub>A</sub> = -40°C ~ 85°C<br>After factory-trimmed<br>(V <sub>DD</sub> Falling edge) |            | 2.02 | 2.1  | 2.18 | V    |
| V <sub>LVD</sub>    | Voltage of Low Voltage Detection   | T <sub>A</sub> = -40°C ~ 85°C<br>(V <sub>DD</sub> Falling edge)                          | LVDS = 000 | 2.17 | 2.25 | 2.33 | V    |
|                     |                                    |                                                                                          | LVDS = 001 | 2.32 | 2.4  | 2.48 | V    |
|                     |                                    |                                                                                          | LVDS = 010 | 2.47 | 2.55 | 2.63 | V    |
|                     |                                    |                                                                                          | LVDS = 011 | 2.62 | 2.7  | 2.78 | V    |
|                     |                                    |                                                                                          | LVDS = 100 | 2.77 | 2.85 | 2.93 | V    |
|                     |                                    |                                                                                          | LVDS = 101 | 2.92 | 3.0  | 3.08 | V    |
|                     |                                    |                                                                                          | LVDS = 110 | 3.07 | 3.15 | 3.23 | V    |
|                     |                                    |                                                                                          | LVDS = 111 | 3.22 | 3.3  | 3.38 | V    |
| V <sub>LVDHST</sub> | LVD Hysteresis                     | V <sub>DD</sub> = 3.3V                                                                   | —          | —    | 100  | —    | mV   |
| t <sub>suLVD</sub>  | LVD Setup time                     | V <sub>DD</sub> = 3.3V                                                                   | —          | —    | —    | 5    | μs   |
| t <sub>atLVD</sub>  | LVD Active Delay Time              | V <sub>DD</sub> = 3.3V                                                                   | —          | —    | —    | —    | μs   |
| I <sub>DDLVD</sub>  | Operation Current <sup>NOTE3</sup> | V <sub>DD</sub> = 3.3V                                                                   | —          | —    | 5    | 15   | μA   |

- Note: 1. Data based on characterization results only, not tested in production.  
2. Guaranteed by design, not tested in production.  
3. Bandgap current is not included.  
4. LVDS field is in the PWRCU LVDCSR register

## External Clock Characteristics

**Table 14 High Speed External Clock (HSE) Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol              | Parameter                                                  | Conditions                                                                                                                           | Min | Typ | Max  | Unit |
|---------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----|-----|------|------|
| V <sub>DD</sub>     | Operation Range                                            | —                                                                                                                                    | 2.0 | —   | 3.6  | V    |
| f <sub>HSE</sub>    | High Speed External Oscillator Frequency (HSE)             | —                                                                                                                                    | 4   | —   | 16   | MHz  |
| C <sub>LHSE</sub>   | Load capacitance                                           | V <sub>DD</sub> = 3.3V, R <sub>ESR</sub> = 100Ω @ 16MHz                                                                              | —   | —   | 22   | pF   |
| R <sub>FHSE</sub>   | Internal Feedback Resistor between XTALIN and XTALOUT pins | —                                                                                                                                    | —   | 1   | —    | MΩ   |
| R <sub>ESR</sub>    | Equivalent Series Resistance*                              | V <sub>DD</sub> = 3.3V, C <sub>L</sub> = 12pF @ 16MHz, HSEDR = 0<br>V <sub>DD</sub> = 2.4V, C <sub>L</sub> = 12pF @ 16MHz, HSEDR = 1 | —   | —   | 160  | Ω    |
| D <sub>HSE</sub>    | HSE Oscillator Duty Cycle                                  | —                                                                                                                                    | 40  | —   | 60   | %    |
| I <sub>DDHSE</sub>  | HSE Oscillator Current Consumption                         | V <sub>DD</sub> = 3.3V @ 16MHz                                                                                                       | —   | TBD | —    | mA   |
| I <sub>PWDHSE</sub> | HSE Oscillator Power Down Current                          | V <sub>DD</sub> = 3.3V                                                                                                               | —   | —   | 0.01 | μA   |
| t <sub>SUHSE</sub>  | HSE Oscillator SStartup Time                               | V <sub>DD</sub> = 3.3V                                                                                                               | —   | —   | 4    | ms   |

**Table 15 Low Speed External Clock (LSE) Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol              | Parameter                                     | Conditions                                                                                                                                         | Min | Typ    | Max  | Unit |
|---------------------|-----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-----|--------|------|------|
| V <sub>DD</sub>     | Operation Range                               | —                                                                                                                                                  | 2.0 | —      | 3.6  | V    |
| f <sub>CK_LSE</sub> | LSE Frequency                                 | V <sub>BAK</sub> = 2.0V ~ 3.6V                                                                                                                     | —   | 32.768 | —    | kHz  |
| R <sub>F</sub>      | Internal Feedback Resistor                    | —                                                                                                                                                  | —   | 10     | —    | MΩ   |
| R <sub>ESR</sub>    | Equivalent Series Resistance                  | V <sub>BAK</sub> = 3.3V                                                                                                                            | 30  | —      | TBD  | kΩ   |
| C <sub>L</sub>      | Recommended Load Capacitances                 | V <sub>BAK</sub> = 3.3V                                                                                                                            | 6   | —      | TBD  | pF   |
| I <sub>DDLSE</sub>  | Oscillator Supply Current (High Current Mode) | F <sub>CK_LSE</sub> = 32.768kHz, R <sub>ESR</sub> = 50KΩ, C <sub>L</sub> ≥ 7pF<br>V <sub>BAK</sub> = 2.0V ~ 2.7V<br>T <sub>A</sub> = -40°C ~ +85°C | —   | 3.3    | 6.3  | μA   |
|                     | Oscillator Supply Current (Low Current Mode)  | F <sub>CK_LSE</sub> = 32.768kHz, R <sub>ESR</sub> = 50KΩ, C <sub>L</sub> < 7pF<br>V <sub>BAK</sub> = 2.0V ~ 3.6V<br>T <sub>A</sub> = -40°C ~ +85°C | —   | 1.8    | 3.3  | μA   |
|                     | Power Down Current                            | —                                                                                                                                                  | —   | —      | 0.01 | μA   |
| t <sub>SULSE</sub>  | Startup Time (Low Current Mode)               | f <sub>CK_LSI</sub> = 32.768kHz, V <sub>BAK</sub> = 2.0V ~ 3.6V                                                                                    | 500 | —      | —    | ms   |

