

200/400 MHz, Arm® Cortex®-R52 on-chip FPU and NEON™, 1.5 MB of on-chip SRAM, Ethernet MAC, EtherCAT, USB 2.0 high-speed, CAN/CANFD, various communications interfaces such as an xSPI and  $\Delta\Sigma$  interface, and security functions

## Features

- On-chip 32-bit Arm Cortex-R52 processor
  - High-speed realtime control with operating frequency of 200/400 MHz
  - On-chip Single 32-bit Arm Cortex-R52 (revision r1p2)
  - Tightly coupled memory (TCM) with ECC
    - CPU0: 128 KB/128 KB
  - Instruction cache/data cache with ECC
    - CPU0: 16 KB per cache
  - High-speed interrupt
  - The FPU supports addition, subtraction, multiplication, division, multiply-and-accumulate, and square-root operations at single-precision and double-precision.
  - The NEON, Advanced SIMD, supports integer or single precision results.
  - Harvard architecture with 8-stage pipeline
  - Supports the memory protection unit (MPU)
  - Arm CoreSight architecture, includes support for debugging through JTAG and SWD interfaces.
- Low power consumption
  - Standby mode and module stop function
- On-chip SRAM
  - 1.5 MB of the on-chip SRAM with ECC
  - 150/200 MHz
- Data transfer
  - DMAC: 8 channels × 2 units
- Event link controller
  - Module operations can be started by event signals rather than by interrupt handlers.
  - Linked operation of modules is available even while the CPU is in the standby state.
- Reset and power supply voltage control
  - Four reset sources including a pin reset
- Clock functions
  - External clock/oscillator input frequency: 25 MHz
  - CPU clock frequency: 200/400 MHz or 150/300 MHz
  - System clock frequency: 200 MHz or 150 MHz
  - Low-speed on-chip oscillator (LOCO): 240 kHz
- Safety functions
  - Register write protection, input clock oscillation stop detection and CRC
  - Master Memory Protection Unit (MPU)
- Security functions (optional)
  - Boot mode with security through encryption
  - JTAG authentication
  - Cryptologic accelerator
  - TRNG
- Various communications interfaces
  - Ethernet
    - EtherCAT slave Controller: 3 ports
    - Ethernet switch: 3 ports
    - Ethernet MAC: 1 port
  - USB 2.0 high-speed host/functions: 1 channel
  - CAN/CANFD (compliant with ISO11898-1): 2 channels
  - SCI with 16-byte transmission and reception FIFOs: 6 channels
  - I2C bus interface: 3 channel for transfer at up to 400 kbps
  - SPI: 4 channels
  - xSPI: 2 channels
- External host interfaces
  - Serial host interface (SHOSTIF)
  - Parallel host interface (PHOSTIF)
- External address space
  - Buses for high-speed data transfer at up to 100 MHz
  - Support for up to 4 CS areas
  - 8- or 16-bit bus space is selectable per area
- Up to 35 extended-function timers
  - 16-bit × 8 + 32-bit MTU3 (9 channels), 32-bit GPT (18 channels): Input capture, output compare, PWM waveform output
  - 16-bit CMT (6 channels), 32-bit CMTW (2 channels)
- $\Delta\Sigma$  interface
  - Up to 6  $\Delta\Sigma$  modulators are connectable externally.
- Trigonometric function unit
  - Simultaneous calculation of sine and cosine
  - Simultaneous calculation of arctangent and hypot\_k
- 12-bit A/D converter
  - 12 bits × 2 unit (4 channels for unit 0, 8 channels for unit 1)
- Temperature sensor for measuring temperature within the chip
- General-purpose I/O ports
  - Input pull-up/pull-down
  - The locations of input/output functions for peripheral modules are selectable from among multiple pins.
- Operating temperature range
  - Tj = -40 to +125°C

## 1. Overview

### 1.1 Outline of Specifications

The MPU is a high-performance ASSP that has Arm Cortex<sup>®</sup>-R52 processor with Floating-Point Unit (FPU) and NEON<sup>™</sup>. It incorporates integrated peripheral functions necessary for system configuration.

**Table 1.1 CPU**

Feature	Functional description
Arm <sup>®</sup> Cortex <sup>®</sup> -R52	<ul style="list-style-type: none"> <li>• Single processor</li> <li>• Operating frequency               <ul style="list-style-type: none"> <li>– 200 MHz/400 MHz (in case of 200 MHz system clock)</li> <li>– 150 MHz/300 MHz (in case of 150 MHz system clock)</li> </ul> </li> <li>• 32-bit CPU Cortex-R52 designed by Arm (core revision r1p2)</li> <li>• Address space: 4 GB</li> <li>• Instruction cache               <ul style="list-style-type: none"> <li>– 16 KB (with ECC)</li> </ul> </li> <li>• Data cache               <ul style="list-style-type: none"> <li>– 16 KB (with ECC)</li> </ul> </li> <li>• Tightly coupled memory (TCM)               <ul style="list-style-type: none"> <li>– ATCM: 128 KB (with ECC) 0 wait</li> <li>– BTCM: 128 KB (with ECC) 0 wait</li> <li>– CTCM: 0 KB (with ECC)</li> </ul> </li> <li>• Instruction set: Arm v8-R architecture, so support includes Thumb<sup>®</sup> and Thumb-2</li> <li>• Data arrangement               <ul style="list-style-type: none"> <li>– Instructions: Little endian</li> <li>– Data: Little endian</li> </ul> </li> <li>• 2-stage memory protection unit (MPU)</li> </ul>
FPU	<ul style="list-style-type: none"> <li>• Supports addition, subtraction, multiplication, division, multiply-and-accumulate, and square-root operations at single- and double-precision.</li> <li>• Registers               <ul style="list-style-type: none"> <li>64-bit single-word registers: 64 bits × 32</li> <li>(can be used as 16 double-word registers: 128 bits × 16)</li> </ul> </li> </ul>
NEON	The Advanced SIMD supporting integer or single precision results

**Table 1.2 Memory**

Feature	Functional description
On-chip system SRAM with ECC	<ul style="list-style-type: none"> <li>• Capacity: Up to 1.5 MB (512 KB × 3 units) (with ECC)</li> <li>• Operating frequency: 150 MHz/200 MHz</li> <li>• SEC-DED (single error correction/double error detection) Error injection supported</li> </ul>
One-time programmable memory	<ul style="list-style-type: none"> <li>• Overwrite protection</li> <li>• Redundancy support</li> <li>• Available information               <ul style="list-style-type: none"> <li>– Unique ID</li> <li>– Authentication settings</li> <li>– Trimming data</li> <li>– Boot mode setting</li> <li>– User area</li> </ul> </li> </ul>

**Table 1.3 System (1 of 2)**

Feature	Functional description
Operating modes	<p>The operating mode can be selected from the following eight boot modes:</p> <ul style="list-style-type: none"> <li>• xSPI0 boot mode (CS0 × 1 boot Serial Flash)</li> <li>• xSPI0 boot mode (CS0 × 8 boot Serial Flash)</li> <li>• 16-bit bus boot mode (CS0 NOR Flash)</li> <li>• SHOSTIF boot mode</li> <li>• PHOSTIF boot mode</li> <li>• xSPI1 boot mode (CS0 × 1 boot Serial Flash)</li> <li>• SCI boot mode</li> <li>• USB boot mode</li> </ul>

Table 1.3 System (2 of 2)

Feature	Functional description
Clock generation circuit	<ul style="list-style-type: none"> <li>The input clock can be selected from an external clock or external resonator.</li> <li>Detection of input clock oscillation stopping</li> <li>The following clocks are generated: <ul style="list-style-type: none"> <li>CPU0 clock: System clock ×1 or ×2</li> <li>System clock: 150 or 200 MHz</li> <li>High-speed peripheral module clock: 150 or 200 MHz</li> <li>Middle-speed peripheral module clock: 75 or 100 MHz</li> <li>Low-speed peripheral module clock: 37.5 or 50 MHz</li> <li>ADC clock in the 12-bit A/D converter: 25 or 18.75 MHz</li> <li>External bus clock: 100 MHz (max.)</li> <li>Low-speed on-chip oscillator: 240 kHz (fixed)</li> </ul> </li> </ul>
Reset	RES# pin reset, software reset, error reset, CPU0 software reset
Low-power consumption function	<ul style="list-style-type: none"> <li>Standby mode (Cortex-R52)</li> <li>Module stop function</li> </ul>
Interrupt controller (ICU)	<ul style="list-style-type: none"> <li>Peripheral function interrupts: 423 sources</li> <li>External interrupts: 16 sources (IRQ0 to IRQ15 pins)</li> <li>Software interrupts: 8 sources</li> <li>Non-maskable interrupts: 1 sources</li> <li>32 levels specifiable for the order of priority</li> </ul>
Bus state controller (BSC)	<ul style="list-style-type: none"> <li>The external address space is divided into four areas (CS0, CS2, CS3, and CS5) for management.</li> <li>The following features are configurable for each area independently: <ul style="list-style-type: none"> <li>Bus size (8 or 16 bits): Available sizes depend on the area. Number of access wait cycles (different wait cycles can be specified for read and write access cycles in some areas). Idle wait cycle insertion (between same area access cycles or different area access cycles). Specifying the memory to be connected to each area enables direct connection to SRAM, SRAM with byte selection, SDRAM, and burst ROM (clocked synchronous or asynchronous). The address/data multiplexed I/O (MPX) interface is also available.</li> </ul> </li> <li>Outputs a chip select signal (CS0# to CS5#) according to the target area (CS assert or negate timing can be selected by software).</li> <li>SDRAM refresh <ul style="list-style-type: none"> <li>Auto refresh or self-refresh mode selectable</li> </ul> </li> <li>SDRAM burst access</li> </ul>

Table 1.4 Direct memory access

Feature	Functional description
Direct memory access controller (DMAC)	<ul style="list-style-type: none"> <li>2 unit (8 channels each unit)</li> <li>Transfer modes: Single transfer mode and block transfer mode</li> <li>Transfer size <ul style="list-style-type: none"> <li>Unit 0: 1/2/4/8/16/32/64 bytes</li> <li>Unit 1: 1/2/4/8/16/32 bytes</li> </ul> </li> <li>Activation sources: Software trigger, external DMA requests (DREQ), external interrupts, and interrupt requests from peripheral functions</li> </ul>

Table 1.5 I/O Ports

Feature	Functional description
General-purpose I/O ports	<ul style="list-style-type: none"> <li>225-pin FBGA <ul style="list-style-type: none"> <li>I/O pins: 134</li> <li>Input pins: 1</li> <li>Pull-up/pull-down resistors: 135</li> </ul> </li> <li>121-pin FBGA <ul style="list-style-type: none"> <li>I/O pins: 71</li> <li>Input pins: 0</li> <li>Pull-up/pull-down resistors: 71</li> </ul> </li> <li>The locations of input/output functions are selectable from among multiple pins.</li> </ul>

**Table 1.6 Event link**

Feature	Functional description
Event link controller (ELC)	<ul style="list-style-type: none"> <li>Up to 217 event signals can be interlinked with the operation of modules.</li> <li>In particular, the operation of timer modules can be started by input event signals.</li> <li>Event-linked operation of signals of ports 16 and port 18 is to be possible.</li> </ul>

**Table 1.7 Timers (1 of 2)**

Feature	Functional description
Multi-function timer pulse unit 3 (MTU3)	<ul style="list-style-type: none"> <li>9 channels (16 bits × 8 channels, 32 bits × 1 channel)</li> <li>Maximum of 28 pulse-input/output and 3 pulse-input possible</li> <li>Select from among 10, 11, 12, or 14 counter-input clock signals for each channel (with maximum operating frequency of 200 MHz)</li> <li>Input capture function</li> <li>39 output compare/input capture registers</li> <li>Counter clear operation (synchronous clearing by compare match/input capture)</li> <li>Simultaneous writing to multiple timer counters (TCNT)</li> <li>Simultaneous register input/output by synchronous counter operation</li> <li>Buffered operation</li> <li>Support for cascade-connected operation</li> <li>Automatic transfer of register data</li> <li>Pulse output mode <ul style="list-style-type: none"> <li>Toggle/PWM/complementary PWM/reset-synchronized PWM</li> </ul> </li> <li>Complementary PWM output mode <ul style="list-style-type: none"> <li>Outputs non-overlapping waveforms for controlling 3-phase inverters</li> <li>Automatic specification of dead times</li> <li>PWM duty cycle: Selectable as any value from 0% to 100%</li> <li>Delay can be applied to requests for A/D conversion.</li> <li>Non-generation of interrupt requests at peak or trough values of counters can be selected.</li> <li>Double buffer configuration</li> </ul> </li> <li>Reset synchronous PWM mode <ul style="list-style-type: none"> <li>Three phases of positive and negative PWM waveforms can be output with desired duty cycles.</li> </ul> </li> <li>Phase-counting mode: 16-bit mode (channels 1 and 2), 32-bit mode (channels 1 and 2 in cascade connection)</li> <li>Counter functionality for dead-time compensation</li> <li>Generation of triggers for A/D converter conversion</li> <li>A/D converter start triggers can be skipped</li> <li>Digital noise filter function for signals on the input capture and external counter clock pins</li> <li>Event linking by the ELC</li> </ul>
General PWM timer (GPT)	<ul style="list-style-type: none"> <li>32 bits × 18 channels</li> <li>Counting up or down (saw-wave), counting up and down (triangle-wave) selectable for all channels</li> <li>Select from among four counter-input clock signals for each channel (with maximum operating frequency of 200 MHz)</li> <li>2 input/output pins per channel</li> <li>2 output compare/input capture registers per channel</li> <li>For the 2 output compare/input capture registers of each channel, 4 registers are provided as buffer registers and are capable of operating as comparison registers when buffering is not in use.</li> <li>In output compare operation, buffer switching can be at peaks or troughs, enabling the generation of laterally asymmetrically PWM waveforms.</li> <li>Registers for setting up frame intervals on each channel (with capability for generating interrupts on overflow or underflow)</li> <li>Synchronizable operation of the several counters</li> <li>Modes of synchronized operation (synchronized, or displaced by desired times for phase shifting)</li> <li>Generation of dead times in PWM operation</li> <li>Through combination of 3 counters, generation of automatic 3-phase PWM waveforms incorporating dead times</li> <li>Starting, clearing, stopping, switching, up/down counters, and input capture in response to external or internal triggers</li> <li>Starting, clearing, stopping, switching, up/down counters, and input capture in response to input level comparison</li> <li>Internal trigger sources: software and compare-match</li> <li>Generation of triggers for A/D converter conversion</li> <li>Digital noise filter function for signals on the input capture and external trigger pins</li> <li>Event linking by the ELC</li> </ul>

**Table 1.7 Timers (2 of 2)**

Feature	Functional description
Compare match timer (CMT)	<ul style="list-style-type: none"> <li>• (16 bits × 2 channels) × 3 units</li> <li>• Select from among four counter-input clock signals for each channel (with maximum operating frequency of 50 MHz)</li> </ul>
Compare match timer W (CMTW)	<ul style="list-style-type: none"> <li>• (32 bits × 1 channel) × 2 units</li> <li>• Compare-match, input-capture input, and output-comparison output are available.</li> <li>• Select from among four counter-input clock signals for each channel (with maximum operating frequency of 50 MHz)</li> <li>• Interrupt requests can be output in response to compare-match, input-capture, and output-comparison events.</li> </ul>
Watchdog timer (WDT)	<ul style="list-style-type: none"> <li>• 14 bits × 1 channel</li> <li>• Select from among six counter-input clock signals for each channel (with maximum operating frequency of 50 MHz)</li> </ul>
Port output enable 3 (POE3)	<ul style="list-style-type: none"> <li>• Control of the high-impedance state of the MTU3 waveform output pins</li> <li>• 5 pins for input from signal sources: POE0#, POE4#, POE8#, POE10#, POE11#</li> <li>• Initiation on detection of short-circuited outputs (detection of simultaneous PWM output to the active level)</li> <li>• Initiation by input clock oscillation-stoppage detection, PLL oscillation anomaly detection, DSMIF error detection, or software</li> <li>• Additional programming of output control target pins is enabled</li> </ul>
Port output enable for GPT (POEG)	<ul style="list-style-type: none"> <li>• Controlling the output disable for GPT waveform output</li> <li>• Initiation by input level detection of GTETRQ pins</li> <li>• Initiation by output disable request from GPT</li> <li>• Initiation by detection of oscillation stop, DSMIF error, or by software</li> </ul>
Real time clock (RTC)	<ul style="list-style-type: none"> <li>• A 100 year calendar from 2000 to 2099</li> <li>• BCD code display</li> <li>• Clock source is division of main oscillator or PLL.</li> <li>• Automatic adjustment function for leap years</li> </ul>

**Table 1.8 Communication interfaces (1 of 3)**

Feature	Functional description
Ethernet MAC (GMAC)	<ul style="list-style-type: none"> <li>• 1 port</li> <li>• IEEE802.3</li> <li>• IEEE1588-2008</li> <li>• IEEE802.3-az-2010 for EEE</li> <li>• 10BASE, 100BASE, and 1000BASE supported</li> <li>• Full duplex and half duplex are supported</li> <li>• Programmable frame length to support both standard and jumbo frames up to 16 KB</li> <li>• 17 MAC address registers for the address filter block</li> <li>• Variety of flexible addresses filtering modes are supported</li> <li>• Advanced IEEE 1588-2002 &amp; 2008 Ethernet frame time-stamping supported</li> <li>• MII/RMII/RGMII interface is supported</li> </ul>