Note: The following guidelines are recommended to increase the stability of the crystal circuit of the HSE / LSE clock in the PCB layout:

- The crystal oscillator should be located as close as possible to the MCU to keep the trace lengths as short as possible to reduce any parasitic capacitance.
- Shield lines in the vicinity of the crystal by using a ground plane to isolate signals and reduce noise.
- Keep any high frequency signal lines away from the crystal area to prevent any crosstalk adverse effects.

## Internal Clock Characteristics

**Table 16 High Speed Internal Clock (HSI) Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol             | Parameter                                            | Conditions                                                    | Min | Typ | Max  | Unit |
|--------------------|------------------------------------------------------|---------------------------------------------------------------|-----|-----|------|------|
| V <sub>DD</sub>    | Operation Range                                      | —                                                             | 2.0 | —   | 3.6  | V    |
| f <sub>HSI</sub>   | HSI Frequency                                        | V <sub>DD</sub> = 3.3V @ 25°C                                 | —   | 8   | —    | MHz  |
| ACC <sub>HSI</sub> | Factory Calibrated HSI Oscillator Frequency Accuracy | V <sub>DD</sub> = 3.3V, T <sub>A</sub> = 25°C                 | -2  | —   | 2    | %    |
|                    |                                                      | V <sub>DD</sub> = 2.5V ~ 3.6V, T <sub>A</sub> = -40°C ~ +85°C | -3  | —   | 3    | %    |
|                    |                                                      | V <sub>DD</sub> = 2.0V ~ 3.6V, T <sub>A</sub> = -40°C ~ +85°C | -4  | —   | 4    | %    |
| Duty               | Duty Cycle                                           | f <sub>HSI</sub> = 8MHz                                       | 35  | —   | 65   | %    |
| I <sub>DDHSI</sub> | Oscillator Supply Current                            | f <sub>HSI</sub> = 8MHz                                       | —   | 300 | 500  | μA   |
|                    | Power down Current                                   |                                                               | —   | —   | 0.05 | μA   |
| t <sub>SuHSI</sub> | Startup Time                                         | f <sub>HSI</sub> = 8MHz                                       | —   | —   | 10   | μs   |

**Table 17 Low Speed Internal Clock (LSI) Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol             | Parameter                                     | Conditions                                                           | Min | Typ | Max | Unit |
|--------------------|-----------------------------------------------|----------------------------------------------------------------------|-----|-----|-----|------|
| f <sub>LSI</sub>   | Low Speed Internal Oscillator Frequency (LSI) | V <sub>DD</sub> = 3.3V, T <sub>A</sub> = -40°C ~ +85°C               | 21  | 32  | 43  | kHz  |
| ACC <sub>LSI</sub> | LSI Frequency Accuracy                        | After factory-trimmed, V <sub>DD</sub> = 3.3V, T <sub>A</sub> = 25°C | -10 | —   | +10 | %    |
| I <sub>DDLSI</sub> | LSI Oscillator Operating Current              | V <sub>DD</sub> = 3.3V, T <sub>A</sub> = 25°C                        | —   | 0.4 | 0.8 | μA   |
| t <sub>SuLSI</sub> | LSI Oscillator Startup Time                   | V <sub>DD</sub> = 3.3V, T <sub>A</sub> = 25°C                        | —   | —   | 100 | μs   |

## PLL Characteristics

**Table 18 PLL Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol              | Parameter        | Conditions | Min | Typ | Max | Unit |
|---------------------|------------------|------------|-----|-----|-----|------|
| f <sub>PLLIN</sub>  | PLL Input Clock  | —          | 4   | —   | 16  | MHz  |
| f <sub>CK_PLL</sub> | PLL Output Clock | —          | 16  | —   | 48  | MHz  |
| t <sub>LOCK</sub>   | PLL Lock Time    | —          | —   | 200 | —   | μs   |

## Memory Characteristics

**Table 19 Flash Memory Characteristics**

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol              | Parameter                                                             | Conditions                     | Min | Typ | Max | Unit     |
|---------------------|-----------------------------------------------------------------------|--------------------------------|-----|-----|-----|----------|
| N <sub>ENDU</sub>   | Number of Guaranteed Program/Erase Cycles Before Failure. (Endurance) | T <sub>A</sub> = -40°C ~ +85°C | 100 | —   | —   | K cycles |
| t <sub>RET</sub>    | Data Retention Time                                                   | T <sub>A</sub> = -40°C ~ +85°C | 10  | —   | —   | Years    |
| t <sub>PROG</sub>   | Word Programming Time                                                 | T <sub>A</sub> = -40°C ~ +85°C | 20  | —   | —   | μs       |
| t <sub>ERASE</sub>  | Page Erase Time                                                       | T <sub>A</sub> = -40°C ~ +85°C | 2   | —   | —   | ms       |
| t <sub>MERASE</sub> | Mass Erase Time                                                       | T <sub>A</sub> = -40°C ~ +85°C | 10  | —   | —   | ms       |

## I/O Port Characteristics

Table 20 I/O Port Characteristics

T<sub>A</sub> = 25°C, unless otherwise specified.

| Symbol           | Parameter                                       | Conditions                                                    | Min                    | Typ                    | Max                    | Unit |
|------------------|-------------------------------------------------|---------------------------------------------------------------|------------------------|------------------------|------------------------|------|
| I <sub>IL</sub>  | Low Level Input Current                         | 3.3V IO                                                       | —                      | —                      | 3                      | μA   |
|                  |                                                 | Reset pin                                                     | —                      | —                      | 3                      | μA   |
| I <sub>IH</sub>  | High Level Input Current                        | 3.3V IO                                                       | —                      | —                      | 3                      | μA   |
|                  |                                                 | Reset pin                                                     | —                      | —                      | 3                      | μA   |
| V <sub>IL</sub>  | Low Level Input Voltage                         | 3.3V IO                                                       | - 0.5                  | —                      | V <sub>DD</sub> × 0.35 | V    |
|                  |                                                 | Reset pin                                                     | - 0.5                  | —                      | V <sub>DD</sub> × 0.35 | V    |
| V <sub>IH</sub>  | High Level Input Voltage                        | 3.3V IO                                                       | V <sub>DD</sub> × 0.65 | —                      | V <sub>DD</sub> + 0.5  | V    |
|                  |                                                 | Reset pin                                                     | V <sub>DD</sub> × 0.65 | —                      | V <sub>DD</sub> + 0.5  | V    |
| V <sub>HYS</sub> | Schmitt Trigger Input Voltage Hysteresis        | 3.3V IO                                                       | —                      | V <sub>DD</sub> × 0.12 | —                      | mV   |
|                  |                                                 | Reset pin                                                     | —                      | V <sub>DD</sub> × 0.12 | —                      | mV   |
| I <sub>OL</sub>  | Low Level Output Current (GPIO Sink Current)    | 3.3V IO 4mA drive, V <sub>OL</sub> = 0.4V                     | 4                      | —                      | —                      | mA   |
|                  |                                                 | 3.3V IO 8mA drive, V <sub>OL</sub> = 0.4V                     | 8                      | —                      | —                      | mA   |
|                  |                                                 | 3.3V IO 12mA drive, V <sub>OL</sub> = 0.4V                    | 12                     | —                      | —                      | mA   |
|                  |                                                 | 3.3V IO 16mA drive, V <sub>OL</sub> = 0.4V                    | 16                     | —                      | —                      | mA   |
| I <sub>OH</sub>  | High Level Output Current (GPIO Source Current) | 3.3V I/O 4mA drive, V <sub>OH</sub> = V <sub>DD</sub> - 0.4V  | 4                      | —                      | —                      | mA   |
|                  |                                                 | 3.3V I/O 8mA drive, V <sub>OH</sub> = V <sub>DD</sub> - 0.4V  | 8                      | —                      | —                      | mA   |
|                  |                                                 | 3.3V I/O 12mA drive, V <sub>OH</sub> = V <sub>DD</sub> - 0.4V | 12                     | —                      | —                      | mA   |
|                  |                                                 | 3.3V I/O 16mA drive, V <sub>OH</sub> = V <sub>DD</sub> - 0.4V | 16                     | —                      | —                      | mA   |
| V <sub>OL</sub>  | Low Level Output Voltage                        | 3.3V 4mA drive IO, I <sub>OL</sub> = 4mA                      | —                      | —                      | 0.4                    | V    |
|                  |                                                 | 3.3V 8mA drive IO, I <sub>OL</sub> = 8mA                      | —                      | —                      | 0.4                    | V    |
|                  |                                                 | 3.3V 12mA drive IO, I <sub>OL</sub> = 12mA                    | —                      | —                      | 0.4                    | V    |
|                  |                                                 | 3.3V 16mA drive IO, I <sub>OL</sub> = 16mA                    | —                      | —                      | 0.4                    | V    |
| V <sub>OH</sub>  | High Level Output Voltage                       | 3.3V 4mA drive IO, I <sub>OH</sub> = 4mA                      | V <sub>DD</sub> - 0.4  | —                      | —                      | V    |
|                  |                                                 | 3.3V 8mA drive IO, I <sub>OH</sub> = 8mA                      | V <sub>DD</sub> - 0.4  | —                      | —                      | V    |
|                  |                                                 | 3.3V 12mA drive IO, I <sub>OL</sub> = 12mA                    | V <sub>DD</sub> - 0.4  | —                      | —                      | V    |
|                  |                                                 | 3.3V 16mA drive IO, I <sub>OL</sub> = 16mA                    | V <sub>DD</sub> - 0.4  | —                      | —                      | V    |
| R <sub>PU</sub>  | Internal Pull-up Resistor                       | 3.3V I/O                                                      | —                      | 46                     | —                      | kΩ   |
| R <sub>PD</sub>  | Internal Pull-down Resistor                     | 3.3V I/O                                                      | —                      | 46                     | —                      | kΩ   |