**Table 1.8 Communication interfaces (2 of 3)**

Feature	Functional description
Ethernet switch (ETHSW)	<ul style="list-style-type: none"> <li>● 3-port PHY interfaces</li> <li>● IEEE802.3</li> <li>● Support for 10/100/1000 Mbps data transfer</li> <li>● Full and half duplex (full only for 1000BASE)</li> <li>● Hardware switching, lookup, and filtering</li> <li>● QoS with frame prioritization</li> <li>● Priority control based on VLAN Priority (IEEE802.1q), which enables priority reassignment</li> <li>● Classification and priority assignment based on IPv4 DiffServ Code Point Field, IPv6 Class of Service</li> <li>● Queue with eight priority levels</li> <li>● Multicasting and broadcasting</li> <li>● VLAN frame</li> <li>● IEEE 1588-2008 compatible</li> <li>● Programmable addition, removal and manipulation of ingress and egress VLAN tags, supporting single and double-tagged VLAN frames on each port</li> <li>● Cut-through and hub features</li> <li>● Device level ring (DLR)</li> <li>● Programmable egress rate limit per port</li> <li>● Ingress Configurable Broadcast/multicast storm protection per port</li> <li>● IEEE802.1X source address authentication supported</li> <li>● IEEE802.1X guest VLAN supported</li> <li>● PRP functionality (IEC 62439-3 edition 2.0- 2012)</li> <li>● Configurable Time Multiplexed (TDMA) output queue scheduler supporting real-time network infrastructures using time slots for bandwidth reservation enabling deterministic delays</li> <li>● Pattern matchers 12 channels</li> <li>● Independent two timer module are available for timestamping and time for TDMA.</li> <li>● Remote monitoring through SNMP</li> <li>● Powerlink capable hub</li> <li>● Ingress filtering and frame header manipulation (active stream identification, flow metering) with Enhanced Frame Parser</li> <li>● 4 additional PTP timer pulse generators</li> <li>● MAC to MAC connection</li> <li>● MII/RMII/RGMII interface is supported</li> </ul>
EtherCAT slave controller (ESC) <sup>*1</sup>	<ul style="list-style-type: none"> <li>● 1 channel (3 ports)</li> <li>● EtherCAT Slave Controller IP core (made by Beckhoff Automation GmbH) implemented</li> <li>● MII/RMII/RGMII interface is supported by external RGMII converter.</li> </ul>
USB 2.0 HS host/function module	<ul style="list-style-type: none"> <li>● 1 port</li> <li>● Compliance with the USB 2.0 specification</li> <li>● OTG support</li> <li>● Transfer rate <ul style="list-style-type: none"> <li>High speed (480 Mbps), full speed (12 Mbps), low speed (1.5 Mbps, host only)</li> </ul> </li> <li>● Communications buffer <ul style="list-style-type: none"> <li>– Incorporates 1 KB of RAM for host mode</li> <li>– Incorporates 8 KB of RAM for function mode</li> </ul> </li> <li>● DMAC (2 channels) incorporated</li> </ul>
Serial communication interface (SCI)	<ul style="list-style-type: none"> <li>● 6 channels</li> <li>● 5 communication mode <ul style="list-style-type: none"> <li>– Asynchronous interfaces</li> <li>– 8-bit clock synchronous interface</li> <li>– Simple I2C (master-only)</li> <li>– Simple SPI</li> <li>– Smart card interface</li> </ul> </li> <li>● Clock source is select from among four internal clock signals</li> <li>● Bit rate specifiable with the on-chip baud rate generator</li> <li>● Full-duplex and half-duplex communication</li> <li>● Data length: 7 to 9 bits (Asynchronous mode)</li> <li>● Bit rate modulation</li> <li>● Double speed mode</li> <li>● Loopback function to enable self-diagnosis (Asynchronous, Clock synchronous mode)</li> </ul>
I <sup>2</sup> C bus interface (IIC)	<ul style="list-style-type: none"> <li>● 3 channels</li> <li>● Communication formats: I2C bus format or SMBus format</li> <li>● Master or slave mode selectable</li> <li>● Supports the multi-master</li> <li>● Maximum transfer rate: 400 kbps (Standard mode and Fast mode)</li> </ul>

**Table 1.8 Communication interfaces (3 of 3)**

Feature	Functional description
CAN-FD module (CANFD)	<ul style="list-style-type: none"> <li>● 2 channels</li> <li>● Comply with CAN-FD ISO 11898-1 (2015)</li> <li>● Communication speed <ul style="list-style-type: none"> <li>– Classical CAN mode: 1 Mbps</li> <li>– CAN FD mode: <ul style="list-style-type: none"> <li>Nominal bit rate: max. 1 Mbps</li> <li>Data bit rate: max. 8 Mbps</li> </ul> </li> </ul> </li> <li>● Total 192 message buffers (in case frame size is 76 bytes) <ul style="list-style-type: none"> <li>– Individual buffers: 64 for TX</li> <li>– Shared buffers: 128 for TX and RX including FIFO</li> </ul> </li> <li>● Selectable ID type with 11-bit Standard and 18-bit Extended</li> <li>● Selectable Frame type: Data Frame and Remote Frame</li> <li>● Up to 256 receive rules</li> </ul>
Serial peripheral interface (SPI)	<ul style="list-style-type: none"> <li>● 4 channels</li> <li>● SPI transfer facility <ul style="list-style-type: none"> <li>– Using the MOSI (master out slave in), MISO (master in slave out), SSL (slave select), and RSPCK (SPI clock) signals enable serial transfer through SPI operation (four lines) or clock-synchronous operation (three lines)</li> <li>– Capable of handling serial transfer as a master or slave</li> </ul> </li> <li>● Data formats <ul style="list-style-type: none"> <li>– Switching between MSB first and LSB first</li> <li>– The number of bits in each transfer can be changed to any number of bits from 8 to 16, or 20, 24, or 32 bits.</li> <li>– 128-bit buffers for transmission and reception</li> <li>– Up to four frames can be transmitted or received in a single transfer operation (with each frame having up to 32 bits)</li> </ul> </li> <li>● Buffered structure <ul style="list-style-type: none"> <li>– Double buffers for both transmission and reception</li> </ul> </li> <li>● RSPCK can be stopped automatically with the reception buffer full for master reception</li> </ul>
Expanded serial peripheral interface (xSPI)	<ul style="list-style-type: none"> <li>● 2 channels</li> <li>● Comply with JESD251</li> <li>● Multiple slave up to 2 slaves (channel 0 only)</li> <li>● Protocol mode: 1/4/8pin with SDR/DDR 1S-1S-1S, 4S-4D-4D, 8D-8D-8D</li> <li>● Support OctaFlash, OctaRAM, HyperFlash and HyperRAM</li> <li>● Protocol mode: 2/4pin with SDR compatible with QSPI 1S-2S-2S, 2S-2S-2S 1S-4S-4S, 4S-4S-4S</li> <li>● Configurable address length</li> <li>● Configurable initial access latency cycle</li> <li>● Support XiP mode</li> <li>● Support up to 64 MB address space each CS</li> <li>● Prefetch function for burst-read with low latency</li> <li>● Outstanding buffer for burst-write with high throughput</li> <li>● Manual command configurable up to 4 commands</li> <li>● Output clock/input strobe port timing shift</li> <li>● Automatic command after released reset: up to 4 commands</li> </ul>

Note 1. EtherCAT is a registered trademark of Beckhoff Automation GmbH, Germany.

**Table 1.9 Analog**

Feature	Functional description
12-bit A/D converter (ADC12)	<ul style="list-style-type: none"> <li>• 12 bits × 2 units (unit 0: 4 channels, unit 1: 8 channels)</li> <li>• 12-bit resolution</li> <li>• Conversion time 0.84 μs per channel</li> <li>• Operating mode Scan mode (single scan mode, continuous scan mode, or 3 group scan mode) Group priority control</li> <li>• Sample-and-hold function Common sample-and-hold circuit included In addition, channel-dedicated sample-and-hold function (3 channels: in unit 0 only) included</li> <li>• Sampling variable Sampling time can be set up for each channel</li> <li>• Double trigger mode (A/D conversion data duplicated)</li> <li>• Three ways to start A/D conversion Software trigger, timer (MTU3, GPT) trigger, external trigger</li> <li>• Event linking by the ELC</li> </ul>
Temperature sensor unit (TSU)	<ul style="list-style-type: none"> <li>• 1 channel</li> <li>• Relative precision: ±1°C (typ)</li> </ul>

**Table 1.10 Hardware accelerator for industrial interfaces**

Feature	Functional description
ΔΣ interface (DSMIF)	<ul style="list-style-type: none"> <li>• 3 channels × 2 units</li> <li>• Selectable 2 inputs (U/V) or 3 inputs (U/V/W)</li> <li>• Up to 6 ΔΣ modulators are externally connectable</li> <li>• Sinc filter can be selected as first, second or third order</li> </ul>
Trigonometric function unit (TFU)	Calculation of sine, cosine, arctangent, hypot_k ( $\sqrt{x^2 + y^2}/k$ ) <ul style="list-style-type: none"> <li>• Simultaneous calculation of sine and cosine</li> <li>• Simultaneous calculation of arctangent and hypot_k</li> </ul>

**Table 1.11 Safety (1 of 2)**

Feature	Functional description
Memory protection unit (MPU)	<ul style="list-style-type: none"> <li>• Cortex-R52 MPU Two stages MPUs (EL2 and EL1) 24 regions each MPU</li> <li>• Master MPU Memory protection for masters except Cortex-R52 (DMAC, USB, Ethernet MAC, CoreSight, SHOSTIF, PHOSTIF)</li> </ul>
Register write protection function	Protects important registers from being overwritten for in case a program runs out of control.
CRC calculator (CRC)	<ul style="list-style-type: none"> <li>• 2 channels</li> <li>• CRC code generation for arbitrary amounts of data in 8-, 16-, or 32-bit units</li> <li>• Select any of four generating polynomials:               <ul style="list-style-type: none"> <li>– <math>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</math> (32-Ethernet)</li> <li>– <math>X^{32} + X^{28} + X^{27} + X^{26} + X^{25} + X^{23} + X^{22} + X^{20} + X^{19} + X^{18} + X^{14} + X^{13} + X^{11} + X^{10} + X^9 + X^8 + X^6 + 1</math> (CRC-32C)</li> <li>– <math>X^{16} + X^{15} + X^2 + 1</math> (CRC-16)</li> <li>– <math>X^{16} + X^{12} + X^5 + 1</math> (CRC-CCITT)</li> <li>– <math>X^8 + X^2 + X + 1</math> (CRC-8)</li> </ul> </li> </ul>
Clock monitor circuit (CLMA)	<ul style="list-style-type: none"> <li>• Monitors the abnormal output clock frequency from the PLL circuit or low-speed on-chip oscillator.</li> <li>• Input clock oscillation stop detection: Available</li> </ul>
Data operation circuit (DOC)	The function to compare, add, or subtract 16-bit data



**Table 1.11 Safety (2 of 2)**

Feature	Functional description
Isolated peripherals	<ul style="list-style-type: none"> <li>● Safety dedicated peripherals are available: <ul style="list-style-type: none"> <li>– GPT: 4 ch</li> <li>– SCI: 1 ch</li> <li>– IIC: 1 ch</li> <li>– SPI: 1 ch</li> <li>– CRC: 1 unit</li> <li>– RTC: 1 unit</li> <li>– GPIO: Sharable with normal GPIO</li> <li>– On-chip system SRAM with ECC</li> </ul> </li> <li>● They are mapped independently from normal peripherals so that access protection can be done by EL2 MPU.</li> </ul>

**Table 1.12 Security**

Feature	Functional description
Security*1	<ul style="list-style-type: none"> <li>● Secure boot</li> <li>● JTAG authentication</li> <li>● SCI/USB boot authentication</li> <li>● Cryptographic accelerators <ul style="list-style-type: none"> <li>– Symmetric Cipher: AES 128/192/256 bits with CBC/ECB/CTR/GCM/XTS</li> <li>– Asymmetric Cipher: ECC 256 bits, RSA 1024/2048/3072 bits, RSAES-OAEP</li> <li>– Hash: SHA-1, SHA-2</li> <li>– Message authentication: HMAC, CMAC, GMAC</li> <li>– Signature algorithms: ECDSA with NIST P-256, RSASSA-PSS, RSASSA-PKCS1</li> </ul> </li> <li>● TRNG</li> </ul>

Note 1. For details, contact our sales representative.

**Table 1.13 Debug**

Feature	Functional description
Debugging interface	<ul style="list-style-type: none"> <li>● CoreSight architecture designed by Arm</li> <li>● Debugging function by the JTAG/SWD interface, and trace function by the trace port interface</li> </ul>

**Table 1.14 External host interface**

Feature	Functional description
Serial host interface (SHOSTIF)	<ul style="list-style-type: none"> <li>● Serial communication is possible in slave mode.</li> <li>● Supported interface <ul style="list-style-type: none"> <li>– Motorola Serial Peripheral Interface (4-wire SPI)</li> <li>– Enhanced SPI Modes with Dual, Quad, or Octal SPI</li> </ul> </li> <li>● Serial clock polarity switching</li> <li>● Serial clock phase switching</li> <li>● Single Data Transfer</li> <li>● Data size is up to 32 bits × 64 burst</li> </ul>
Parallel host interface (PHOSTIF)	<ul style="list-style-type: none"> <li>● Synchronous/Asynchronous SRAM Interface Mode</li> <li>● Synchronous Burst SRAM Type Transfer Mode</li> <li>● Bus width: 8 or 16 bits</li> <li>● Synchronous relations <ul style="list-style-type: none"> <li>– HCKIO synchronous</li> </ul> </li> <li>● Write buffer</li> <li>● Read buffer</li> <li>● Multiplexing of addresses and data (Synchronous Burst SRAM Type only)</li> </ul>
Mailbox and semaphore (MBXSEM)	<ul style="list-style-type: none"> <li>● Eight semaphores</li> <li>● Four 32-bit mailboxes for both external host CPU to Cortex-R52 and Cortex-R52 to external host CPU</li> <li>● Interrupts can be generated and cleared from both external host CPU and Cortex-R52</li> </ul>

**Table 1.15 Others**

Feature	Functional description
Power supply voltage	VDD = 1.1 V (Core) VCC18 = 1.8 V (PLL, USB, ADC, TSU) VCC33 = 3.3 V (I/O, USB) VCC1833 = 1.8 V or 3.3 V (RGMII/RMII/MII*1, xSPI)
Operating temperature	Tj = -40 to +125°C
Packages	225 pin FBGA 13 × 13 mm, 0.8-mm pitch 121 pin FBGA 10 × 10 mm, 0.8-mm pitch

Note 1. Regarding Ethernet interface, RGMII mode should be set to 1.8 V. RMII and MII modes should be set to 3.3 V.

## 1.2 Function Comparison

**Table 1.16 Comparison of Functions for Different Packages**

Module/Function		225-pin FBGA	121-pin FBGA
CPU	ARM Cortex-R52	Single	
External bus	External bus width	8, 16 bits	Not supported
Interrupt	External interrupt	NMI, IRQ0 to IRQ15	NMI, IRQ0 to IRQ3, IRQ5 to IRQ8, IRQ11 to IRQ13
DMA	DMA controller (DMAC)	2 units (DMAC0: 8 channels, DMAC1: 8 channels)	
Timer	Multi-function timer pulse unit 3 (MTU3)	9 channels	9 channels* <sup>1</sup>
	General PWM timer (GPT)	18 channels	18 channels* <sup>1</sup>
	Compare match timer (CMT)	6 channels	
	Compare match timer W (CMTW)	2 channels	2 channels* <sup>1</sup>
	Watchdog timer	1 channel	
	Port output enable 3 (POE3)	Available	Available* <sup>1</sup>
	Port output enable for GPT (POEG)	Available	Available* <sup>1</sup>
	Real time clock (RTC)	Available	
Communication function	Ethernet MAC (GMAC)	1 port	
	Ethernet switch (ETHSW)	3 ports (PHY interface)	2 ports (PHY interface)
	EtherCAT slave controller (ESC)	3 ports	2 ports
	USB 2.0 HS host/function module (USB)	1 port	Not supported
	Serial communication interface (SCI)	6 channels	5 channels* <sup>1</sup>
	I2C bus interface (IIC)	3 channels	3 channels
	CANFD module (CANFD)	2 channels	2 channels* <sup>1</sup>
	Serial peripheral interface (SPI)	4 channels	2 channels* <sup>1</sup>
	Expanded serial peripheral interface (xSPI)	2 channels (1.8 V or 3.3 V)	1 channel* <sup>1</sup> (3.3 V)
$\Delta\Sigma$ interface (DSMIF)		2 units (DSMIF0: 3 channels, DSMIF1: 3 channels)	2 units (DSMIF0: 2 channels, DSMIF1: 2 channels)
Trigonometric function unit (TFU)		Available	
12-bit A/D converter (ADC12)		2 units (ADC120: 4 channels, ADC121: 8 channels)	Not supported
Temperature sensor unit (TSU)		Available	
CRC calculator (CRC)		2 channels	
Clock monitor circuit (CLMA)		Available	
Data operation circuit (DOC)		Available	
Security* <sup>3</sup>		Optional	
One-time programmable memory (OTP)		Available	
External host interface	Serial host interface (SHOSTIF)	1 channel	1 channel* <sup>2</sup>
	Parallel host interface (PHOSTIF)	1 channel	Not supported
	Mailbox and Semaphore (MBXSEM)	Available	
Event link controller (ELC)		Available	

Note 1. A part of external signals are not available.

Note 2. Up to quad connection

Note 3. For details, contact our sales representative.

### 1.3 Product Lineup

**Table 1.17 Product Lineup**

Group	Part Number	Package	Security
RZ/N2L	R9A07G084M08GBG	PLBG0225GB-A	Available
	R9A07G084M04GBG	PLBG0225GB-A	Not available
	R9A07G084M08GBA	PLBG0121GF-A	Available
	R9A07G084M04GBA	PLBG0121GF-A	Not available

### 1.4 Block Diagram

Figure 1.1 shows a block diagram of the 225-pin device.