## ADC Characteristics

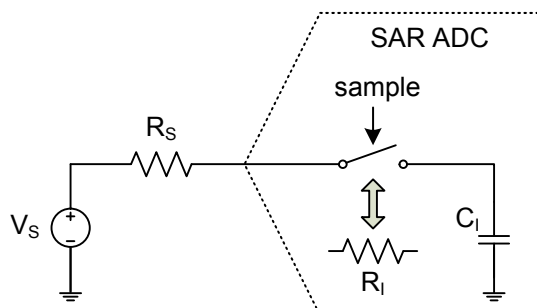
**Table 21 ADC Characteristics**

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

| Symbol        | Parameter                         | Conditions                                      | Min  | Typ       | Max        | Unit                  |
|---------------|-----------------------------------|-------------------------------------------------|------|-----------|------------|-----------------------|
| $V_{DDA}$     | Operating Voltage                 | —                                               | 2.7  | 3.3       | 3.6        | V                     |
| $V_{ADCIN}$   | A/D Converter Input Voltage Range | —                                               | 0    | —         | $V_{REF+}$ | V                     |
| $V_{REF+}$    | A/D Converter Reference Voltage   | —                                               | —    | $V_{DDA}$ | $V_{DDA}$  | V                     |
| $I_{ADC}$     | Current Consumption               | $V_{DDA} = 3.3\text{V}$                         | —    | 1         | TBD        | mA                    |
| $I_{ADC\_DN}$ | Power Down Current Consumption    | $V_{DDA} = 3.3\text{V}$                         | —    | —         | 0.1        | $\mu\text{A}$         |
| $f_{ADC}$     | A/D Converter Clock               | —                                               | 0.7  | —         | 16         | MHz                   |
| $f_s$         | Sampling Rate                     | —                                               | 0.05 | —         | 1          | MHz                   |
| $t_{DL}$      | Data Latency                      | —                                               | —    | 12.5      | —          | $1/f_{ADC}$<br>Cycles |
| $t_{S\&H}$    | Sampling & Hold Time              | —                                               | —    | 3.5       | —          | $1/f_{ADC}$<br>Cycles |
| $t_{ADCCONV}$ | A/D Converter Conversion Time     | —                                               | —    | 16        | —          | $1/f_{ADC}$<br>Cycles |
| $R_i$         | Input Sampling Switch Resistance  | —                                               | —    | —         | 1          | k $\Omega$            |
| $C_i$         | Input Sampling Capacitance        | No pin/pad capacitance included                 | —    | 16        | —          | pF                    |
| $t_{SU}$      | Startup Up Time                   | —                                               | —    | —         | 1          | $\mu\text{s}$         |
| $N$           | Resolution                        | —                                               | —    | 12        | —          | bits                  |
| INL           | Integral Non-linearity Error      | $f_s = 750\text{kHz}$ , $V_{DDA} = 3.3\text{V}$ | —    | $\pm 2$   | $\pm 5$    | LSB                   |
| DNL           | Differential Non-linearity Error  | $f_s = 750\text{kHz}$ , $V_{DDA} = 3.3\text{V}$ | —    | $\pm 1$   | —          | LSB                   |
| $E_o$         | Offset Error                      | —                                               | —    | —         | $\pm 10$   | LSB                   |
| $E_G$         | Gain Error                        | —                                               | —    | —         | $\pm 10$   | LSB                   |

Note: 1. Guaranteed by design, not tested in production.

2. The figure below shows the equivalent circuit of the A/D Converter Sample-and-Hold input stage where  $C_i$  is the storage capacitor,  $R_i$  is the resistance of the sampling switch and  $R_s$  is the output impedance of the signal source  $V_s$ . Normally the sampling phase duration is approximately,  $3.5/f_{ADC}$ . The capacitance,  $C_i$ , must be charged within this time frame and it must be ensured that the voltage at its terminals becomes sufficiently close to  $V_s$  for accuracy. To guarantee this,  $R_s$  is not allowed to have an arbitrarily large value.



**Figure 10 ADC Sampling Network Model**

The worst case occurs when the extremities of the input range (0V and  $V_{REF}$ ) are sampled consecutively. In this situation a sampling error below  $\frac{1}{4}$  LSB is ensured by using the following equation:

$$R_s < \frac{3.5}{f_{ADC} C_i \ln(2^{N+2})} - R_i$$

Where  $f_{ADC}$  is the ADC clock frequency and  $N$  is the ADC resolution ( $N = 12$  in this case). A safe margin should be considered due to the pin/pad parasitic capacitances, which are not accounted for in this simple model.

If, in a system where the A/D Converter is used, there are no rail-to-rail input voltage variations between consecutive sampling phases,  $R_s$  may be larger than the value indicated by the equation above.

## SCTM/GPTM/MCTM Characteristics

**Table 22 SCTM/GPTM/MCTM Characteristics**

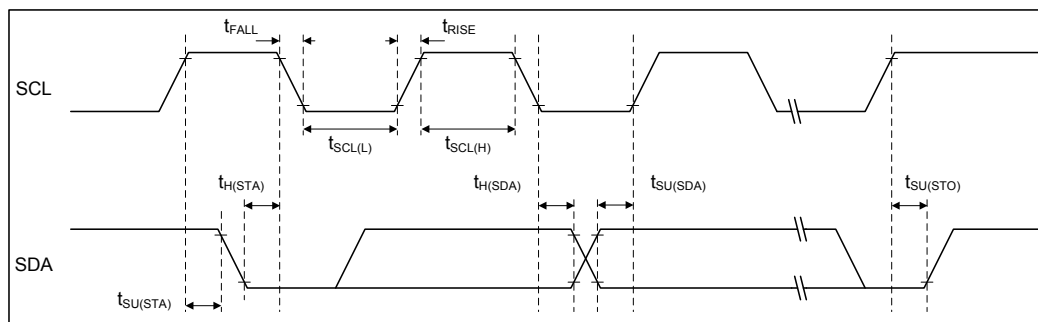
| Symbol    | Parameter                                  | Conditions | Min | Typ | Max | Unit     |
|-----------|--------------------------------------------|------------|-----|-----|-----|----------|
| $f_{TM}$  | Timer Clock Source for GPTM and MCTM       | —          | —   | —   | 48  | MHz      |
| $t_{RES}$ | Timer Resolution Time                      | —          | 1   | —   | —   | $f_{TM}$ |
| $f_{EXT}$ | External Single Frequency on Channel 1 ~ 4 | —          | —   | —   | 1/2 | $f_{TM}$ |
| RES       | Timer Resolution                           | —          | —   | —   | 16  | bits     |

## I<sup>2</sup>C Characteristics

**Table 23 I<sup>2</sup>C Characteristics**

| Symbol               | Parameter                  | Standard mode |     | Fast mode |      | Fast mode plus |       | Unit |
|----------------------|----------------------------|---------------|-----|-----------|------|----------------|-------|------|
|                      |                            | Min           | Max | Min       | Max  | Min            | Max   |      |
| f <sub>SCL</sub>     | SCL Clock Frequency        | —             | 100 | —         | 400  | —              | 1000  | kHz  |
| t <sub>SCL(H)</sub>  | SCL Clock High Time        | 4.5           | —   | 1.125     | —    | 0.45           | —     | μs   |
| t <sub>SCL(L)</sub>  | SCL Clock Low Time         | 4.5           | —   | 1.125     | —    | 0.45           | —     | μs   |
| t <sub>FALL</sub>    | SCL and SDA Fall Time      | —             | 1.3 | —         | 0.34 | —              | 0.135 | μs   |
| t <sub>RISE</sub>    | SCL and SDA Rise Time      | —             | 1.3 | —         | 0.34 | —              | 0.135 | μs   |
| t <sub>SU(SDA)</sub> | SDA Data Setup Time        | 500           | —   | 125       | —    | 50             | —     | ns   |
| t <sub>H(SDA)</sub>  | SDA Data Hold Time         | 0             | —   | 0         | —    | 0              | —     | ns   |
| t <sub>SU(STA)</sub> | START Condition Setup Time | 500           | —   | 125       | —    | 50             | —     | ns   |
| t <sub>H(STA)</sub>  | START Condition Hold Time  | 0             | —   | 0         | —    | 0              | —     | ns   |
| t <sub>SU(STO)</sub> | STOP Condition Setup Time  | 500           | —   | 125       | —    | 50             | —     | ns   |

- Note: 1. Guaranteed by design, not tested in production.  
2. To achieve 100 kHz standard mode, the peripheral clock frequency must be higher than 2MHz.  
3. To achieve 400 kHz fast mode, the peripheral clock frequency must be higher than 8MHz.  
4. To achieve 1MHz fast mode plus, the peripheral clock frequency must be higher than 20MHz.  
5. The above characteristic parameters of the I<sup>2</sup>C bus timing are based on: SEQ\_FILTER = 01 and COMB\_FILTER\_En is disabled.



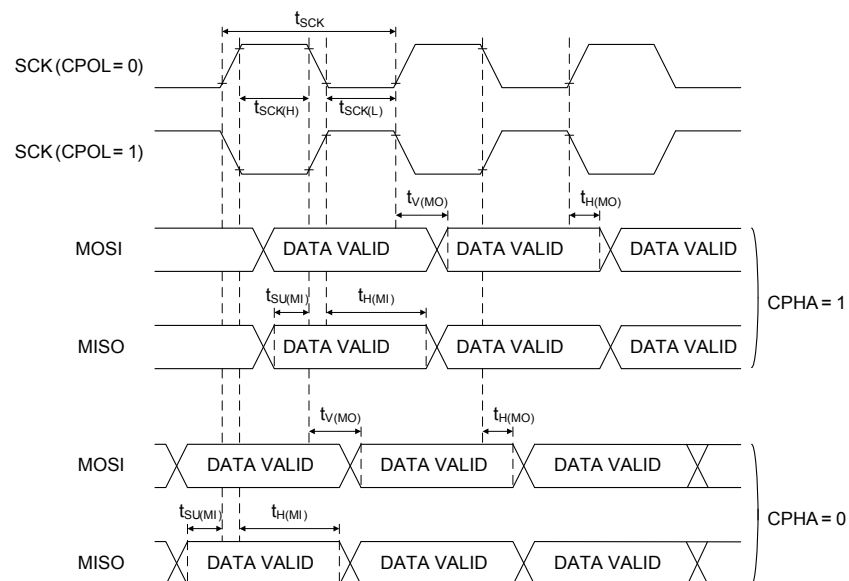
**Figure 11 I<sup>2</sup>C Timing Diagrams**