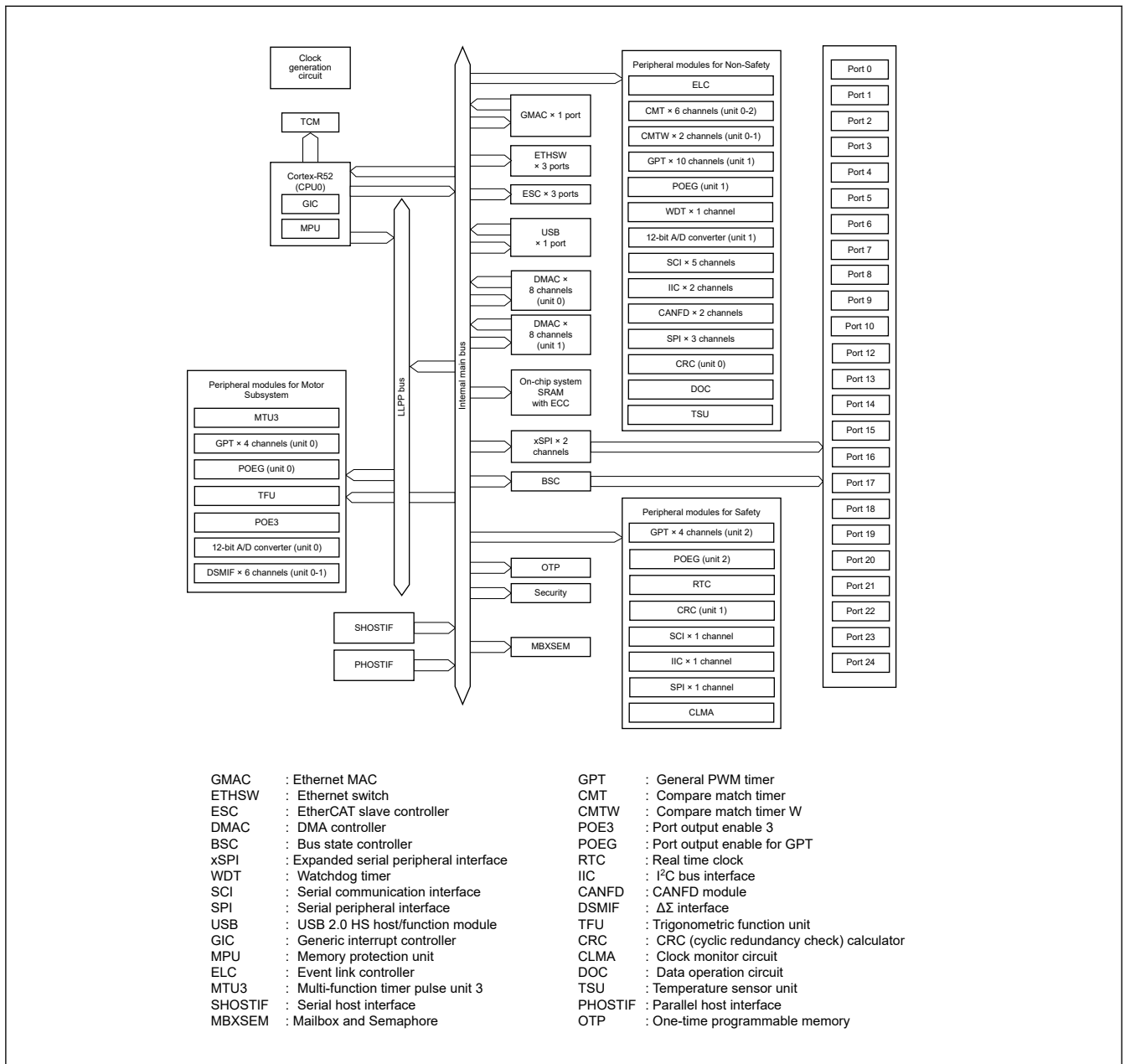


Figure 1.1 Block diagram of a 225-pin device

## 1.5 Pin Functions

Table 1.18 lists the pin functions.

**Table 1.18 Pin functions (1 of 7)**

Classification	Pin name	I/O	Description
Power supply	VDD	Input	Power supply pin. Connect this pin to the system power supply.
	VSS	Input	Ground pin. Connect this pin to the system power supply (0 V).
	VCC1833_0 VCC1833_1 VCC1833_2 VCC1833_3 VCC1833_4	Input	Power supply pin for each I/O domains. (1.8 V or 3.3 V) This pin is available for BGA package product only.
	VCC33	Input	Power supply pin for I/O pins.
	VCC18_PLL0, VCC18_PLL1	Input	Power supply pins for the on-chip PLL oscillator
	AVCC18_TSU	Input	Power supply pin for the temperature sensor unit
	Clock	XTAL	Output
EXTAL		Input	
EXTCLKIN		Input	Inputs the external clock. When a crystal resonator is connected, it should be driven low.
CKIO		Output	Outputs the external bus clock for external devices.
ETH0_REFCLK		Output	Outputs 25 MHz clock for EtherPHY 0
ETH1_REFCLK		Output	Outputs 25 MHz clock for EtherPHY 1
ETH2_REFCLK		Output	Outputs 25 MHz clock for EtherPHY 2
RMII0_REFCLK		Output	Outputs 50 MHz clock for RMII0
RMII1_REFCLK		Output	Outputs 50 MHz clock for RMII1
RMII2_REFCLK		Output	Outputs 50 MHz clock for RMII2
Operating mode control	MDX	Input	This signal should be driven low.
	MD0 to MD2	Input	Input the operating mode select signal. The signal level on these pins must not be changed during operation mode transition on release from the reset state.
	MDV0 to MDV4	Input	Input the operating voltage select signal. The signal level on these pins must not be changed during operation mode transition on release from the reset state.
	MDD	Input	Input the enabling JTAG authentication by hash signal. The signal level on this pin must not be changed during operation mode transition on release from the reset state.
System control	RES#	Input	Inputs the reset signal. This MPU enters the reset state when this signal goes low.
	BSCANP	Input	Inputs the boundary scan enable signal. Boundary scan is enabled when this pin goes high. When boundary scan is not used, this pin should be driven low.
	RSTOUT#	Output	Outputs the reset signal externally

**Table 1.18 Pin functions (2 of 7)**

Classification	Pin name	I/O	Description
Debugging interface	TRST#	Input	Test reset pin for the on-chip emulator
	TMS	I/O	Test mode select pin for the on-chip emulator Functions as the SWDIO pin in serial wire debug (SWD) mode
	TDI	Input	Test data input pin for the on-chip emulator
	TDO	Output	Test data output pin for the on-chip emulator
	TCK	Input	Test clock pin for the on-chip emulator Functions as the SWCLK pin in serial wire debug (SWD) mode
	TRACECLK	Output	Outputs the clock for synchronization with trace data
	TRACECTL	Output	Outputs the enable signal for trace control
	TRACEDATA0 to TRACEDATA7	Output	Output trace data
Bus state controller (BSC)	A25 to A0	Output	Output the address
	D15 to D0	I/O	Input and output the data
	CS0#, CS2#, CS3#, CS5#	Output	Output the chip select signal for the external memory or device.
	RD#	Output	Outputs the strobe signal which indicates a read is in progress.
	RD/WR#	Output	Outputs the strobe signal which indicates a read or write access
	BS#	Output	Outputs the status signal which indicates the start of the bus cycle
	AH#	Output	Outputs the address hold signal for the device that uses the multiplexed I/O interface
	WAIT#	Input	Inputs the external wait control signal which inserts a wait cycle into the bus cycle
	WE0#	Output	Outputs the write strobe signal to D7 to D0
	WE1#	Output	Outputs the write strobe signal to D15 to D8
	DQMLL	Output	Outputs the data mask enable signal to D7 to D0 when SDRAM is connected
	DQMLU	Output	Outputs the data mask enable signal to D15 to D8 when SDRAM is connected
	RAS#	Output	Outputs the row-address strobe signal to the SDRAM. This pin should be connected to the RAS# pin on the SDRAM.
	CAS#	Output	Outputs the column-address strobe signal to the SDRAM. This pin should be connected to the CAS# pin on the SDRAM.
	CKE	Output	Outputs the clock enable signal to the SDRAM. This pin should be connected to the CKE pin on the SDRAM.
Direct memory access controller (DMAC)	DREQ	Input	Inputs the DMA transfer request signal from the external device
	DACK	Output	Outputs the acknowledge signal which indicates acceptance of the DMA transfer request from the external device
	TEND	Output	Outputs the DMA transfer end signal
Interrupt	NMI	Input	Inputs the non-maskable interrupt request signal
	IRQ0 to IRQ15	Input	Input the external interrupt request signal

**Table 1.18 Pin functions (3 of 7)**

Classification	Pin name	I/O	Description
Multi-function timer pulse unit 3 (MTU3)	MTIOC0A, MTIOC0B, MTIOC0C, MTIOC0D	I/O	TGRA0 to TGRD0 input capture input, output compare output, and PWM output pins
	MTIOC1A, MTIOC1B	I/O	TGRA1 and TGRB1 input capture input, output compare output, and PWM output pins
	MTIOC2A, MTIOC2B	I/O	TGRA2 and TGRB2 input capture input, output compare output, and PWM output pins
	MTIOC3A, MTIOC3B, MTIOC3C, MTIOC3D	I/O	TGRA3 to TGRD3 input capture input, output compare output, and PWM output pins
	MTIOC4A, MTIOC4B, MTIOC4C, MTIOC4D	I/O	TGRA4 to TGRD4 input capture input, output compare output, and PWM output pins
	MTIC5U, MTIC5V, MTIC5W	Input	TGRU5, TGRV5, and TGRW5 input capture input and dead time compensation input pins
	MTIOC6A, MTIOC6B, MTIOC6C, MTIOC6D	I/O	TGRA6 to TGRD6 input capture input/output compare output/PWM output pins
	MTIOC7A, MTIOC7B, MTIOC7C, MTIOC7D	I/O	TGRA7 to TGRD7 input capture input/output compare output/PWM output pins
	MTIOC8A, MTIOC8B, MTIOC8C, MTIOC8D	I/O	TGRA8 to TGRD8 input capture input/output compare output/PWM output pins
	MTCLKA, MTCLKB, MTCLKC, MTCLKD	Input	External clock input pins for MTU3
Port output enable 3 (POE3)	POE0#, POE4#, POE8#, POE10#, POE11#	Input	Input the request signal to place the MTU3 in the high-impedance state
General PWM timer (GPT)/ Port output enable for GPT (POEG)	GTETRGA, GTETRGB, GTETRGC, GTETRGD	Input	External trigger input and output-disable request input pins
	GTETRGS A, GTETRGS B	Input	External trigger input and output-disable request input pins (SAFETY)
	GTIOC0A to GTIOC17A, GTIOC0B to GTIOC17B	I/O	Input capture input/output compare output/PWM output pins
	GTADSML0, GTADSML1, GTADSMP0, GTADSMP1	Output	Output pins for monitoring A/D conversion start requests
Compare match timer W (CMTW)	CMTW0_TIC0, CMTW0_TIC1, CMTW1_TIC0, CMTW1_TIC1	Input	CMTW input capture input pins
	CMTW0_TOC0, CMTW0_TOC1, CMTW1_TOC0, CMTW1_TOC1	Output	CMTW output compare output pins
Real time clock (RTC)	RTCAT1HZ	Output	RTC 1 Hz output pin



Table 1.18 Pin functions (4 of 7)

Classification	Pin name	I/O	Description
Serial communication interface (SCI)	SCK0 to SCK5	I/O	Clock I/O pins (clock synchronous mode/simple SPI mode/smart card mode)
	RXD0 to RXD5	Input	Input the receive data (asynchronous mode/clock synchronous mode/smart card mode)
	TXD0 to TXD5	Output	Output the transmit data (asynchronous mode/clock synchronous mode/smart card mode)
	CTS0# to CTS5#	Input	Input the start of transmission (asynchronous mode/clock synchronous mode) active-low
	RTS0# to RTS5#	Output	Output the reception (asynchronous mode/clock synchronous mode) active-low
	SCL0 to SCL5	I/O	Input/output the I2C clocks (simple I2C mode)
	SDA0 to SDA5	I/O	Input/output the I2C data (simple I2C mode)
	MISO0 to MISO5	I/O	Input/output the data for slave transmission (simple SPI mode)
	MOSI0 to MOSI5	I/O	Input/output the data for master transmission (simple SPI mode)
	SS0# to SS5#	Input	Chip-select input pins (simple SPI mode) active-low
	DE0 to DE5	Output	Driver enable output pins (asynchronous mode)
I2C bus interface (IIC)	IIC_SCL0 to IIC_SCL2	I/O	Clock I/O pins
	IIC_SDA0 to IIC_SDA2	I/O	Data I/O pins
Ethernet	ETH0_TXCLK to ETH2_TXCLK	I/O	TX clock input pins (MII mode) TX clock output pins (RGMII mode)
	ETH0_TXD0 to ETH2_TXD0	Output	TX data 0 pins (RGMII, RMII, and MII modes)
	ETH0_TXD1 to ETH2_TXD1	Output	TX data 1 pins (RGMII, RMII, and MII modes)
	ETH0_TXD2 to ETH2_TXD2	Output	TX data 2 pins (RGMII and MII modes)
	ETH0_TXD3 to ETH2_TXD3	Output	TX data 3 pins (RGMII and MII modes)
	ETH0_TXEN to ETH2_TXEN	Output	TX data enable pins (RMII and MII modes) TX data enable/TX data error (TX_CTL) pins (RGMII mode)
	ETH0_TXER to ETH2_TXER	Output	TX data error pins (MII mode)
	ETH0_RXCLK to ETH2_RXCLK	Input	RX clock pins (RGMII, RMII, and MII modes)
	ETH0_RXD0 to ETH2_RXD0	Input	RX data 0 pins (RGMII, RMII, and MII modes)
	ETH0_RXD1 to ETH2_RXD1	Input	RX data 1 pins (RGMII, RMII, and MII modes)
	ETH0_RXD2 to ETH2_RXD2	Input	RX data 2 pins (RGMII and MII modes)
	ETH0_RXD3 to ETH2_RXD3	Input	RX data 3 pins (RGMII and MII modes)
	ETH0_RXDV to ETH2_RXDV	Input	RX data valid pins (MII mode) Carrier sense/RX data valid (CRS_DV) pins (RMII mode) RX data valid/RX error (RX_CTL) pins (RGMII mode)
	ETH0_RXER to ETH2_RXER	Input	RX data error pins (RMII and MII modes)
	ETH0_CRS to ETH2_CRS	Input	Carrier sense pins (MII mode)
ETH0_COL to ETH2_COL	Input	Collision detection pins (MII mode)	
Ethernet MAC (GMAC)	GMAC_PTPTRG0	Input	PTP timer trigger external input 0
	GMAC_PTPTRG1	Input	PTP timer trigger external input 1
	GMAC_MDC	Output	Management data clock output pin
	GMAC_MDIO	I/O	Management data I/O pin

**Table 1.18 Pin functions (5 of 7)**

Classification	Pin name	I/O	Description
Ethernet switch (ETHSW)	ETHSW_LPI0	Output	Port 0 MAC status indicates that it is currently receiving low-power-idle sequences from the PHY
	ETHSW_LPI1	Output	Port 1 MAC status indicates that it is currently receiving low-power-idle sequences from the PHY
	ETHSW_LPI2	Output	Port 2 MAC status indicates that it is currently receiving low-power-idle sequences from the PHY
	ETHSW_PTPOUT0 to ETHSW_PTPOUT3	Output	Ethernet switch timer pulse output pins
	ETHSW_TDMAOUT0 to ETHSW_TDMAOUT3	Output	Ethernet switch TDMA timer output pins
	ETHSW_PHYLINK0 to ETHSW_PHYLINK2	Input	Ethernet switch PHY link status input pins
	ETHSW_MDC	Output	Management data clock output pin
	ETHSW_MDIO	I/O	Management data I/O pin
EtherCAT slave controller (ESC)	ESC_LEDRUN	Output	Outputs the EtherCAT RUN LED signal
	ESC_IRQ	Output	Outputs the EtherCAT IRQ signal
	ESC_LEDSTER	Output	Outputs the EtherCAT Dual-color state LED signal
	ESC_LEDERR	Output	Outputs the EtherCAT error LED signal
	ESC_LINKACT0 to ESC_LINKACT2	Output	Output the EtherCAT link/activity LED signal
	ESC_SYNC0, ESC_SYNC1	Output	Output the EtherCAT SYNC signal
	ESC_LATCH0, ESC_LATCH1	Input	Input the EtherCAT LATCH signal
	ESC_RESETOUT#	Output	Output the EtherCAT reset signal
	ESC_I2CCLK	Output	Outputs the EtherCAT EEPROM I2C clock signal
	ESC_I2CDATA	I/O	Inputs and outputs the EtherCAT EEPROM I2C data signal
	ESC_PHYLINK0 to ESC_PHYLINK2	Input	Inputs the EtherCAT PHY link status signal.
	ESC_MDC	Output	Management data clock output pin
	ESC_MDIO	I/O	Management data I/O pin
USB 2.0 host/function module	VCC33_USB	Input	Power supply input pin for USB
	VCC18_USB	Input	Power supply input pin for USB
	VSS_USB	Input	Ground input pins for USB
	AVCC18_USB	Input	Analog power supply input pin for USB
	USB_RREF	Input	Reference current input pin for USB. Connect this pin to the VSS_USB pin with 1.8 kΩ (±1%).
	USB_DP	I/O	USB bus D+ data I/O pin
	USB_DM	I/O	USB bus D- data I/O pin
	USB_VBUSEN	Output	Outputs the VBUS power enable signal for USB
	USB_OVRCUR	Input	Inputs the overcurrent signal for USB
	USB_VBUSIN	Input	USB cable connection/disconnection detection input pin
	USB_EXICEN	Output	OTG power supply IC control pin
	USB_OTGID	Input	OTG ID pin

**Table 1.18 Pin functions (6 of 7)**

Classification	Pin name	I/O	Description
CANFD module (CANFD)	CANRX0, CANRX1	Input	Receive data input pins
	CANTX0, CANTX1	Output	Transmit data output pins
	CANRXDP0, CANRXDP1	Output	Receive data phase output pins
	CANTXDP0, CANTXDP1	Output	Transmit data phase output pins
Serial peripheral interface (SPI)	SPI_RSPCK0 to SPI_RSPCK3	I/O	Clock I/O pins
	SPI_MOSI0 to SPI_MOSI3	I/O	Master transmit data I/O pins
	SPI_MISO0 to SPI_MISO3	I/O	Slave transmit data I/O pins
	SPI_SSL00 to SPI_SSL30	I/O	Slave select signal I/O pins
Expanded serial peripheral interface (xSPI)	SPI_SSL01 to SPI_SSL31, SPI_SSL02 to SPI_SSL32, SPI_SSL13 to SPI_SSL33	Output	Slave select signal output pins
	XSPI0_CKP, XSPI1_CKP, XSPI0_CKN	Output	Clock output pins
	XSPI0_CS0#, XSPI1_CS0#, XSPI0_CS1#	Output	Chip select output pins
	XSPI0_DS, XSPI1_DS	I/O	Read data strobe/write data mask input/output pin
	XSPI0_IO0 to XSPI0_IO7, XSPI1_IO0 to XSPI1_IO7	I/O	Data0 to Data7 input/output pins
	XSPI0_RESET0#, XSPI0_RESET1#	Output	Master reset status output pins
	XSPI0_RSTO0#, XSPI0_RSTO1#	Input	Slave reset status input pins
	XSPI0_INT0#, XSPI0_INT1#	Input	Interrupt input pins
	XSPI0_ECS0#, XSPI0_ECS1#	Input	Error correction status input pins
XSPI0_WP0#, XSPI0_WP1#	Output	Write protect output pins	
$\Delta\Sigma$ interface (DSMIF)	MCLK0 to MCLK5	I/O	Clock I/O pins
	MDAT0 to MDAT5	Input	Data input pins
12-bit A/D converter (ADC12)	AN000 to AN003, AN100 to AN107	Input	Analog input pins for the A/D converter
	ADTRG0#, ADTRG1#	Input	External trigger input pins for the start of A/D conversion
Serial host interface (SHOSTIF)	HSPI_CK	Input	Clock input pin
	HSPI_CS#	Input	Chip select input pin
	HSPI_IO0 to HSPI_IO7	I/O	Data0 to Data7 input/output pins
	HSPI_INT#	Output	Interrupt output pin