## SPI Characteristics

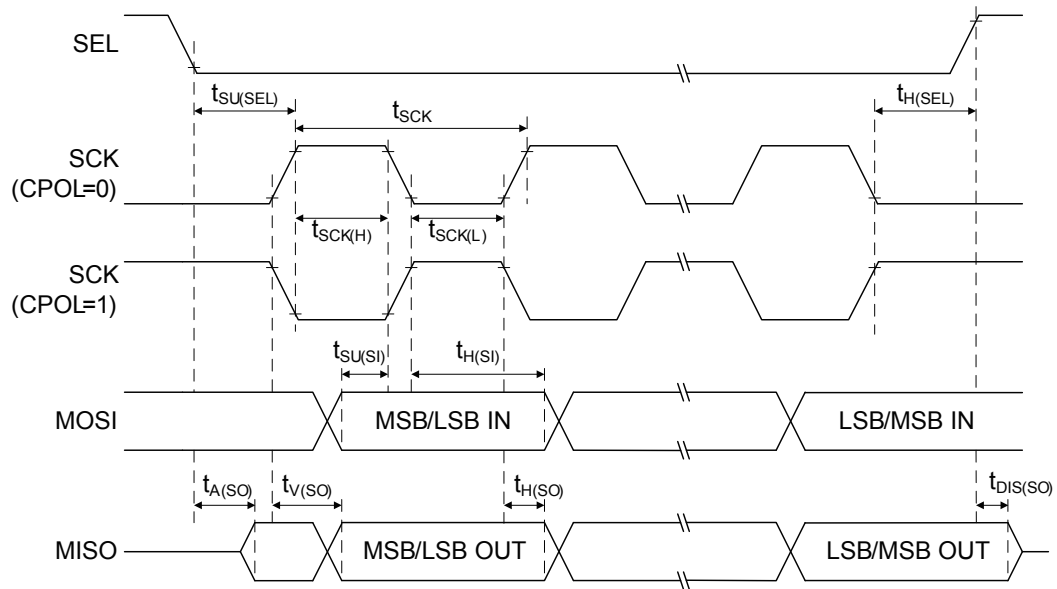
**Table 24 SPI Characteristics**

| Symbol                       | Parameter                             | Conditions                                             | Min             | Typ | Max             | Unit |
|------------------------------|---------------------------------------|--------------------------------------------------------|-----------------|-----|-----------------|------|
| <b>SPI Master Mode</b>       |                                       |                                                        |                 |     |                 |      |
| $f_{SCK}$<br>( $1/t_{SCK}$ ) | SPI master output SCK clock frequency | Master mode, SPI peripheral clock frequency $f_{PCLK}$ | —               | —   | $f_{PCLK}/2$    | MHz  |
| $t_{SCK(H)}$<br>$t_{SCK(L)}$ | SCK clock high and low time           |                                                        | $t_{SCK}/2 - 2$ | —   | $t_{SCK}/2 + 1$ | ns   |
| $t_{V(MO)}$                  | Data output valid time                | —                                                      | —               | —   | 5               | ns   |
| $t_{H(MO)}$                  | Data output hold time                 | —                                                      | 2               | —   | —               | ns   |
| $t_{SU(MI)}$                 | Data input setup time                 | —                                                      | 5               | —   | —               | ns   |
| $t_{H(MI)}$                  | Data input hold time                  | —                                                      | 5               | —   | —               | ns   |
| <b>SPI Slave Mode</b>        |                                       |                                                        |                 |     |                 |      |
| $f_{SCK}$<br>( $1/t_{SCK}$ ) | SPI master output SCK clock frequency | Slave mode, SPI peripheral clock frequency $f_{PCLK}$  | —               | —   | $f_{PCLK}/3$    | MHz  |
| Duty <sub>SCK</sub>          | SPI slave input SCK clock duty cycle  |                                                        | 30              | —   | 70              | %    |
| $t_{SU(SEL)}$                | SEL enable setup time                 | —                                                      | 3 $t_{PCLK}$    | —   | —               | ns   |
| $t_{H(SEL)}$                 | SEL enable hold time                  | —                                                      | 2 $t_{PCLK}$    | —   | —               | ns   |
| $t_{A(SO)}$                  | Data output access time               | —                                                      | —               | —   | 3 $t_{PCLK}$    | ns   |
| $t_{DIS(SO)}$                | Data output disable time              | —                                                      | —               | —   | 10              | ns   |
| $t_{V(SO)}$                  | Data output valid time                | —                                                      | —               | —   | 25              | ns   |
| $t_{H(SO)}$                  | Data output hold time                 | —                                                      | 15              | —   | —               | ns   |
| $t_{SU(SI)}$                 | Data input setup time                 | —                                                      | 5               | —   | —               | ns   |
| $t_{H(SI)}$                  | Data input hold time                  | —                                                      | 4               | —   | —               | ns   |

Note:  $t_{SCK} = 1/f_{SCK}$ ;  $t_{PCLK} = 1/f_{PCLK}$ . SPI output (input) clock frequency  $f_{SCK}$ ; SPI peripheral clock frequency  $f_{PCLK}$ .



**Figure 12 SPI Timing Diagrams – SPI Master Mode**



**Figure 13 SPI Timing Diagrams – SPI Slave Mode with CPHA=1**

## USB Characteristics

The USB interface is USB-IF certified – Full Speed.

**Table 25 USB DC Electrical Characteristics**

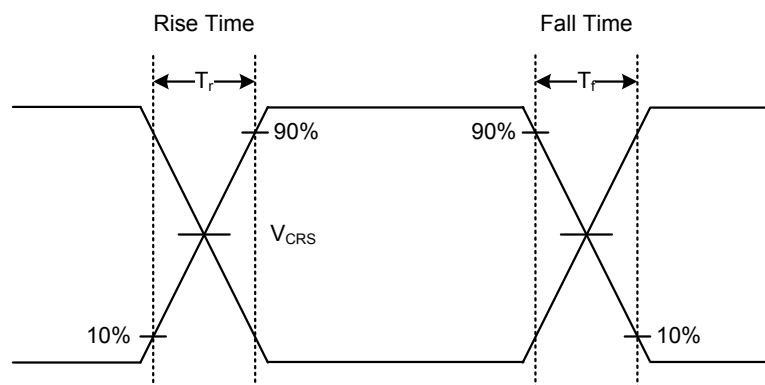
| Symbol     | Parameter                                      | Conditions                           | Min | Typ | Max | Unit     |
|------------|------------------------------------------------|--------------------------------------|-----|-----|-----|----------|
| $V_{DD33}$ | USB Operating Voltage                          | —                                    | 3.0 | —   | 3.6 | V        |
| $V_{DI}$   | Differential Input Sensitivity                 | USBDP - USBDM                        | 0.2 | —   | —   | V        |
| $V_{CM}$   | Common Mode Voltage Range                      | —                                    | 0.8 | —   | 2.5 | V        |
| $V_{SE}$   | Single-ended Receiver Threshold                | —                                    | 0.8 | —   | 2.0 | V        |
| $V_{OL}$   | Pad Output Low Voltage                         | $R_L$ of 1.5k $\Omega$ to $V_{DD33}$ | 0   | —   | 0.3 | V        |
| $V_{OH}$   | Pad Output High Voltage                        |                                      | 2.8 | —   | 3.6 | V        |
| $V_{CRS}$  | Differential Output Signal Cross-point Voltage |                                      | 1.3 | —   | 2.0 | V        |
| $Z_{DRV}$  | Driver Output Resistance                       | —                                    | —   | 10  | —   | $\Omega$ |
| $C_{IN}$   | Transceiver Pad Capacitance                    | —                                    | —   | —   | 20  | pF       |

Note: 1. Guaranteed by design, not tested in production.

2. To be compliant with the USB 2.0 full-speed electrical specification, the USBDP pin should be pulled up with a 1.5k $\Omega$  external resistor to a 3.0V to 3.6V voltage supply.

3. The USB functionality is ensured down to 2.7V but for not the full USB electrical characteristics which will experience degradation in the 2.7V to 3.0V  $V_{DD33}$  voltage range.

4.  $R_L$  is the load connected to the USB driver USBDP.



**Figure 14 USB Signal Rise Time and Fall Time and Cross-point Voltage ( $V_{CRS}$ ) Definition**

**Table 26 USB AC Electrical Characteristics**

| Symbol    | Parameter                      | Conditions            | Min | Typ | Max | Unit |
|-----------|--------------------------------|-----------------------|-----|-----|-----|------|
| $t_r$     | Rise time                      | $C_L = 50\text{pF}$   | 4   | —   | 20  | ns   |
| $t_f$     | Fall time                      | $C_L = 50\text{pF}$   | 4   | —   | 20  | ns   |
| $t_{r/f}$ | Rise time / fall time matching | $t_{r/f} = t_r / t_f$ | 90  | —   | 110 | %    |

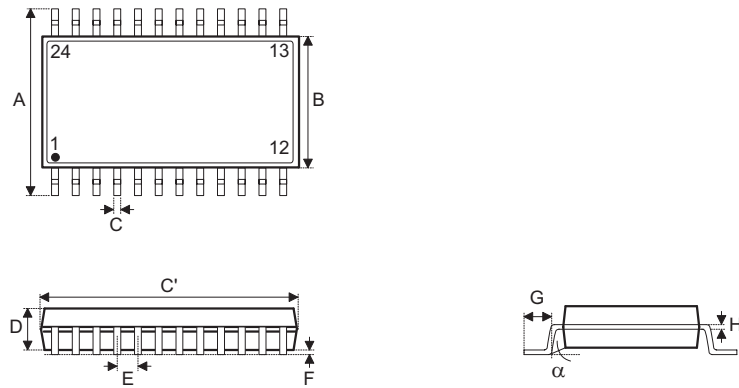
## 6 Package Information

Note that the package information provided here is for consultation purposes only. As this information may be updated at regular intervals users are reminded to consult the [Holtek website](http://www.holtek.com) for the latest version of the [Package/Carton Information](#).

Additional supplementary information with regard to packaging is listed below. Click on the relevant section to be transferred to the relevant website page.

- [Package Information \(include Outline Dimensions, Product Tape and Reel Specifications\)](#)
- [The Operation Instruction of Packing Materials](#)
- [Carton information](#)

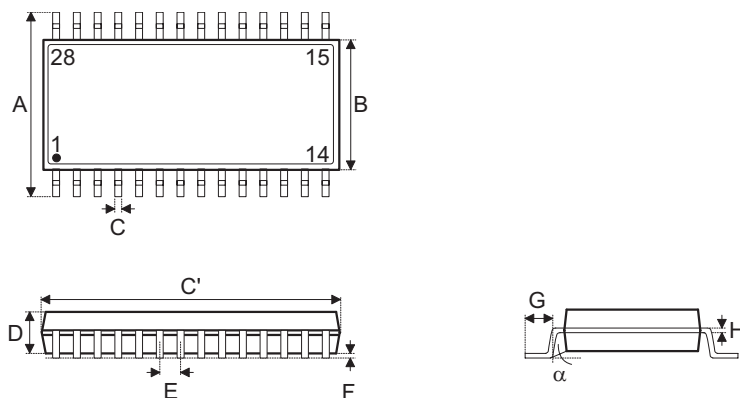
## 24-pin SSOP (150mil) Outline Dimensions



| Symbol   | Dimensions in inch |           |       |
|----------|--------------------|-----------|-------|
|          | Min.               | Nom.      | Max.  |
| A        | —                  | 0.236 BSC | —     |
| B        | —                  | 0.154 BSC | —     |
| C        | 0.008              | —         | 0.012 |
| C'       | —                  | 0.341 BSC | —     |
| D        | —                  | —         | 0.069 |
| E        | —                  | 0.025 BSC | —     |
| F        | 0.004              | —         | 0.010 |
| G        | 0.016              | —         | 0.050 |
| H        | 0.004              | —         | 0.010 |
| $\alpha$ | 0°                 | —         | 8°    |

| Symbol   | Dimensions in mm |           |       |
|----------|------------------|-----------|-------|
|          | Min.             | Nom.      | Max.  |
| A        | —                | 6.000 BSC | —     |
| B        | —                | 3.900 BSC | —     |
| C        | 0.200            | —         | 0.300 |
| C'       | —                | 8.660 BSC | —     |
| D        | —                | —         | 1.750 |
| E        | —                | 0.635 BSC | —     |
| F        | 0.100            | —         | 0.250 |
| G        | 0.410            | —         | 1.270 |
| H        | 0.100            | —         | 0.250 |
| $\alpha$ | 0°               | —         | 8°    |

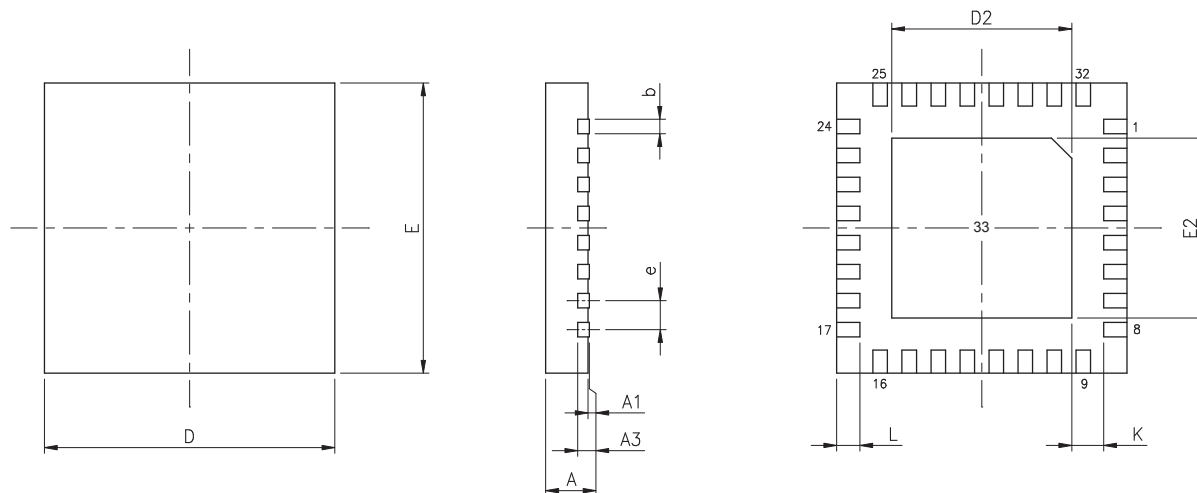
## 28-pin SSOP (150mil) Outline Dimensions