**Table 1.18 Pin functions (7 of 7)**

Classification	Pin name	I/O	Description
Parallel host interface (PHOSTIF)	HCKIO	Input	Bus clock input pin
	HA0 to HA20	Input	Address input pins
	HD0 to HD15	I/O	Data I/O pins
	HCS0#	Input	Chip select input pin supporting burst transfer
	HCS1#	Input	Chip select input pin supporting BSC ADMUX mode
	HRD#	Input	Strobe input pin indicating a read access
	HWAIT#	Output	Output pin indicating that the bus cycle is in wait state
	HWRSTB#	Input	Strobe input pin indicating a write access
	HWR0#	Input	Write strobe/byte enable input pin to HD7 to HD0
	HWR1#	Input	Write strobe/byte enable input pin to HD15 to HD8
	HERROUT#	Output	Outputs the bus access error interrupt signal
	HBS#	Input	Bus cycle input pin
Mailbox and Semaphore (MBXSEM)	MBX_HINT#	Output	Mailbox (Cortex-R52 to Host CPU) interrupt output pin
Analog power supply	VCC18_ADC0, VCC18_ADC1	Input	Analog power supply input pin for the 12-bit A/D converter. Connect this pin to the 1.8 V power supply if the 12-bit A/D converter is not to be used.
	VREFH0, VREFH1	Input	Reference voltage input pin for the 12-bit A/D converter. Connect this pin to the 1.8 V power supply if the 12-bit A/D converter is not to be used.
I/O ports	P00_0 to P24_2	I/O	General-purpose input/output pins

### 1.6 FBGA 225 Pin Assignments

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
A	VSS	P01_0	P00_2	P00_4	P24_0	P22_1	P22_0	P21_3	P20_4	VSS	AN106	AN104	AN103	AN101	VSS	A
B	P01_5	P01_2	P00_3	P00_5	P24_1	P22_3	P21_7	P21_1	P20_1	AN105	AN102	AN100	AN000	AN002	P19_0	B
C	P01_7	P01_3	P00_6	P00_0	P24_2	P22_2	P21_5	P21_2	AN107	VREFH1	VREFH0	AN001	AN003	AVCC18_TSU	P18_6	C
D	P02_1	P01_6	P01_1	P00_7	P00_1	P23_7	P21_6	P20_2	P20_3	VSS	VSS	VSS	P18_5	P18_2	P18_1	D
E	P02_3	TRST#	P02_0	P01_4	VCC1833_2	VCC33	P21_4	VCC33	VCC18_ADC1	VSS	VCC18_ADC0	P18_4	P18_3	P18_0	P17_7	E
F	P02_7	P02_5	P02_2	P02_4	P02_6	VDD	VSS	VDD	VDD	VDD	VCC1833_4	P17_0	P17_4	P17_3	P17_5	F
G	P03_5	BSCANP	P03_0	P03_6	P03_7	VDD	VSS	VSS	VSS	VDD	P16_6	P16_3	P16_0	P16_7	P17_6	G
H	P04_0	P04_1	P04_5	P04_4	P04_6	VDD	VSS	VSS	VSS	VDD	P16_1	P15_6	P15_4	P16_2	P16_5	H
J	P04_7	P05_1	P05_3	P05_2	P05_0	VDD	VSS	VSS	VSS	VDD	VCC1833_3	P14_5	P14_4	P15_5	P15_7	J
K	P05_4	P05_5	P05_6	P06_3	VCC1833_1	VDD	VDD	VDD	VSS	VDD	P15_3	P14_2	P14_6	P15_1	P15_2	K
L	VSS	P06_0	P06_1	P06_6	VCC33	VCC1833_0	P09_7	P10_2	P10_3	P13_2	P15_0	P13_4	P14_0	P14_1	VSS	L
M	P05_7	P06_2	P06_7	P07_3	P08_6	P09_4	P09_6	P10_1	P10_4	VCC33	P13_7	P13_5	P13_6	P14_3	P14_7	M
N	P06_4	P06_5	P07_1	P08_4	P08_7	P09_2	P09_5	P10_0	VCC18_PLL1	VSS	P12_4	P13_3	VSS_USB	VSS	VSS_USB	N
P	P07_0	P07_2	P08_5	P09_0	MDX	RES#	VDD	VSS	VCC18_PLL0	AVCC18_USB	VCC18_USB	VSS_USB	USB_DM	VSS_USB	USB_RREF	P
R	VSS	P07_4	P09_1	P09_3	VSS	EXT_CLKIN	EXTAL	XTAL	VSS	AVCC18_USB	VCC33_USB	VSS_USB	USB_DP	VSS_USB	VSS	R
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

Figure 1.2 Pin arrangement (225-pin FBGA) (top view)

Table 1.19 List of pins and pin functions (225-pin FBGA) (1 of 8)

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTI F, PHOSTIF)
A1	—	VSS	—	—	—	—	—	—	—	—
A2	VCC1833_2	—	P01_0	CAS#	MTIOC4C / GTIOC3A	GMAC_MDIO / ETHSW_MDIO / ESC_MDIO / CTS2#	MCLK1	—	—	—
A3	VCC1833_2	—	P00_2	RD#	MTIC5V	ETH2_TXEN / TXD2 / SDA2 / MOSI2 / USB_OVRCUR	—	—	—	—
A4	VCC1833_2	—	P00_4	WAIT#	MTIOC3A / GTIOC0A	ETH2_RXER	MCLK0	IRQ13	—	HWAIT#
A5	VCC1833_2	—	P24_0	D12 / CKE / DREQ	MTIOC0B / GTETRGB	ETH2_RXD1 / RXD1 / SCL1 / MISO1	MDAT4	—	—	HD12
A6	—	TRACECTL	P22_1	D8	GTETRGB / POE4#	ESC_LINKACT2 / SS4# / CTS4# / RTS4#	—	—	—	HD8
A7	—	TRACEDATA7	P22_0	D7	MTIOC7D / GTIOC17B	DE5	MDAT3	IRQ15	—	HD7
A8	—	TRACEDATA2	P21_3	D2	MTIOC6C / GTIOC15A	TXD5 / SDA5 / MOSI5 / SPI_SSL33	MCLK1	—	—	HD2
A9	—	MDV3	P20_4	—	—	ETHSW_TDMAOUT3 / ETHSW_PTPOUTO / ESC_LINKACT1	—	—	—	—
A10	—	VSS	—	—	—	—	—	—	—	—
A11	—	—	—	—	—	—	—	—	AN106	—
A12	—	—	—	—	—	—	—	—	AN104	—
A13	—	—	—	—	—	—	—	—	AN103	—
A14	—	—	—	—	—	—	—	—	AN101	—

Table 1.19 List of pins and pin functions (225-pin FBGA) (2 of 8)

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTIF, PHOSTIF)
A15	—	VSS	—	—	—	—	—	—	—	—
B1	VCC1833_2	—	P01_5	WE0# / DQMLL	—	ETH2_TXD0	—	—	—	—
B2	VCC1833_2	—	P01_2	CS2#	MTIOC4B / GTIOC2B	ETH2_TXD3	—	IRQ2	—	—
B3	VCC1833_2	—	P00_3	RD/WR#	MTIC5W	ETH2_REFCLK / RMII2_REFCLK / SS2# / CTS2# / RTS2#	—	IRQ1	—	—
B4	VCC1833_2	—	P00_5	CS0#	MTIOC3C / GTIOC0B	ETHSW_PHYLINK2 / ETHSW_PHYLINK0 / ESC_PHYLINK2 / ESC_PHYLINK0	MDAT0	—	—	—
B5	VCC1833_2	—	P24_1	D13 / CAS#	MTIOC0C / GTETRGC / POE8#	ETH2_RXCLK	MCLK5	—	—	HD13
B6	—	—	P22_3	D10	MTIOC8D / GTETRGSB	RXD5 / SCL5 / MISO5	—	—	—	HD10
B7	—	TRACEDATA6	P21_7	D6 / DREQ	MTIOC7C / GTIOC17A	DE0	MCLK3	IRQ10	—	HD6
B8	—	TRACEDATA0	P21_1	D0	MTIOC6A / GTIOC14A / CMTW0_TIC0	ESC_SYNC0 / ESC_SYNC1 / SCK5 / SPI_SSL20 / IIC_SCL1	MCLK0	—	—	HSPL_INT # / HD0
B9	—	MDV0	P20_1	—	—	ETHSW_TDMAOUT0 / ETHSW_PTPOUT3 / ESC_LINKACT0	—	—	—	—
B10	—	—	—	—	—	—	—	—	AN105	—
B11	—	—	—	—	—	—	—	—	AN102	—
B12	—	—	—	—	—	—	—	—	AN100	—
B13	—	—	—	—	—	—	—	—	AN000	—
B14	—	—	—	—	—	—	—	—	AN002	—
B15	VCC1833_4	MDV4	P19_0	—	—	USB_VBUSEN	—	—	—	—
C1	—	TRACEDATA1	P01_7	A19	MTIOC1B / GTIOC9B	ETHSW_LPI1 / SCK1 / SPI_RSPCK3 / CANRX0	—	—	ADTRG0#	HA19
C2	VCC1833_2	—	P01_3	AH#	MTIOC4D / GTIOC3B	ETH2_TXD2	—	—	—	—
C3	VCC1833_2	—	P00_6	CS5#	MTIOC3B / GTIOC1A	ETH2_TXCLK	—	—	—	—
C4	VCC1833_2	—	P00_0	D15	—	ETH2_RXD3 / SCK2 / DE2	—	—	—	HD15
C5	VCC1833_2	—	P24_2	D14 / RAS#	MTIOC0D / GTETRGD	ETH2_RXD2 / TXD1 / SDA1 / MOSI1	MDAT5	—	—	HD14
C6	—	TRACECLK	P22_2	D9	MTIOC8C / GTETRGSB	SPI_SSL12	MCLK1	IRQ4	—	HD9
C7	—	TRACEDATA4	P21_5	D4	MTIOC7A / GTIOC16A / CMTW1_TOC1	CTS5# / SPI_MISO0	MCLK2	IRQ6	ADTRG1#	HD4
C8	—	TRACEDATA1	P21_2	D1	MTIOC6B / GTIOC14B / CMTW0_TIC1	ESC_SYNC0 / ESC_SYNC1 / RXD5 / SCL5 / MISO5 / SPI_MISO2 / IIC_SDA1	MDAT0	—	—	HD1
C9	—	—	—	—	—	—	—	—	AN107	—
C10	—	VREFH1	—	—	—	—	—	—	—	—
C11	—	VREFH0	—	—	—	—	—	—	—	—
C12	—	—	—	—	—	—	—	—	AN001	—
C13	—	—	—	—	—	—	—	—	AN003	—
C14	—	AVCC18_TSU	—	—	—	—	—	—	—	—
C15	VCC1833_4	TRACECLK	P18_6	—	MTIC5W	XSPI1_IO7 / ETH1_COL / SCK4 / DE4 / SPI_MISO2 / IIC_SCL2	—	IRQ11	ADTRG0#	—
D1	—	—	P02_1	A17	—	ETHSW_PTPOUT1 / ESC_SYNC1 / ESC_SYNC0 / DE1	—	—	—	HA17

Table 1.19 List of pins and pin functions (225-pin FBGA) (3 of 8)

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTIF, PHOSTIF)
D2	—	TRACEDATA0	P01_6	A20	MTIOC1A / GTIOC9A	GMAC_PTPTRG1 / ESC_LATCH1 / ESC_LATCH0 / CTS1# / CANTXDP1	—	—	—	HA20
D3	VCC1833_2	—	P01_1	CKE	MTIOC3D / GTIOC1B	GMAC_MDC / ETHSW_MDC / ESC_MDC / DE2	MDAT1	—	—	—
D4	VCC1833_2	—	P00_7	RAS#	MTIOC4A / GTIOC2A	—	—	IRQ13	—	—
D5	VCC1833_2	—	P00_1	A13	MTIC5U	ETH2_RXDV / RXD2 / SCL2 / MISO2	—	IRQ0	—	—
D6	VCC1833_2	—	P23_7	D11 / BS#	MTIOC0A / GTETRGA	ETH2_RXD0 / SCK1	MCLK4	—	—	HD11
D7	—	TRACEDATA5	P21_6	D5 / TEND	MTIOC7B / GTIOC16B	CTS0#	MDAT2	IRQ9	—	HD5
D8	—	MDV1	P20_2	—	—	ETHSW_TDMAOUT1 / ETHSW_PTPOUT2 / ESC_LED RUN / ESC_LEDSTER / DE3	—	—	—	—
D9	—	MDV2	P20_3	—	—	ETHSW_TDMAOUT2 / ETHSW_PTPOUT1 / ESC_LEDERR	—	—	—	—
D10	—	VSS	—	—	—	—	—	—	—	—
D11	—	VSS	—	—	—	—	—	—	—	—
D12	—	VSS	—	—	—	—	—	—	—	—
D13	VCC1833_4	TRACECTL	P18_5	RAS#	MTIC5V	XSPI1_IO6 / ETH2_COL / RXD4 / SCL4 / MISO4 / SPI_MOSI2 / CANRX0	—	—	—	—
D14	VCC1833_4	—	P18_2	BS#	MTIOC4B / MTIOC4D / GTIOC2B / GTIOC3B	XSPI1_CS0# / ETH1_COL / SCK0 / IIC_SDA2	—	—	—	—
D15	VCC1833_4	—	P18_1	WE1# / DQMLU	MTIOC3D / GTIOC1B	SS3# / CTS3# / RTS3#	—	IRQ10	ADTRG1#	HSPI_I07 / HWR1#
E1	—	—	P02_3	A15 / AH#	MTIOC2B / GTIOC10B / POE11#	ETHSW_TDMAOUT1 / SS1# / CTS1# / RTS1# / SPI_SSL30 / CANRX1	—	IRQ15	—	HA15
E2	—	TRST#	—	—	—	—	—	—	—	—
E3	—	TRACEDATA2	P02_0	A18	GTADSMLO	ETHSW_LPI2 / RXD1 / SCL1 / MISO1 / SPI_MISO3 / CANTX1 / USB_OTGID	—	IRQ4	—	HA18
E4	VCC1833_2	—	P01_4	WE1# / DQMLU	POE0#	ETH2_TXD1	—	IRQ3	—	—
E5	VCC1833_2	VCC1833_2	—	—	—	—	—	—	—	—
E6	—	VCC33	—	—	—	—	—	—	—	—
E7	—	TRACEDATA3	P21_4	D3	MTIOC6D / GTIOC15B	ETHSW_PTPOUT1 / ESC_SYNC0 / ESC_SYNC1 / SS5# / CTS5# / RTS5# / SPI_SSL02	MDAT1 / MBX_HI NT#	—	—	HD3
E8	—	VCC33	—	—	—	—	—	—	—	—
E9	—	VCC18_ADC1	—	—	—	—	—	—	—	—
E10	—	VSS	—	—	—	—	—	—	—	—
E11	—	VCC18_ADC0	—	—	—	—	—	—	—	—
E12	VCC1833_4	—	P18_4	CAS#	MTIC5U	XSPI1_IO5 / ETH1_CRS / TXD4 / SDA4 / MOSI4 / SPI_RSPCK2 / CANTX0	—	IRQ1	—	—
E13	VCC1833_4	—	P18_3	CKE	MTIOC4D / MTIOC4B / GTIOC3B / GTIOC2B / CMTW1_TIC1	XSPI1_IO4 / ETH2_CRS / CANRXDP1	—	IRQ0	—	—
E14	VCC1833_4	—	P18_0	WE0# / DQMLL	MTIOC4C / MTIOC4A / GTIOC3A / GTIOC2A	TXD3 / SDA3 / MOSI3	—	—	—	HSPI_I06 / HWR0#

Table 1.19 List of pins and pin functions (225-pin FBGA) (4 of 8)

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTIF, PHOSTIF)
E15	VCC1833_4	—	P17_7	RD# / DACK	MTIOC4A / MTIOC4C / GTIOC2A / GTIOC3A	XSPI1_CKP / RXD3 / SCL3 / MISO3	—	—	—	HRD#
F1	—	TCK	P02_7	—	—	TXD5 / SDA5 / MOSI5	—	—	—	—
F2	—	TDI	P02_5	WE1# / DQMLU	—	ETHSW_TDMAOUT3 / SCK5 / SPI_SSL31	—	—	—	—
F3	—	—	P02_2	A16	MTIOC2A / GTIOC10A / POE10# / RTCAT1HZ	ETHSW_TDMAOUT0 / TXD1 / SDA1 / MOSI1 / SPI_MOSI3 / CANTX0	—	IRQ14	—	HA16
F4	—	TDO	P02_4	WE0# / DQMLL	—	DE1 / SPI_SSL33	—	—	—	—
F5	—	TMS	P02_6	—	—	RXD5 / SCL5 / MISO5	—	—	—	—
F6	—	VDD	—	—	—	—	—	—	—	—
F7	—	VSS	—	—	—	—	—	—	—	—
F8	—	VDD	—	—	—	—	—	—	—	—
F9	—	VDD	—	—	—	—	—	—	—	—
F10	—	VDD	—	—	—	—	—	—	—	—
F11	VCC1833_4	VCC1833_4	—	—	—	—	—	—	—	—
F12	VCC1833_4	MDD	P17_0	—	—	XSPI1_IO1 / ESC_IRQ / SS0# / CTS0# / RTS0#	—	—	—	—
F13	VCC1833_4	TRACECLK	P17_4	DACK	MTIOC3C / GTETRGB / GTIOC0A	XSPI1_IO3 / CTS3# / SPI_SSL32	—	—	—	—
F14	VCC1833_4	TRACECTL	P17_3	DREQ	GTETRGA / POE0#	XSPI1_IO2 / SPI_SSL31	—	—	ADTRG1#	—
F15	VCC1833_4	RSTOUT#	P17_5	TEND	MTIOC3A / GTETRGC / GTIOC0B	USB_OVRCUR	—	—	—	—
G1	—	—	P03_5	A12	MTIOC3A / GTIOC4A	ETH2_CRS / RXD2 / SCL2 / MISO2	MCLK2	IRQ5	—	HA12
G2	—	BSCANP	—	—	—	—	—	—	—	—
G3	—	TRACEDATA3	P03_0	A14 / CS5#	GTADSM1	SCK2 / SPI_SSL32 / CANTXDP1	—	IRQ14	—	HA14
G4	—	TRACEDATA4	P03_6	A11	MTIOC3B / GTIOC4B	ETH2_COL / TXD2 / SDA2 / MOSI2 / SPI_SSL13	MDAT2	IRQ8	—	HA11
G5	—	TRACEDATA5	P03_7	A10	MTIOC3C / GTIOC5A	ETH2_TXER / SCK3	—	IRQ9	—	HA10
G6	—	VDD	—	—	—	—	—	—	—	—
G7	—	VSS	—	—	—	—	—	—	—	—
G8	—	VSS	—	—	—	—	—	—	—	—
G9	—	VSS	—	—	—	—	—	—	—	—
G10	—	VDD	—	—	—	—	—	—	—	—
G11	VCC1833_4	—	P16_6	CS0#	MTIC5V	RXD0 / SCL0 / MISO0	—	IRQ8	—	HSPI_IO5 / HCS0#
G12	VCC1833_3	—	P16_3	CS3#	GTADSM1	XSPI0_RST00# / ETH1_TXER / ETH1_CRS / SCK0 / SPI_SSL30	—	IRQ7	—	HSPI_IO3
G13	VCC1833_3	—	P16_0	—	—	XSPI0_CS1# / ETH0_TXER / ETH2_REFCLK / TXD0 / SDA0 / MOSI0 / SPI_MOSI3	MCLK3	—	—	HSPI_CS#
G14	VCC1833_4	—	P16_7	A13	MTIC5W	XSPI1_IO0 / SCK0	—	—	—	HA13
G15	VCC1833_4	—	P17_6	RD/WR#	MTIOC3B / GTIOC1A	XSPI1_DS / SCK3	—	—	—	HWRSTB#
H1	—	TRACEDATA6	P04_0	A9	MTIOC3D / GTIOC5B	RXD3 / SCL3 / MISO3	—	—	—	HA9
H2	—	—	P04_1	CKIO	—	TXD3 / SDA3 / MOSI3 / SPI_MOSI0 / IIC_SDA2	—	—	—	HCKIO
H3	—	MD0	P04_5	A7	—	ETHSW_PTPOUT0 / ESC_SYNC0 / ESC_SYNC1 / DE3	—	—	—	HA7



Table 1.19 List of pins and pin functions (225-pin FBGA) (5 of 8)

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTIF, PHOSTIF)
H4	—	TRACEDATA7	P04_4	A8	GTADSMP0 / POE10#	CTS3# / SPI_RSPCK1	—	IRQ10	—	HA8
H5	—	MD1	P04_6	A6 / DACK	RTCAT1HZ	ETH1_TXER	—	—	—	HA6
H6	—	VDD	—	—	—	—	—	—	—	—
H7	—	VSS	—	—	—	—	—	—	—	—
H8	—	VSS	—	—	—	—	—	—	—	—
H9	—	VSS	—	—	—	—	—	—	—	—
H10	—	VDD	—	—	—	—	—	—	—	—
H11	VCC1833_3	—	P16_1	CS2#	CMTW0_TOC1	XSPI0_RESET0# / RXD0 / SCL0 / MISO0 / SPI_MISO3	MDAT3	—	ADTRG0#	HCS1#
H12	VCC1833_3	—	P15_6	D14	—	XSPI0_IO7 / SPI_SSL12	MDAT2	—	—	—
H13	VCC1833_3	—	P15_4	D12	MTIOC8D	XSPI0_IO5	MDAT1	—	—	—
H14	VCC1833_3	—	P16_2	—	—	XSPI0_RESET1# / CTS0# / SPI_RSPCK3 / USB_EXICEN	—	NMI	—	HSPI_IO2 / HERROUT#
H15	VCC1833_4	—	P16_5	A15	MTIC5U	TXD0 / SDA0 / MOSI0	—	—	—	HSPI_IO4
J1	—	MD2	P04_7	A5	—	ETH0_TXER / ETH2_TXER / SPI_SSL21	—	—	—	HA5
J2	—	—	P05_1	A3	MTIOC4B / GTIOC6B / CMTW0_TIC1	ETH1_COL / CTS5# / CANRXDP0 / USB_EXICEN	MDAT3	IRQ13	—	HA3
J3	—	—	P05_3	A1	MTIOC4D / GTETRGSB / GTIOC7B / POE11# / CMTW0_TIC0	ETH0_COL / SCK4 / IIC_SDA1 / CANTX0 / USB_EXICEN	—	IRQ15	—	HA1
J4	—	—	P05_2	A2 / DREQ	MTIOC4C / GTETRGSB / GTIOC7A / CMTW0_TOC0	ETH0_CRS / DE5 / IIC_SCL1 / CANRX0 / USB_VBUSEN	—	IRQ14	—	HA2
J5	—	—	P05_0	A4	MTIOC4A / GTIOC6A / CMTW0_TOC0	ETH1_CRS / SS5# / CTS5# / RTS5# / CANTXDP0 / USB_VBUSEN	MCLK3	IRQ12	—	HA4
J6	—	VDD	—	—	—	—	—	—	—	—
J7	—	VSS	—	—	—	—	—	—	—	—
J8	—	VSS	—	—	—	—	—	—	—	—
J9	—	VSS	—	—	—	—	—	—	—	—
J10	—	VDD	—	—	—	—	—	—	—	—
J11	VCC1833_3	VCC1833_3	—	—	—	—	—	—	—	—
J12	VCC1833_3	—	P14_5	CS3#	POE8#	XSPI0_CKN	—	—	—	HSPI_INT#
J13	VCC1833_3	—	P14_4	BS#	MTIOC0B	XSPI0_DS / ESC_IRQ	—	—	—	HBS#
J14	VCC1833_3	—	P15_5	D13	—	XSPI0_IO6	MCLK2	—	—	—
J15	VCC1833_3	—	P15_7	TEND	—	XSPI0_CS0# / CTS5# / SPI_SSL13	—	—	—	—
K1	VCC1833_1	—	P05_4	A0 / DACK	GTIOC14A	ETHSW_LPI0 / RXD4 / SCL4 / MISO4 / SPI_SSL00 / CANTXDP0 / USB_OVRCUR	—	IRQ12	—	HA0
K2	VCC1833_1	—	P05_5	—	GTIOC14B / CMTW0_TOC1	ETHSW_PHYLINK1 / ESC_PHYLINK1 / SPI_RSPCK2	—	—	—	—
K3	VCC1833_1	—	P05_6	—	GTIOC15A / CMTW1_TIC0	ETH1_RXER / SPI_SSL22	—	IRQ12	—	—
K4	VCC1833_1	—	P06_3	D3	GTIOC17B / CMTW1_TIC1	ETH1_TXD0 / DE4 / SPI_MISO1 / CANTXDP1	—	—	—	—
K5	VCC1833_1	VCC1833_1	—	—	—	—	—	—	—	—
K6	—	VDD	—	—	—	—	—	—	—	—

Table 1.19 List of pins and pin functions (225-pin FBGA) (6 of 8)

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTIF, PHOSTIF)
K7	—	VDD	—	—	—	—	—	—	—	—
K8	—	VDD	—	—	—	—	—	—	—	—
K9	—	VSS	—	—	—	—	—	—	—	—
K10	—	VDD	—	—	—	—	—	—	—	—
K11	VCC1833_3	—	P15_3	D11	MTIOC8C	XSPI0_IO4	MCLK1	—	—	—
K12	VCC1833_3	—	P14_2	—	MTIOC8B / GTIOC8B	XSPI0_ECS0# / ETH0_CR5 / ETH2_CR5	—	IRQ6	—	HSPI_CK
K13	VCC1833_3	—	P14_6	A21	—	XSPI0_CKP	—	—	—	—
K14	VCC1833_3	—	P15_1	A24 / CAS#	MTIOC0C	XSPI0_IO2 / TXD5 / SDA5 / MOSI5 / SPI_SSL10	—	—	—	—
K15	VCC1833_3	—	P15_2	A25 / RAS#	MTIOC0D	XSPI0_IO3 / SS5# / CTS5# / RTS5# / SPI_SSL11	—	—	—	—
L1	—	VSS	—	—	—	—	—	—	—	—
L2	VCC1833_1	—	P06_0	D0	GTIOC16A / CMTW1_TOC0	ETH1_TXD3 / SS4# / CTS4# / RTS4# / SPI_SSL23 / CANRX1	—	—	—	—
L3	VCC1833_1	—	P06_1	D1	GTIOC16B	ETH1_REFCLK / RMI11_REFCLK / CTS4# / SPI_SSL22 / CANTX1	—	—	—	—
L4	VCC1833_1	—	P06_6	D6	GTIOC12A	ETH1_RXD0 / SPI_SSL10	—	—	—	—
L5	—	VCC33	—	—	—	—	—	—	—	—
L6	VCC1833_0	VCC1833_0	—	—	—	—	—	—	—	—
L7	VCC1833_0	—	P09_7	—	—	ETH0_TXCLK	—	—	—	—
L8	VCC1833_0	—	P10_2	—	—	ETH0_RXD1	—	—	—	—
L9	VCC1833_0	—	P10_3	—	RTCAT1HZ	ETH0_RXD2	—	—	—	—
L10	—	TRACEDATA6	P13_2	D9 / A13	MTIOC0A / GTIOC10A / POE8#	ETHSW_PTPOUT2 / ESC_I2CCLK / SS1# / CTS1# / RTS1# / SPI_MISO0 / IIC_SCL0	MCLK4	IRQ5	—	—
L11	VCC1833_3	—	P15_0	A23 / CKE	—	XSPI0_IO1 / RXD5 / SCL5 / MISO5 / SPI_MOSI1	—	—	—	—
L12	—	—	P13_4	A0	MTIOC0D / GTIOC8B	ESC_RESETOUT#	—	—	—	—
L13	VCC1833_3	—	P14_0	—	MTCLKD	XSPI0_INT0# / ETHSW_PTPOUT1 / ESC_SYNC1 / ESC_SYNC0	—	—	—	—
L14	VCC1833_3	—	P14_1	—	MTIOC8A / GTIOC8A	XSPI0_INT1# / ETH1_COL / GMAC_PTPTRG1 / ESC_LATCH0 / ESC_LATCH1	—	—	—	HSPI_IO0
L15	—	VSS	—	—	—	—	—	—	—	—
M1	VCC1833_1	—	P05_7	—	GTIOC15B / CMTW1_TOC1	ETH1_TXD2 / TXD4 / SDA4 / MOSI4 / SPI_SSL23	—	—	—	—
M2	VCC1833_1	—	P06_2	D2	GTIOC17A	ETH1_TXD1 / CANRXDP1	—	—	—	—
M3	VCC1833_1	—	P06_7	D7	GTIOC12B	ETH1_RXD1 / SPI_SSL11	—	—	—	—
M4	VCC1833_1	—	P07_3	—	—	ETH1_RXCLK	—	—	—	—
M5	VCC1833_0	—	P08_6	—	MTIOC6C	ETH0_RXCLK	—	—	—	—
M6	VCC1833_0	—	P09_4	—	—	ETH0_TXD2	—	—	—	—
M7	VCC1833_0	—	P09_6	—	—	ETH0_TXD0	—	—	—	—
M8	VCC1833_0	—	P10_1	—	—	ETH0_RXD0	—	—	—	—
M9	VCC1833_0	—	P10_4	—	—	ETHSW_PHYLINK0 / ESC_PHYLINK0	—	IRQ11	—	—
M10	—	VCC33	—	—	—	—	—	—	—	—
M11	VCC1833_3	—	P13_7	—	MTCLKC	XSPI0_ECS1# / GMAC_PTPTRG1 / ESC_LATCH1 / ESC_LATCH0	MBX_HI NT#	—	—	—

Table 1.19 List of pins and pin functions (225-pin FBGA) (7 of 8)

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTIF, PHOSTIF)
M12	VCC1833_3	—	P13_5	—	MTCLKA	XSPI0_WP1# / GMAC_PTPTRG0 / ESC_LATCH0 / ESC_LATCH1 / SPI_RSPCK1 / IIC_SCL2	—	—	—	—
M13	VCC1833_3	—	P13_6	—	MTCLKB	XSPI0_WP0# / ETHSW_PTPOUT0 / ESC_SYNC0 / ESC_SYNC1	—	—	—	—
M14	VCC1833_3	—	P14_3	—	MTIOC0A	XSPI0_RSTO1# / ETH0_COL / ETH2_COL	—	—	—	HSPI_IO1
M15	VCC1833_3	—	P14_7	A22 / BS#	—	XSPI0_IO0 / SCK5 / SPI_MISO1	—	—	—	—
N1	VCC1833_1	—	P06_4	D4	GTIOC11A	ETH1_TXCLK / SPI_MOSI1	—	—	—	—
N2	VCC1833_1	—	P06_5	D5	GTIOC11B	ETH1_TXEN	—	—	—	—
N3	VCC1833_1	—	P07_1	—	GTIOC13B	ETH1_RXD3	—	—	—	—
N4	VCC1833_0	—	P08_4	—	MTIOC6A	ETH0_RXD3	—	—	—	—
N5	VCC1833_0	—	P08_7	—	MTIOC6D	GMAC_MDC / ETHSW_MDC / ESC_MDC	—	—	—	—
N6	VCC1833_0	—	P09_2	—	MTIOC7C	ETH0_RXER	—	IRQ0	—	—
N7	VCC1833_0	—	P09_5	—	—	ETH0_TXD1	—	—	—	—
N8	VCC1833_0	—	P10_0	—	—	ETH0_TXEN	—	—	—	—
N9	—	VCC18_PLL1	—	—	—	—	—	—	—	—
N10	—	VSS	—	—	—	—	—	—	—	—
N11	—	TRACEDATA0	P12_4	D15	MTIOC8B / GTIOC8B	ETH1_CRS / SPI_SSL01	MBX_HI NT#	—	—	—
N12	—	TRACEDATA7	P13_3	D8 / RD#	MTIOC0C / MTIOC0B / GTIOC10B / CMTW1_TOC0	ETHSW_PTPOUT3 / ESC_I2CDATA / CTS1# / SPI_RSPCK0 / IIC_SDA0	MDAT4	—	—	—
N13	—	VSS_USB	—	—	—	—	—	—	—	—
N14	—	VSS	—	—	—	—	—	—	—	—
N15	—	VSS_USB	—	—	—	—	—	—	—	—
P1	VCC1833_1	—	P07_0	—	GTIOC13A	ETH1_RXD2	—	—	—	—
P2	VCC1833_1	—	P07_2	—	—	ETH1_RXDV	—	—	—	—
P3	VCC1833_0	—	P08_5	—	MTIOC6B	ETH0_RXDV	—	—	—	—
P4	VCC1833_0	—	P09_0	—	MTIOC7A	GMAC_MDIO / ETHSW_MDIO / ESC_MDIO	—	—	—	—
P5	—	MDX	—	—	—	—	—	—	—	—
P6	—	RES#	—	—	—	—	—	—	—	—
P7	—	VDD	—	—	—	—	—	—	—	—
P8	—	VSS	—	—	—	—	—	—	—	—
P9	—	VCC18_PLL0	—	—	—	—	—	—	—	—
P10	—	AVCC18_USB	—	—	—	—	—	—	—	—
P11	—	VCC18_USB	—	—	—	—	—	—	—	—
P12	—	VSS_USB	—	—	—	—	—	—	—	—
P13	—	—	—	—	—	USB_DM	—	—	—	—
P14	—	VSS_USB	—	—	—	—	—	—	—	—
P15	—	—	—	—	—	USB_RREF	—	—	—	—
R1	—	VSS	—	—	—	—	—	—	—	—
R2	—	—	P07_4	—	—	USB_VBUSIN	—	IRQ1	ADTRG0#	—
R3	VCC1833_0	—	P09_1	—	MTIOC7B	ETH0_REFCLK / RMII0_REFCLK	—	—	—	—
R4	VCC1833_0	—	P09_3	—	MTIOC7D	ETH0_TXD3	—	—	—	—

**Table 1.19 List of pins and pin functions (225-pin FBGA) (8 of 8)**

Pin number	I/O power domain	Power supply clock system control	I/O port	Bus, DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD, USB)	Others (DSMIF, Mailbox)	Interrupt	ADC12	Host interface (SHOSTIF, PHOSTIF)
R5	—	VSS	—	—	—	—	—	—	—	—
R6	—	EXTCLKIN	—	—	—	—	—	—	—	—
R7	—	EXTAL	—	—	—	—	—	—	—	—
R8	—	XTAL	—	—	—	—	—	—	—	—
R9	—	VSS	—	—	—	—	—	—	—	—
R10	—	AVCC18_USB	—	—	—	—	—	—	—	—
R11	—	VCC33_USB	—	—	—	—	—	—	—	—
R12	—	VSS_USB	—	—	—	—	—	—	—	—
R13	—	—	—	—	—	USB_DP	—	—	—	—
R14	—	VSS_USB	—	—	—	—	—	—	—	—
R15	—	VSS	—	—	—	—	—	—	—	—

### 1.7 FBGA 121 Pin Assignments

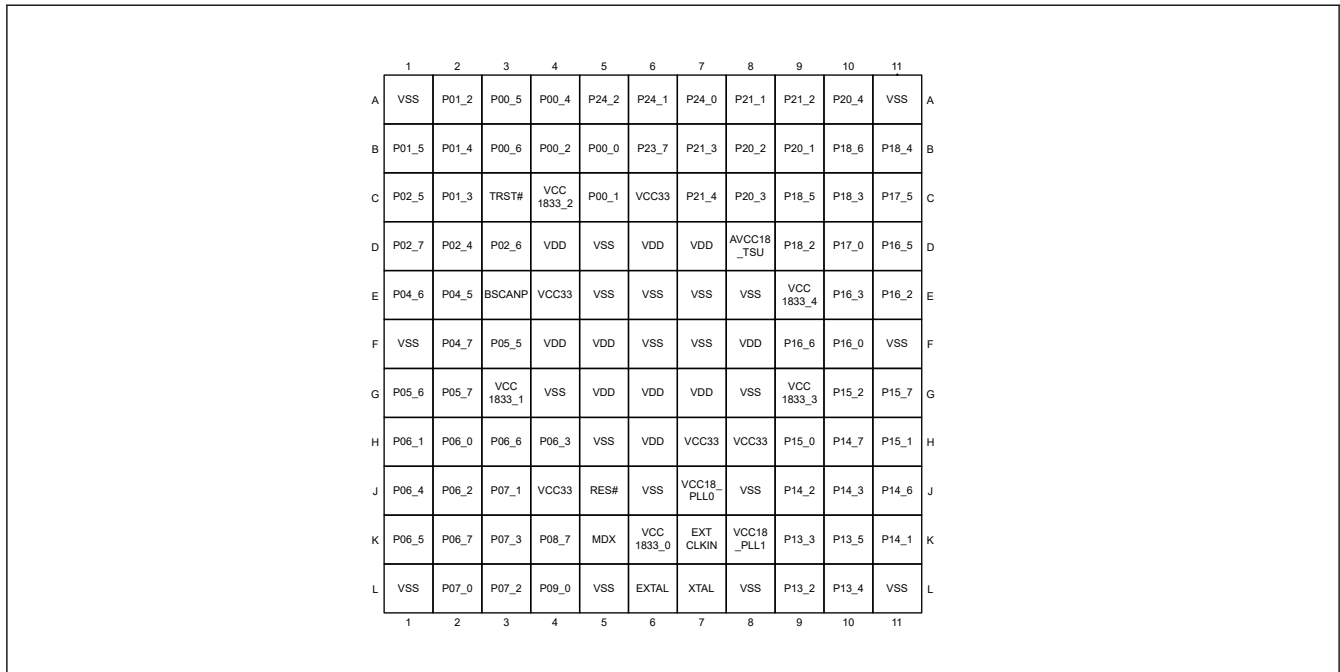


Figure 1.3 Pin arrangement (121-pin FBGA) (top view)