| Symbol   | Dimensions in inch |           |        |
|----------|--------------------|-----------|--------|
|          | Min.               | Nom.      | Max.   |
| A        | —                  | 0.236 BSC | —      |
| B        | —                  | 0.154 BSC | —      |
| C        | 0.008              | —         | 0.012  |
| C'       | —                  | 0.390 BSC | —      |
| D        | —                  | —         | 0.069  |
| E        | —                  | 0.025 BSC | —      |
| F        | 0.004              | —         | 0.0098 |
| G        | 0.016              | —         | 0.050  |
| H        | 0.004              | —         | 0.010  |
| $\alpha$ | 0°                 | —         | 8°     |

| Symbol   | Dimensions in mm |           |       |
|----------|------------------|-----------|-------|
|          | Min.             | Nom.      | Max.  |
| A        | —                | 6.000 BSC | —     |
| B        | —                | 3.900 BSC | —     |
| C        | 0.200            | —         | 0.300 |
| C'       | —                | 9.900 BSC | —     |
| D        | —                | —         | 1.750 |
| E        | —                | 0.635 BSC | —     |
| F        | 0.100            | —         | 0.250 |
| G        | 0.410            | —         | 1.270 |
| H        | 0.100            | —         | 0.250 |
| $\alpha$ | 0°               | —         | 8°    |

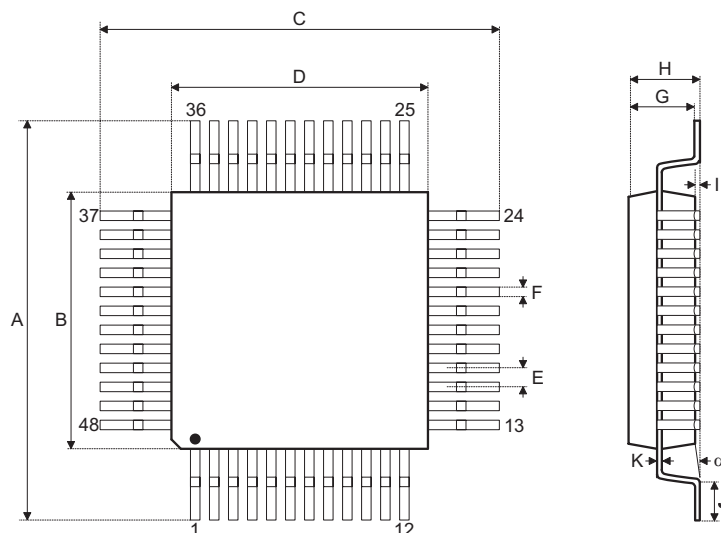
## SAW Type 33-pin (4mm×4mm) QFN Outline Dimensions



| Symbol | Dimensions in inch |           |       |
|--------|--------------------|-----------|-------|
|        | Min.               | Nom.      | Max.  |
| A      | 0.028              | 0.030     | 0.031 |
| A1     | 0.000              | 0.001     | 0.002 |
| A3     | —                  | 0.008 BSC | —     |
| b      | 0.006              | 0.008     | 0.010 |
| D      | —                  | 0.157 BSC | —     |
| E      | —                  | 0.157 BSC | —     |
| e      | —                  | 0.016 BSC | —     |
| D2     | 0.104              | 0.106     | 0.108 |
| E2     | 0.104              | 0.106     | 0.108 |
| L      | 0.014              | 0.016     | 0.018 |
| K      | 0.008              | —         | —     |

| Symbol | Dimensions in mm |           |       |
|--------|------------------|-----------|-------|
|        | Min.             | Nom.      | Max.  |
| A      | 0.700            | 0.750     | 0.800 |
| A1     | 0.000            | 0.020     | 0.050 |
| A3     | —                | 0.203 BSC | —     |
| b      | 0.150            | 0.200     | 0.250 |
| D      | —                | 4.000 BSC | —     |
| E      | —                | 4.000 BSC | —     |
| e      | —                | 0.400 BSC | —     |
| D2     | 2.650            | 2.700     | 2.750 |
| E2     | 2.650            | 2.700     | 2.750 |
| L      | 0.350            | 0.400     | 0.450 |
| K      | 0.200            | —         | —     |

## 48-pin LQFP (7mm×7mm) Outline Dimensions



| Symbol   | Dimensions in inch |           |       |
|----------|--------------------|-----------|-------|
|          | Min.               | Nom.      | Max.  |
| A        | —                  | 0.354 BSC | —     |
| B        | —                  | 0.276 BSC | —     |
| C        | —                  | 0.354 BSC | —     |
| D        | —                  | 0.276 BSC | —     |
| E        | —                  | 0.020 BSC | —     |
| F        | 0.007              | 0.009     | 0.011 |
| G        | 0.053              | 0.055     | 0.057 |
| H        | —                  | —         | 0.063 |
| I        | 0.002              | —         | 0.006 |
| J        | 0.018              | 0.024     | 0.030 |
| K        | 0.004              | —         | 0.008 |
| $\alpha$ | 0°                 | —         | 7°    |

| Symbol   | Dimensions in mm |           |       |
|----------|------------------|-----------|-------|
|          | Min.             | Nom.      | Max.  |
| A        | —                | 9.000 BSC | —     |
| B        | —                | 7.000 BSC | —     |
| C        | —                | 9.000 BSC | —     |
| D        | —                | 7.000 BSC | —     |
| E        | —                | 0.500 BSC | —     |
| F        | 0.170            | 0.220     | 0.270 |
| G        | 1.350            | 1.400     | 1.450 |
| H        | —                | —         | 1.600 |
| I        | 0.050            | —         | 0.150 |
| J        | 0.450            | 0.600     | 0.750 |
| K        | 0.090            | —         | 0.200 |
| $\alpha$ | 0°               | —         | 7°    |

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