Table 1.20 List of pins and pin functions (121-pin FBGA) (1 of 4)

Pin number	I/O power domain	Power supply clock system control	I/O port	DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD)	Others (DSMIF, Mailbox)	Interrupt	Host interface (SHOSTIF)
A1	—	VSS	—	—	—	—	—	—	
A2	VCC1833_2	—	P01_2	—	MTIOC4B / GTIOC2B	ETH2_TXD3	—	IRQ2	
A3	VCC1833_2	—	P00_5	—	MTIOC3C / GTIOC0B	ETHSW_PHYLINK2 / ETHSW_PHYLINK0 / ESC_PHYLINK0	MDAT0	—	
A4	VCC1833_2	—	P00_4	—	MTIOC3A / GTIOC0A	ETH2_RXER	MCLK0	IRQ13	
A5	VCC1833_2	—	P24_2	—	MTIOC0D / GTETRGRD	ETH2_RXD2 / TXD1 / SDA1 / MOSI1	MDAT5	—	
A6	VCC1833_2	—	P24_1	—	MTIOC0C / GTETRGC / POE8#	ETH2_RXCLK	MCLK5	—	
A7	VCC1833_2	—	P24_0	DREQ	MTIOC0B / GTETRGRB	ETH2_RXD1 / RXD1 / SCL1 / MISO1	MDAT4	—	
A8	—	TRACEDATA0	P21_1	—	MTIOC6A / GTIOC14A / CMTW0_TIC0	ESC_SYNC0 / ESC_SYNC1 / SCK5 / SPI_SSL20 / IIC_SCL1	MCLK0	—	HSPI_INT #
A9	—	TRACEDATA1	P21_2	—	MTIOC6B / GTIOC14B / CMTW0_TIC1	ESC_SYNC0 / ESC_SYNC1 / RXD5 / SCL5 / MISO5 / SPI_MISO2 / IIC_SDA1	MDAT0	—	—
A10	—	MDV3	P20_4	—	—	ETHSW_TDMAOUT3 / ETHSW_PTPOUT0 / ESC_LINKACT1	—	—	—
A11	—	VSS	—	—	—	—	—	—	—
B1	VCC1833_2	—	P01_5	—	—	ETH2_TXD0	—	—	—
B2	VCC1833_2	—	P01_4	—	POE0#	ETH2_TXD1	—	IRQ3	—
B3	VCC1833_2	—	P00_6	—	MTIOC3B / GTIOC1A	ETH2_TXCLK	—	—	—
B4	VCC1833_2	—	P00_2	—	MTIC5V	ETH2_TXEN / TXD2 / SDA2 / MOSI2	—	—	—
B5	VCC1833_2	—	P00_0	—	—	ETH2_RXD3 / SCK2 / DE2	—	—	—
B6	VCC1833_2	—	P23_7	—	MTIOC0A / GTETRGA	ETH2_RXD0 / SCK1	MCLK4	—	—
B7	—	TRACEDATA2	P21_3	—	MTIOC6C / GTIOC15A	TXD5 / SDA5 / MOSI5	MCLK1	—	—

Table 1.20 List of pins and pin functions (121-pin FBGA) (2 of 4)

Pin number	I/O power domain	Power supply clock system control	I/O port	DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD)	Others (DSMIF, Mailbox)	Interrupt	Host interface (SHOSTIF)
B8	—	MDV1	P20_2	—	—	ETHSW_TDMAOUT1 / ETHSW_PTPOUT2 / ESC_LED RUN / ESC_LEDSTER	—	—	—
B9	—	MDV0	P20_1	—	—	ETHSW_TDMAOUT0 / ETHSW_PTPOUT3 / ESC_LINKACT0	—	—	—
B10	VCC1833_4	TRACECLK	P18_6	—	MTIC5W	ETH1_COL / SCK4 / DE4 / SPI_MISO2 / IIC_SCL2	—	IRQ11	—
B11	VCC1833_4	—	P18_4	—	MTIC5U	ETH1_CRS / TXD4 / SDA4 / MOSI4 / SPI_RSPCK2 / CANTX0	—	IRQ1	—
C1	—	TDI	P02_5	—	—	ETHSW_TDMAOUT3 / SCK5	—	—	—
C2	VCC1833_2	—	P01_3	—	MTIOC4D / GTIOC3B	ETH2_TXD2	—	—	—
C3	—	TRST#	—	—	—	—	—	—	—
C4	VCC1833_2	VCC1833_2	—	—	—	—	—	—	—
C5	VCC1833_2	—	P00_1	—	MTIC5U	ETH2_RXDV / RXD2 / SCL2 / MISO2	—	IRQ0	—
C6	—	VCC33	—	—	—	—	—	—	—
C7	—	TRACEDATA3	P21_4	—	MTIOC6D / GTIOC15B	ETHSW_PTPOUT1 / ESC_SYNC0 / ESC_SYNC1 / SS5# / CTS5# / RTS5#	MDAT1 / MBX_HIN T#	—	—
C8	—	MDV2	P20_3	—	—	ETHSW_TDMAOUT2 / ETHSW_PTPOUT1 / ESC_LEDERR	—	—	—
C9	VCC1833_4	TRACECTL	P18_5	—	MTIC5V	ETH2_COL / RXD4 / SCL4 / MISO4 / SPI_MOSI2 / CANRX0	—	—	—
C10	VCC1833_4	—	P18_3	—	MTIOC4D / MTIOC4B / GTIOC3B / GTIOC2B / CMTW1_TIC1	ETH2_CRS / CANRXDP1	—	IRQ0	—
C11	VCC1833_4	RSTOUT#	P17_5	TEND#	MTIOC3A / GTETRGC / GTIOC0B	—	—	—	—
D1	—	TCK	P02_7	—	—	TXD5 / SDA5 / MOSI5	—	—	—
D2	—	TDO	P02_4	—	—	DE1	—	—	—
D3	—	TMS	P02_6	—	—	RXD5 / SCL5 / MISO5	—	—	—
D4	—	VDD	—	—	—	—	—	—	—
D5	—	VSS	—	—	—	—	—	—	—
D6	—	VDD	—	—	—	—	—	—	—
D7	—	VDD	—	—	—	—	—	—	—
D8	—	AVCC18_TSU	—	—	—	—	—	—	—
D9	VCC1833_4	—	P18_2	—	MTIOC4B / MTIOC4D / GTIOC2B / GTIOC3B	ETH1_COL / SCK0 / IIC_SDA2	—	—	—
D10	VCC1833_4	MDD	P17_0	—	—	ESC_IRQ / SS0# / CTS0# / RTS0#	—	—	—
D11	VCC1833_4	—	P16_5	—	MTIC5U	TXD0 / SDA0 / MOSI0	—	—	—
E1	—	MD1	P04_6	DACK#	RTCAT1HZ	ETH1_TXER	—	—	—
E2	—	MD0	P04_5	—	—	ETHSW_PTPOUT0 / ESC_SYNC0 / ESC_SYNC1	—	—	—
E3	—	BSCANP	—	—	—	—	—	—	—
E4	—	VCC33	—	—	—	—	—	—	—
E5	—	VSS	—	—	—	—	—	—	—
E6	—	VSS	—	—	—	—	—	—	—
E7	—	VSS	—	—	—	—	—	—	—
E8	—	VSS	—	—	—	—	—	—	—
E9	VCC1833_4	VCC1833_4	—	—	—	—	—	—	—
E10	VCC1833_3	—	P16_3	—	GTADSM P1	XSPI0_RST00# / ETH1_TXER / ETH1_CRS / SCK0	—	IRQ7	HSPI_I03
E11	VCC1833_3	—	P16_2	—	—	XSPI0_RESET1# / CTS0#	—	NMI	HSPI_I02

Table 1.20 List of pins and pin functions (121-pin FBGA) (3 of 4)

Pin number	I/O power domain	Power supply clock system control	I/O port	DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD)	Others (DSMIF, Mailbox)	Interrupt	Host interface (SHOSTIF)
F1	—	VSS	—	—	—	—	—	—	—
F2	—	MD2	P04_7	—	—	ETH2_TXER / SPI_SSL21	—	—	—
F3	VCC1833_1	—	P05_5	—	GTIOC14B / CMTW0_TOC1	ETHSW_PHYLINK1 / ESC_PHYLINK1 / SPI_RSPCK2	—	—	—
F4	—	VDD	—	—	—	—	—	—	—
F5	—	VDD	—	—	—	—	—	—	—
F6	—	VSS	—	—	—	—	—	—	—
F7	—	VSS	—	—	—	—	—	—	—
F8	—	VDD	—	—	—	—	—	—	—
F9	VCC1833_4	—	P16_6	—	MTIC5V	RXD0 / SCL0 / MISO0	—	IRQ8	—
F10	VCC1833_3	—	P16_0	—	—	XSPI0_CS1# / ETH2_REFCLK / TXD0 / SDA0 / MOSI0	—	—	HSPI_CS#
F11	—	VSS	—	—	—	—	—	—	—
G1	VCC1833_1	—	P05_6	—	GTIOC15A / CMTW1_TIC0	ETH1_RXER / SPI_SSL22	—	IRQ12	—
G2	VCC1833_1	—	P05_7	—	GTIOC15B / CMTW1_TOC1	ETH1_TXD2 / TXD4 / SDA4 / MOSI4 / SPI_SSL23	—	—	—
G3	VCC1833_1	VCC1833_1	—	—	—	—	—	—	—
G4	—	VSS	—	—	—	—	—	—	—
G5	—	VDD	—	—	—	—	—	—	—
G6	—	VDD	—	—	—	—	—	—	—
G7	—	VDD	—	—	—	—	—	—	—
G8	—	VSS	—	—	—	—	—	—	—
G9	VCC1833_3	VCC1833_3	—	—	—	—	—	—	—
G10	VCC1833_3	—	P15_2	—	MTIOC0D	XSPI0_IO3 / SS5# / CTS5# / RTS5# / SPI_SSL11	—	—	—
G11	VCC1833_3	—	P15_7	TEND#	—	XSPI0_CS0# / CTS5# / SPI_SSL13	—	—	—
H1	VCC1833_1	—	P06_1	—	GTIOC16B	ETH1_REFCLK / RMII1_REFCLK / CTS4# / SPI_SSL22 / CANTX1	—	—	—
H2	VCC1833_1	—	P06_0	—	GTIOC16A / CMTW1_TOC0	ETH1_TXD3 / SS4# / CTS4# / RTS4# / SPI_SSL23 / CANRX1	—	—	—
H3	VCC1833_1	—	P06_6	—	GTIOC12A	ETH1_RXD0 / SPI_SSL10	—	—	—
H4	VCC1833_1	—	P06_3	—	GTIOC17B / CMTW1_TIC1	ETH1_TXD0 / DE4 / SPI_MISO1 / CANTXDP1	—	—	—
H5	—	VSS	—	—	—	—	—	—	—
H6	—	VDD	—	—	—	—	—	—	—
H7	—	VCC33	—	—	—	—	—	—	—
H8	—	VCC33	—	—	—	—	—	—	—
H9	VCC1833_3	—	P15_0	—	—	XSPI0_IO1 / RXD5 / SCL5 / MISO5 / SPI_MOSI1	—	—	—
H10	VCC1833_3	—	P14_7	—	—	XSPI0_IO0 / SCK5 / SPI_MISO1	—	—	—
H11	VCC1833_3	—	P15_1	—	MTIOC0C	XSPI0_IO2 / TXD5 / SDA5 / MOSI5 / SPI_SSL10	—	—	—
J1	VCC1833_1	—	P06_4	—	GTIOC11A	ETH1_TXCLK / SPI_MOSI1	—	—	—
J2	VCC1833_1	—	P06_2	—	GTIOC17A	ETH1_TXD1 / CANRXDP1	—	—	—
J3	VCC1833_1	—	P07_1	—	GTIOC13B	ETH1_RXD3	—	—	—
J4	—	VCC33	—	—	—	—	—	—	—
J5	—	RES#	—	—	—	—	—	—	—
J6	—	VSS	—	—	—	—	—	—	—
J7	—	VCC18_PLL0	—	—	—	—	—	—	—
J8	—	VSS	—	—	—	—	—	—	—

**Table 1.20 List of pins and pin functions (121-pin FBGA) (4 of 4)**

Pin number	I/O power domain	Power supply clock system control	I/O port	DMAC	Timer (MTU3, POEG, GPT / POE3, CMTW, RTC)	Communication (xSPI, GMAC, ETHSW, ESC, SCI, SPI, IIC, CANFD)	Others (DSMIF, Mailbox)	Interrupt	Host interface (SHOSTIF)
J9	VCC1833_3	—	P14_2	—	MTIOC8B / GTIOC8B	XSPI0_ECS0 # / ETH2_CRS	—	IRQ6	HSPI_CK
J10	VCC1833_3	—	P14_3	—	MTIOC0A	XSPI0_RST01# / ETH2_COL	—	—	HSPI_I01
J11	VCC1833_3	—	P14_6	—	—	XSPI0_CKP	—	—	—
K1	VCC1833_1	—	P06_5	—	GTIOC11B	ETH1_TXEN	—	—	—
K2	VCC1833_1	—	P06_7	—	GTIOC12B	ETH1_RXD1 / SPI_SSL11	—	—	—
K3	VCC1833_1	—	P07_3	—	—	ETH1_RXCLK	—	—	—
K4	VCC1833_0	—	P08_7	—	MTIOC6D	GMAC_MDC / ETHSW_MDC / ESC_MDC	—	—	—
K5	—	MDX	—	—	—	—	—	—	—
K6	VCC1833_0	VCC1833_0	—	—	—	—	—	—	—
K7	—	EXTCLKIN	—	—	—	—	—	—	—
K8	—	VCC18_PLL1	—	—	—	—	—	—	—
K9	—	—	P13_3	—	MTIOC0C / MTIOC0B / GTIOC10B / CMTW1_TOC0	ETHSW_PTPOUT3 / ESC_I2CDATA / CTS1# / IIC_SDA0	MDAT4	—	—
K10	VCC1833_3	—	P13_5	—	MTCLKA	XSPI0_WP1# / GMAC_PTPTRG0 / ESC_LATCH0 / ESC_LATCH1 / SPI_RSPCK1 / IIC_SCL2	—	—	—
K11	VCC1833_3	—	P14_1	—	MTIOC8A / GTIOC8A	XSPI0_INT1# / ETH1_COL / GMAC_PTPTRG1 / ESC_LATCH0 / ESC_LATCH1	—	—	HSPI_I00
L1	—	VSS	—	—	—	—	—	—	—
L2	VCC1833_1	—	P07_0	—	GTIOC13A	ETH1_RXD2	—	—	—
L3	VCC1833_1	—	P07_2	—	—	ETH1_RXDV	—	—	—
L4	VCC1833_0	—	P09_0	—	MTIOC7A	GMAC_MDIO / ETHSW_MDIO / ESC_MDIO	—	—	—
L5	—	VSS	—	—	—	—	—	—	—
L6	—	EXTAL	—	—	—	—	—	—	—
L7	—	XTAL	—	—	—	—	—	—	—
L8	—	VSS	—	—	—	—	—	—	—
L9	—	—	P13_2	—	MTIOC0A / GTIOC10A / POE8#	ETHSW_PTPOUT2 / ESC_I2CCLK / SS1# / CTS1# / RTS1# / IIC_SCL0	MCLK4	IRQ5	—
L10	—	—	P13_4	—	MTIOC0D / GTIOC8B	ESC_RESETOUT#	—	—	—
L11	—	VSS	—	—	—	—	—	—	—



## 2. Electrical Characteristics

Electrical characteristics of this LSI is defined with the following conditions unless otherwise described.

Conditions:

VDD = 1.05 to 1.15 V

VCC18 = VCC1833\_n (1.8-V mode) = VCC18\_PLL0 = VCC18\_PLL1 = VCC18\_USB = AVCC18\_USB = VCC18\_ADC0 = VCC18\_ADC1 = AVCC18\_TSU = VREFH0 = VREFH1 = 1.70 to 1.95 V

VCC33 = VCC1833\_n (3.3-V mode) = VCC33\_USB = 3.135 to 3.465 V

VSS = VSS\_USB = 0 V

T<sub>j</sub> = -40 to 125°C

### 2.1 Absolute Maximum Ratings

**Table 2.1 Absolute maximum ratings**

Parameter	Symbol	Value	Unit
Power supply voltage (3.3-V mode)	VCC33, VCC1833_0, VCC1833_1, VCC1833_2, VCC1833_3, VCC1833_4	-0.3 to +3.8	V
Power supply voltage (1.8-V mode)	(VCC18) VCC1833_0 VCC1833_1, VCC1833_2, VCC1833_3, VCC1833_4	-0.3 to +2.5	V
Power supply voltage	VDD	-0.3 to +1.5	V
Input voltage	V <sub>in</sub> (3.3-V logic)	-0.3 to VCC33 + 0.3	V
Input voltage	V <sub>in</sub> (1.8-V logic)	-0.3 to VCC18 + 0.3	V
Analog power supply voltage	VCC18_PLL0, VCC18_PLL1, VCC18_USB, AVCC18_USB, VCC18_ADC0, VCC18_ADC1, AVCC18_TSU <sup>1</sup>	-0.3 to smaller value of VCC18 <sup>2</sup> + 0.3 or 2.5	V
	VCC33_USB	-0.3 to smaller value of VCC33 + 0.3 or 3.8	V
Voltage difference between power supply pins	VCC33-VCC18	-2.5 to + 2.1	V
Analog input voltage	VAN	-0.3 to smaller value of VCC18_ADC0/1 + 0.3 or 2.5	V
Reference voltage	VREFH0, VREFH1	-0.3 to smaller value of VCC18_ADC0/1 + 0.3 or 2.5	V
Crystal oscillator pins input voltage	XTAL, EXTAL	-0.3 to +1.5	V
Operating temperature (Junction temperature)	T <sub>j</sub>	-40 to +125	°C
Storage temperature	T <sub>stg</sub>	-55 to +125	°C

Note 1. Connect Analog power supply pins to VCC18 when Analog block(s) are not used. Do not leave these pins open.

Note 2. For convention, "VCC18" virtually represents any 1.8-V power supplies of the chip such as VCC1833\_n in 1.8-V mode.

**Caution: Permanent damage to the LSI might result if absolute maximum ratings are exceeded.**

## 2.2 Power Supply

**Table 2.2 Power supply**

Parameter	Symbol	Value	Min.	Typ.	Max.	Unit
Power supply voltages	VCC33		3.135	—	3.465	V
	VDD		1.05	1.1	1.15	V
	VSS		—	0	—	V
Power supply voltages supporting multi voltage mode	VCC1833_0, VCC1833_1, VCC1833_2, VCC1833_3, VCC1833_4	3.3-V mode	3.135	3.3	3.465	V
		1.8-V mode (VCC18)	1.70	1.8	1.95	V
Analog power supply voltages	VCC18_PLL0		—	VCC18	—	V
	VCC18_PLL1		—	VCC18	—	V
	VCC33_USB		—	VCC33	—	V
	VCC18_USB		—	VCC18	—	V
	AVCC18_USB		—	VCC18	—	V
	VCC18_ADC0		—	VCC18	—	V
	VCC18_ADC1		—	VCC18	—	V
	AVCC18_TSU		—	VCC18	—	V
	VSS_USB		—	0	—	V

## 2.3 Power On/Off Sequence

Power on/off sequence and timing are shown in the figure and table below.

For power-up, 1.1-V and 1.8-V power (i.e. VDD, VCC18, and AVCC) must be supplied first, then 3.3-V power (i.e. VCC33) must be supplied. The power-up sequence must be completed within 100 ms. Reset signal (i.e. RES#) must be held to Low level during the power-up.

For Power-down, 3.3-V power (i.e. VCC33) must go down first and then 1.1-V and 1.8-V power (i.e. VDD, VCC18, and AVCC). The power-down sequence must be completed within 100 ms.

Rise and fall time of each power supply for the power-up and the power-down must be larger than 10  $\mu$ s.

Power supply voltages and reset signal must be applied with monotonic increase.

Do not apply a negative voltage to power supply voltages.

Stable clock must be supplied to EXTAL/XTAL or EXTCLKIN pin when reset signal (i.e. RES#) is driven high.

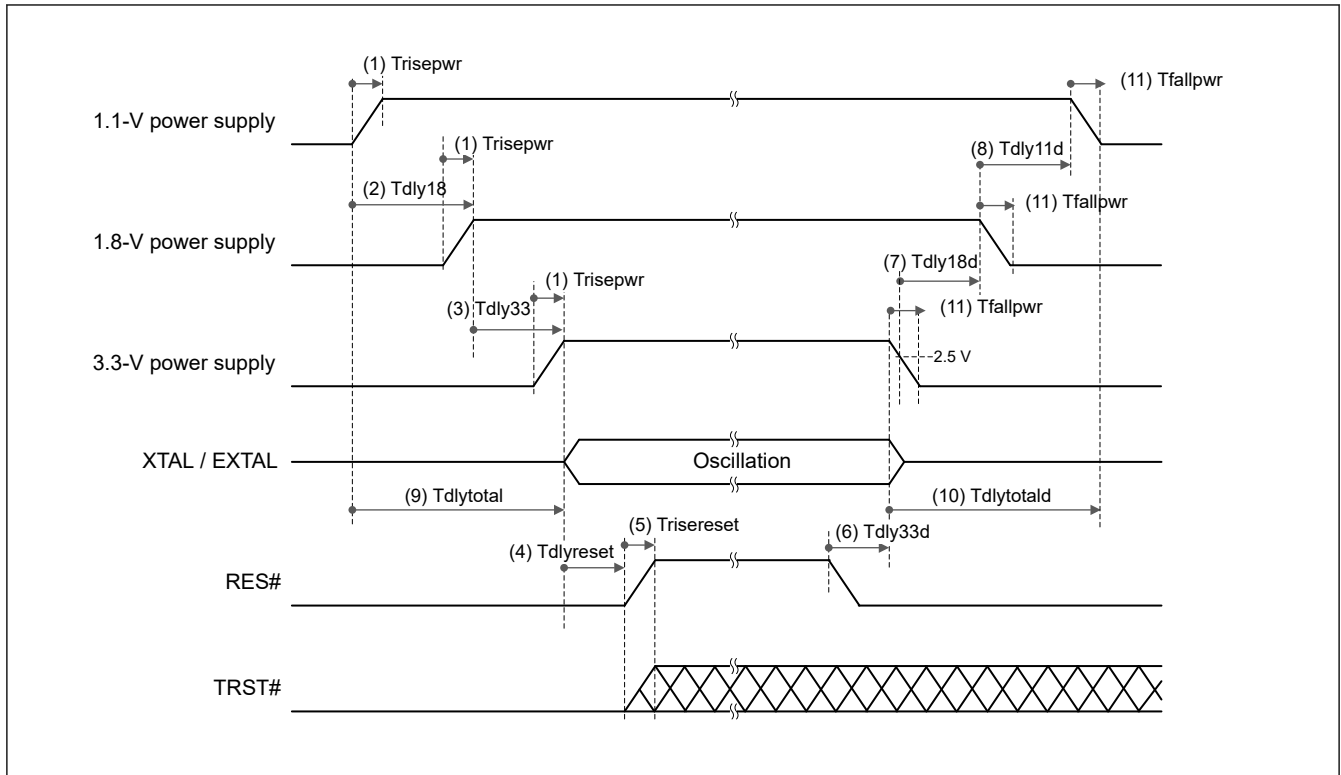


Figure 2.1 Power on/off sequence

Table 2.3 Power on/off sequence timing

No.	Symbol	Description	Value		
			Min.	Typ.	Max.
(1)	Trisepw	Rising time of the power supply voltage	10 $\mu$ s	—	30 ms
(2)	Tdly18	Delay time from start of rising of the 1.1-V power supply voltage to completion of rising of the 1.8-V power supply voltage	0	—	100 ms
(3)	Tdly33	Delay time from completion of rising of the 1.8-V power supply voltage to completion of rising of the 3.3-V power supply voltage	0	—	100 ms
(4)	Tdlyreset	Delay time from completion of rising of the 3.3-V power supply voltage to start of rising of RES# when XTAL/EXTAL is used.	10 ms	—	—
		Delay time from completion of rising of the 3.3-V power supply voltage to start of rising of RES# when EXTCLKIN is used.	1 ms	—	—
(5)	Trisereset	Rising time of RES#	—	—	150 $\mu$ s
(6)	Tdly33d	Delay time from start of falling of RES# to start of falling of the 3.3-V power supply voltage	10 $\mu$ s	—	—
(7)	Tdly18d	Delay time from start of falling time of the 3.3-V power supply voltage to start of falling of the 1.8-V power supply voltage	0	—	100 ms
(8)	Tdly11d	Delay time from start of falling of the 1.8-V power supply voltage to start of falling of the 1.1-V power supply voltage	0	—	100 ms
(9)	Tdlytotal	Startup time of all power supply voltage	—	—	100 ms
(10)	Tdlytotald	Shut down time of all power supply voltage	—	—	100 ms
(11)	Tfallpw	Falling time of the power supply voltage	10 $\mu$ s	—	30 ms

## 2.4 DC Characteristics

Table 2.4 DC Characteristics (3.3-V mode)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input High-level voltage	$V_{IH33}$	3.3-V mode, Schmitt Trigger Control Disabled, Except P07_4 pin	2.0	—	$V_{CC33} + 0.3$	V
Input Low-level voltage	$V_{IL33}$		-0.3	—	0.8	V
Positive trigger voltage	$V_{T33+}$	3.3-V mode, Schmitt Trigger Control Enabled, Except P07_4 pin	0.9	—	2.1	V
Negative trigger voltage	$V_{T33-}$		0.7	—	1.9	V
Hysteresis voltage	$\Delta V_{T33}$		0.2	—	—	V
Input High-level voltage 2	$V_{IH33\_2}$	3.3-V mode, Schmitt Trigger Control Disabled, P07_4 pin ONLY	$V_{CC33} \times 0.7$	—	$V_{CC33} + 0.3$	V
Input Low-level voltage 2	$V_{IL33\_2}$		-0.3	—	$V_{CC33} \times 0.3$	V
Positive trigger voltage 2	$V_{T33+\_2}$	3.3-V mode, Schmitt Trigger Control Enabled, P07_4 pin ONLY	—	—	$V_{CC33} \times 0.72$	V
Negative trigger voltage 2	$V_{T33-\_2}$		$V_{CC33} \times 0.3$	—	—	V
Hysteresis voltage 2	$\Delta V_{T33\_2}$		$V_{CC33} \times 0.1$	—	—	V
Output High-level voltage	$V_{OH33}$	Low, IOH = -2 mA	$V_{CC33} - 0.4$	—	—	V
	$V_{OH33}$	Middle, IOH = -4 mA	$V_{CC33} - 0.4$	—	—	V
	$V_{OH33}$	High, IOH = -8 mA	$V_{CC33} - 0.4$	—	—	V
	$V_{OH33}$	Ultra High, IOH = -12 mA	$V_{CC33} - 0.4$	—	—	V
Output Low-level voltage	$V_{OL33}$	Low, IOL = 2 mA	—	—	0.4	V
	$V_{OL33}$	Middle, IOL = 4 mA	—	—	0.4	V
	$V_{OL33}$	High, IOL = 8 mA	—	—	0.4	V
	$V_{OL33}$	Ultra High, IOL = 12 mA	—	—	0.4	V
Input leakage current	$ I_{in} $	$V_{in} = 0\text{ V}, V_{in} = V_{CC33}$	—	—	10	$\mu\text{A}$
Three-State leakage current (off state)	$ I_{TS} $	$V_{in} = 0\text{ V}, V_{in} = V_{CC33}$	—	—	10	$\mu\text{A}$
Input Pull-up resistors resistance	$R_{pu}$	$V_{in} = 0\text{ V}$	15	—	300	k $\Omega$
Input Pull-up resistors current	$I_{pu}$	$V_{in} = 0\text{ V}$	-220	—	-11	$\mu\text{A}$
Input Pull-down resistors resistance	$R_{pd}$	$V_{in} = V_{CC33}$	15	—	300	k $\Omega$
Input Pull-down resistors current	$I_{pd}$	$V_{in} = V_{CC33}$	11	—	220	$\mu\text{A}$
Input Capacitance	$C_{in}$	All input/output and input pins	—	—	10	pF

Table 2.5 DC Characteristics (1.8-V mode) (1 of 2)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input High-level voltage	$V_{IH18}$	1.8-V mode, Schmitt Trigger Control Disabled	$V_{CC18} \times 0.65$	—	$V_{CC18} + 0.3$	V
Input Low-level voltage	$V_{IL18}$		-0.3	—	$V_{CC18} \times 0.35$	V
Positive trigger voltage	$V_{T18+}$	1.8-V mode, Schmitt Trigger Control Enabled	$V_{CC18} \times 0.4$	—	$V_{CC18} \times 0.7$	V
Negative trigger voltage	$V_{T18-}$		$V_{CC18} \times 0.3$	—	$V_{CC18} \times 0.6$	V
Hysteresis voltage	$\Delta V_{T18}$		$V_{CC18} \times 0.1$	—	—	V
Output High-level voltage	$V_{OH18}$	Low, IOH = -2 mA	$V_{CC18} - 0.45$	—	—	V
	$V_{OH18}$	Middle, IOH = -4 mA	$V_{CC18} - 0.45$	—	—	V
	$V_{OH18}$	High, IOH = -8 mA	$V_{CC18} - 0.45$	—	—	V
	$V_{OH18}$	Ultra High, IOH = -12 mA	$V_{CC18} - 0.45$	—	—	V

**Table 2.5 DC Characteristics (1.8-V mode) (2 of 2)**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Output Low-level voltage	$V_{OL18}$	Low, IOL = 2 mA	—	—	0.45	V
	$V_{OL18}$	Middle, IOL = 4 mA	—	—	0.45	V
	$V_{OL18}$	High, IOL = 8 mA	—	—	0.45	V
	$V_{OL18}$	Ultra High, IOL = 12 mA	—	—	0.45	V
Input leakage current	$ I_{in} $	$V_{in} = 0\text{ V}$ , $V_{in} = V_{CC18}$	—	—	10	$\mu\text{A}$
Three-State leakage current (off state)	$ I_{TSI} $	$V_{in} = 0\text{ V}$ , $V_{in} = V_{CC18}$	—	—	10	$\mu\text{A}$
Input Pull-up resistors resistance	$R_{pu}$	$V_{in} = 0\text{ V}$	15	—	300	$\text{k}\Omega$
Input Pull-up resistors current	$I_{pu}$	$V_{in} = 0\text{ V}$	-120	—	-6	$\mu\text{A}$
Input Pull-down resistors resistance	$R_{pd}$	$V_{in} = V_{CC18}$	15	—	300	$\text{k}\Omega$
Input Pull-down resistors current	$I_{pd}$	$V_{in} = V_{CC18}$	6	—	120	$\mu\text{A}$
Input Capacitance	$C_{in}$	All input/output and input pins	—	—	10	pF

**Table 2.6 USB2.0 USB\_RREF Pin**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Reference resistor*1	$R_{REF}$	—	—	1.8 ( $\pm 1\%$ )	—	$\text{k}\Omega$

Note 1. The reference resistor connected to the USB\_RREF pin is for external connection to this LSI.

**Table 2.7 USB2.0 Pull-Up/Pull-Down Resistors**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
USB_DP pull-up resistor (when the function controller is selected)	$R_{PU}$	Idle	0.900	—	1.575	$\text{k}\Omega$
		Transmission/reception	1.425	—	3.090	$\text{k}\Omega$
USB_DP/USB_DM pull-down resistors (when the host controller is selected)	$R_{PD}$	—	14.25	—	24.80	$\text{k}\Omega$

**Table 2.8 USB2.0 Host/Function-Related Pins (Low/Full Speed)**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input high level voltage	$V_{FSIH}$	—	2.0	—	—	V
Input low level voltage	$V_{FSIL}$	—	—	—	0.8	V
Differential input sensitivity	$V_{FSDI}$	$ (USB\_DP) - (USB\_DM) $	0.2	—	—	V
Differential common mode range	$V_{FSCM}$	—	0.8	—	2.5	V
Output low level voltage	$V_{FSOL}$	IFSOL = 2 mA	0.0	—	0.3	V
Output high level voltage	$V_{FSOH}$	IFSOH = -200 $\mu\text{A}$	2.8	—	3.6	V
Output signal crossover voltage	$V_{FSCRS}$	—	1.3	—	2.0	V

**Table 2.9 USB2.0 Host/Function-Related Pins (High Speed) (1 of 2)**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Squelch detection threshold voltage (differential voltage)	$V_{HSSQ}$	—	100	—	150	mV
Disconnection detection threshold voltage (differential voltage)	$V_{HSDSC}$	—	525	—	625	mV
Common mode voltage range	$V_{HSCM}$	—	-50	—	500	mV
Idle state	$V_{HSOI}$	—	-10.0	—	10.0	mV
Output high level voltage	$V_{HSOH}$	—	360	—	440	mV

**Table 2.9 USB2.0 Host/Function-Related Pins (High Speed) (2 of 2)**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Output low level voltage	$V_{HSOL}$	—	-10.0	—	10.0	mV
Chirp J output voltage (differential)	$V_{CHIRPJ}$	—	700	—	1100	mV
Chirp K output voltage (differential)	$V_{CHIRPK}$	—	-900	—	-500	mV

**Table 2.10 Supply Current**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Normal operation	$I_{VDD}$	ICLK = 200 MHz, CPU0CLK = 400 MHz, $T_J \leq 110^\circ\text{C}$	—	—	310	mA
	$I_{VCC33}$	*1	—	25	—	mA
	$I_{VCC1833\_0}$	*1	—	9	—	mA
	$I_{VCC1833\_1}$	*1	—	9	—	mA
	$I_{VCC1833\_2}$	*1	—	9	—	mA
	$I_{VCC1833\_3}$	*1	—	9	—	mA
	$I_{VCC1833\_4}$	*1	—	9	—	mA
	$I_{VCC18\_PLL0}$	—	—	—	6	mA
	$I_{VCC18\_PLL1}$	—	—	—	6	mA
	$I_{VCC18\_USB}$	—	—	—	39	mA
	$I_{VCC18\_ADC0}$	—	—	—	3	mA
	$I_{VCC18\_ADC1}$	—	—	—	3	mA
	$I_{VCC18\_TSU}$	—	—	—	2	mA
	$I_{VCC33\_USB}$	—	—	—	6	mA
Low power consumption mode*2	$I_{VDD}$	All modules inactive	—	6	—	mA
	$I_{VCC33}$	—	—	6	—	mA
	$I_{VCC1833\_0}$	—	—	2	—	mA
	$I_{VCC1833\_1}$	—	—	2	—	mA
	$I_{VCC1833\_2}$	—	—	2	—	mA
	$I_{VCC1833\_3}$	—	—	2	—	mA
	$I_{VCC1833\_4}$	—	—	2	—	mA
	$I_{VCC18\_PLL0}$	—	—	3.5	—	mA
	$I_{VCC18\_PLL1}$	—	—	0.1	—	mA
	$I_{VCC18\_USB}$	—	—	0.5	—	mA
	$I_{VCC18\_ADC0}$	—	—	0.2	—	mA
	$I_{VCC18\_ADC1}$	—	—	0.2	—	mA
	$I_{VCC18\_TSU}$	—	—	0.1	—	mA
	$I_{VCC33\_USB}$	—	—	0.3	—	mA

Note: These values are reference values. The actual operating current greatly depends on the system (such as unsharpened waveforms due to I/O load and toggle frequency). Be sure to measure these current values in the system.

Note 1. IO supply current ( $I_{VCC33}$ ,  $I_{VCC1833\_n}$  (n = 0 to 4)) should be 80 mA or less. ( $\Sigma I_{OH}$  in Table 2.11)

Note 2. All applicable modules are stopped or standby mode with the lowest clock frequency setting, no pull-up/down or operation for all I/O ports, and room temperature.

**Table 2.11 Permissible Output Currents**

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Permissible output low current (max. value per pin)	IOL	All output pins	—	—	12	mA
Permissible output low current (total)	ΣIOL	Sum of all output pins	—	—	80	mA
Permissible output high current (max. value per pin)	IOH	All output pins	—	—	-12	mA
Permissible output high current (total)	ΣIOH	Sum of all output pins	—	—	-80	mA

Note: All output current values shall be within the values in this table to ensure the reliability of this LSI.

**Table 2.12 Thermal Resistance value (Reference)**

Item	Symbol	Package	Max.	Unit
Thermal Resistance	Θja	225 pin FBGA 13 × 13 mm, 0.8-mm pitch	30.1	°C/W
		121 pin FBGA 10 × 10 mm, 0.8-mm pitch	30.5	°C/W
	Ψjt	225 pin FBGA 13 × 13 mm, 0.8-mm pitch	0.42	°C/W
		121 pin FBGA 10 × 10 mm, 0.8-mm pitch	0.42	°C/W

Note: Package thermal resistance values above are based on EIA/JESD51-9 (2s2p) condition and reference only.

## 2.5 AC Characteristics

**Table 2.13 Operating frequency**

Parameter		Symbol	Min.	Max.	Unit
Operating frequency	CPU clock (CPU0CLK)	f	150 200	300 400	MHz
	System clock (ICLK)		150	200	
	Peripheral module clock H (PCLKH)		150	200	
	Peripheral module clock M (PCLKM)		75	100	
	Peripheral module clock L (PCLKL)		37.5	50	
	Peripheral module clock for ADC (PCLKADC)		18.75	25	
	Peripheral module clock for SCIn (PCLKSCIn, n = 0 to 5)		75	100	
	Peripheral module clock for SPIn (PCLKSPIn, n = 0 to 3)		75	100	
	External bus clock output (CKIO)		18.75	100	
	Ethernet PHY reference clock (ETHn_REFCLK, n = 0 to 2)		25		
	Ethernet PHY reference clock (RMIn_REFCLK, n = 0 to 2)		50		

AC Characteristics are defined in condition of the IO setting (DRCTLm register setting) show in [Table 2.14](#).

**Table 2.14 IO setting (DRCTLm register setting) condition (1 of 2)**

Module	Signal		IO type	Voltage	DRCTLm register		
					DRVn	SRn	SMTn
Bus	CKIO	SDRAM and High drive	—	3.3 V	High	Fast	—
		Other than the above	—	3.3 V	Middle	Fast	—
	Other than the above		Type A	3.3 V	Middle	Slow	Disable
			Type B	3.3 V	Low	Slow	Disable
DMAC, MTU3, IIC, CANFD, DSMIF	All signals		Type A	3.3 V	Middle	Slow	Disable
			Type B	3.3 V	Low	Slow	Disable

**Table 2.14 IO setting (DRCTLm register setting) condition (2 of 2)**

Module	Signal	IO type	Voltage	DRCTLm register		
				DRVn	SRn	SMTn
GPT (n = 0 to 17) (m = 0, 1)	GTIOCnA, GTIOCnB	Type A	3.3 V	Middle	Slow	Disable
		Type B	3.3 V	Low	Slow	Disable
	GTADSMLm, GTADSMPm	—	3.3 V	Low	Slow	Disable
SCI, SPI	All signals	—	3.3 V	High	Fast	Disable
xSPI (n = 0, 1; m = 0, 1)	XSPIn_CKP, XSPIn_CKN, XSPIn_IO[7:0], XSPIn_CSm#, XSPIn_DS	—	1.8 V	High	Fast	Disable
		—	3.3 V	High	Fast	Enable
	Other than the above	—	—	Low	Slow	Disable
Ethernet Interface (n = 0 to 2)	ETHn_TXCLK, ETHn_TXD[3:0]	—	1.8 V/3.3 V	High	Fast	Disable
	ETHn_TXER	—	3.3 V	Middle	Fast	—
	ETHn_RXCLK, ETHn_RXD[3:0]	—	1.8 V/3.3 V	—	—	Disable
	ETHn_RXER, ETHn_COL, ETHn_CRS	—	3.3 V	—	—	Disable
	ETHn_REFCLK, RMIIIn_REFCLK	—	3.3 V	High	Fast	—
	Other than the above	—	—	Low	Slow	Disable
SHOSTIF	HSPI_CK, HSPI_CS#, HSPI_IO[7:0]	—	1.8 V/3.3 V	High	Fast	Disable
	HSPI_INT#	—	1.8 V/3.3 V	Low	Slow	Disable
PHOSTIF	All signals	Type A	3.3 V	Middle	Slow	Disable
		Type B	3.3 V	Low	Slow	Disable
Debug Interface	TRACECLK, TRACECTL, TRACEDATA[7:0], TDO, TMS	—	3.3 V	High	Fast	Disable
	Other than the above	—	—	Low	Slow	Disable
Other than the above		—	—	Low	Slow	Disable

## 2.5.1 Clock Timing

### 2.5.1.1 CKIO Pin Output Timing

**Table 2.15 CKIO pin output timing**

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
CKIO pin output cycle time	$t_{CKcyc}$	Figure 2.2	10	—	53.4	ns
CKIO pin output high level pulse width	$t_{CKH}$		$t_{CKcyc} / 2 - t_{CKr}$	—	—	ns
CKIO pin output low level pulse width	$t_{CKL}$		$t_{CKcyc} / 2 - t_{CKf}$	—	—	ns
CKIO pin output rising time 1	$t_{CKr}$	CKIO: High drive output Setting	—	—	3.8	ns
CKIO pin output falling time 1	$t_{CKf}$		—	—	3.8	ns
CKIO pin output rising time 2	$t_{CKr}$	CKIO: Normal output setting	—	—	9	ns
CKIO pin output falling time 2	$t_{CKf}$		—	—	9	ns



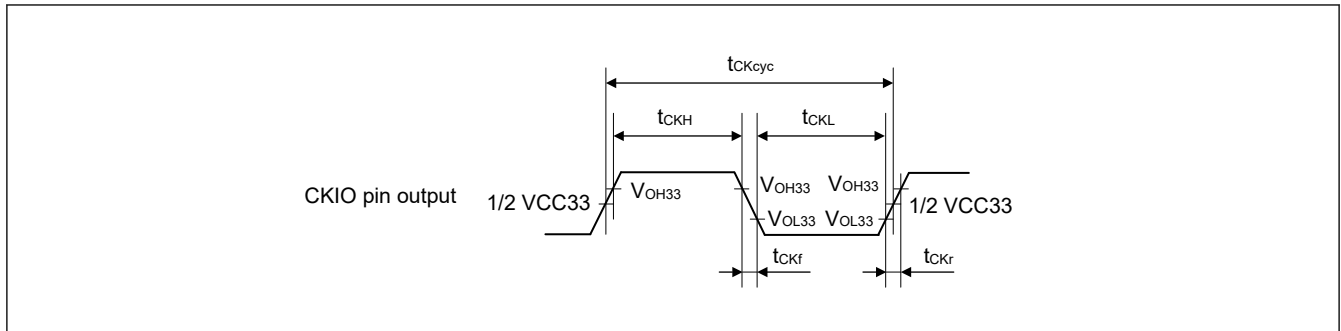


Figure 2.2 CKIO pin output timing

### 2.5.1.2 Ethernet PHY Reference Clock Output Timing

Conditions:

$C = 30 \text{ pF}$  (ETHn\_REFCLK)

$C = 20 \text{ pF}$  (RMIIIn\_REFCLK)

Table 2.16 Ethernet PHY reference clock output timing

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
ETHn_REFCLK cycle time	$t_{CK}$	Figure 2.3	40	—	—	ns
ETHn_REFCLK frequency	—		25.00 ± 50 ppm			MHz
ETHn_REFCLK duty	—		45	—	55	%
ETHn_REFCLK rising/falling time	$t_{CKr} / t_{CKf}$		0.5	—	4.0	ns
RMIIIn_REFCLK cycle time	$t_{CK}$		20	—	—	ns
RMIIIn_REFCLK frequency	—		50.00 ± 50 ppm			MHz
RMIIIn_REFCLK duty	—		45	—	55	%
RMIIIn_REFCLK rising/falling time	$t_{CKr} / t_{CKf}$		0.5	—	3.5	ns

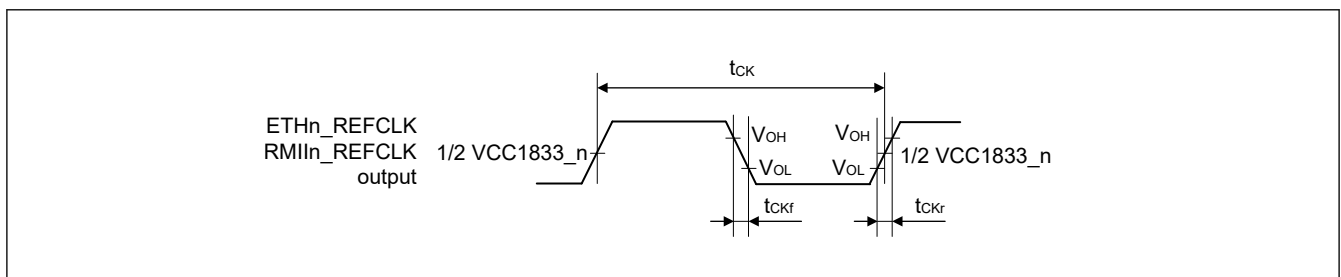


Figure 2.3 Ethernet PHY reference clock output timing

### 2.5.1.3 EXTCLKIN External Clock Input

Table 2.17 EXTCLKIN clock timing

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
EXTCLKIN external clock frequency	$f_{EXTCLKIN}$	—	25.00 ± 50 ppm			MHz
		EtherCAT in use	25.00 ± 25 ppm			MHz
EXTCLKIN duty	$\Gamma_{EXTCLKIN}$	—	±5%			—
EXTCLKIN rising time	$t_{EXTCLKIN}$	—	0	—	5	ns
EXTCLKIN falling time	$t_{EXTCLKIN}$	—	0	—	5	ns

Note: When using crystal resonator (i.e. EXTA/XTAL clock is used), EXTCLKIN should be driven low.

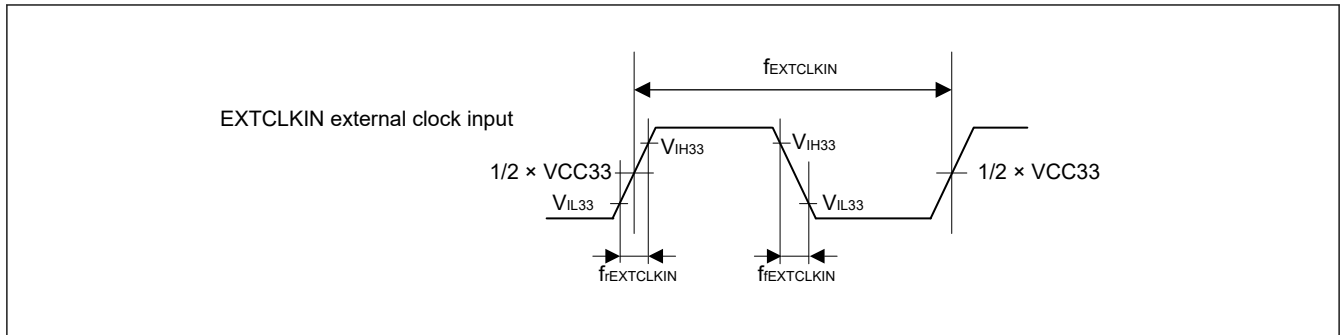


Figure 2.4 EXTCLKIN external clock input timing

2.5.1.4 EXTAL/XTAL Clock Timing

Table 2.18 EXTAL/XTAL clock timing

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
EXTAL/XTAL clock frequency*1	f <sub>XTAL</sub>	—		25.00 ± 50 ppm		MHz
		EtherCAT in use		25.00 ± 25 ppm		MHz

Note: When using an external oscillator, be sure to leave XTAL open-circuit and make sure that EXTAL is driven low.

Note 1. When using the EXTAL/XTAL clock (i.e. crystal resonator), ask the oscillator manufacturer to evaluate oscillation of the oscillator. For the oscillation stabilization time, see the evaluation result provided by the oscillator manufacturer.

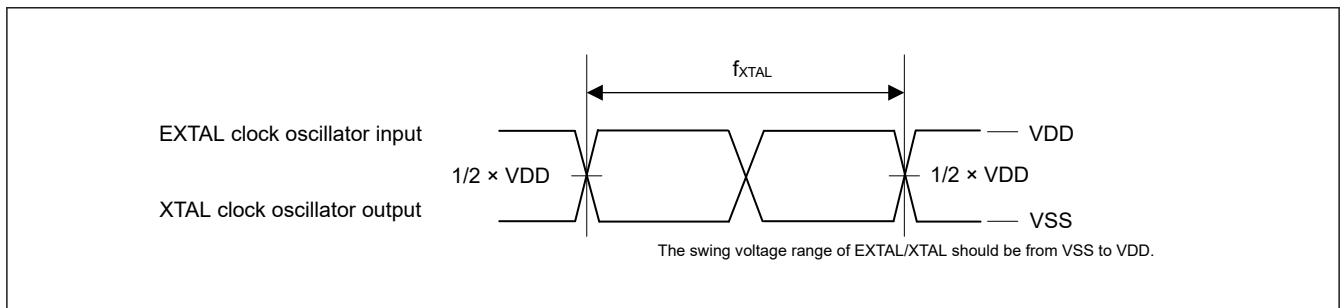


Figure 2.5 EXTAL clock oscillator input and XTAL clock oscillator output timing

2.5.1.5 LOCO Clock Timing

Table 2.19 LOCO clock timing

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
LOCO clock cycle time	t <sub>Lcyc</sub>	—	4.62	4.17	3.79	µs
LOCO clock oscillation frequency	f <sub>LOCO</sub>	—	216	240	264	kHz
LOCO clock oscillation stabilization wait time	t <sub>LOCOWT</sub>	—	—	—	40	µs

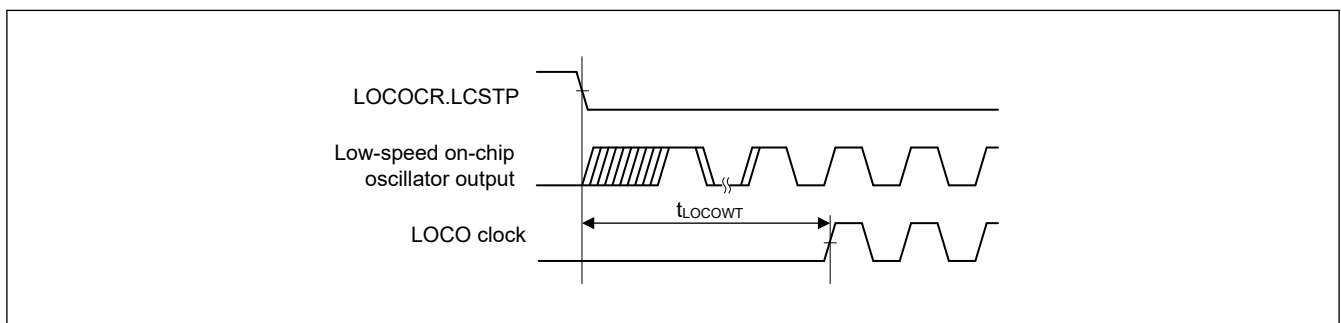


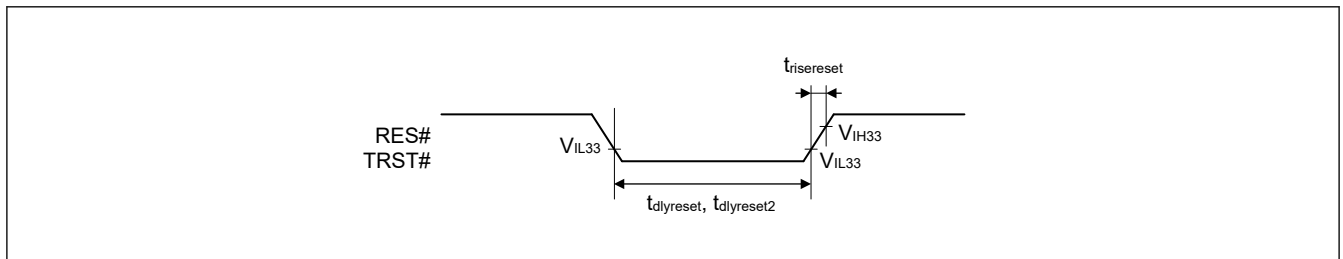
Figure 2.6 LOCO clock oscillation start timing

### 2.5.2 Reset, Interrupt, and Mode Timing

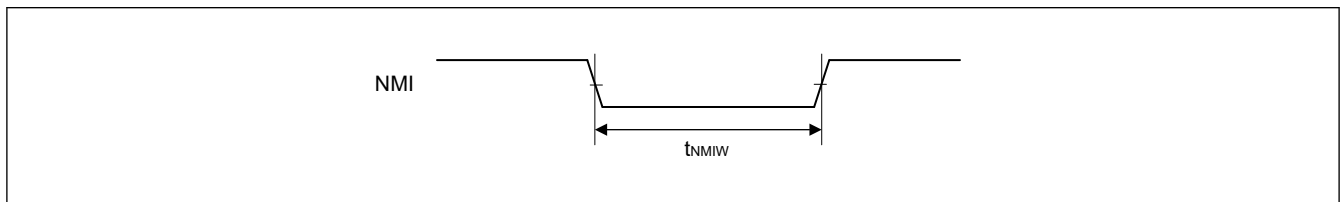
**Table 2.20** Reset, interrupt, and mode timing

Parameter		Symbol	Conditions	Min.*1	Typ.	Max.	Unit
RES# pulse width	At power on	$t_{dlyreset}$	Figure 2.7	10	—	—	ms
	Other than above	$t_{dlyreset2}$		1	—	—	ms
RES# rising time		$t_{risereset}$		—	—	150	$\mu$ s
TRST# pulse width	At power on	$t_{dlyreset}$		10	—	—	ms
	Other than above	$t_{dlyreset2}$		1	—	—	ms
TRST# rising time		$t_{risereset}$		—	—	150	$\mu$ s
NMI pulse width		$t_{NMIW}$	Figure 2.8	$t_{cyc} \times 2$	—	—	ns
IRQ pulse width		$t_{IRQW}$	Figure 2.9	$t_{cyc} \times 2$	—	—	ns
Mode hold time (to RES#)	At power on	$t_{MDH}$	Figure 2.10	250	—	—	ns

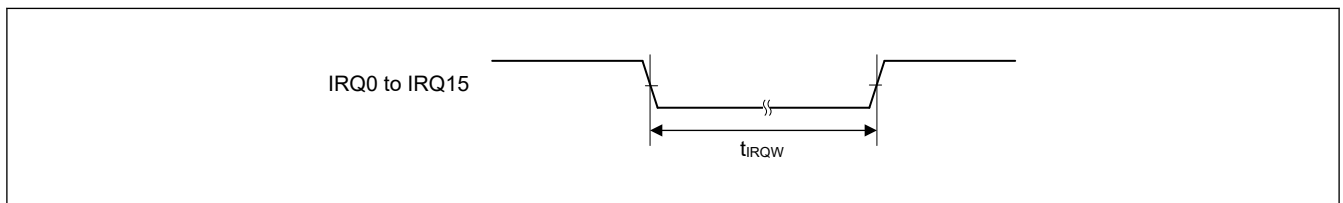
Note 1.  $t_{cyc}$ : ICLK cycle



**Figure 2.7** Reset input timing



**Figure 2.8** NMI interrupt input timing



**Figure 2.9** IRQ interrupt input timing

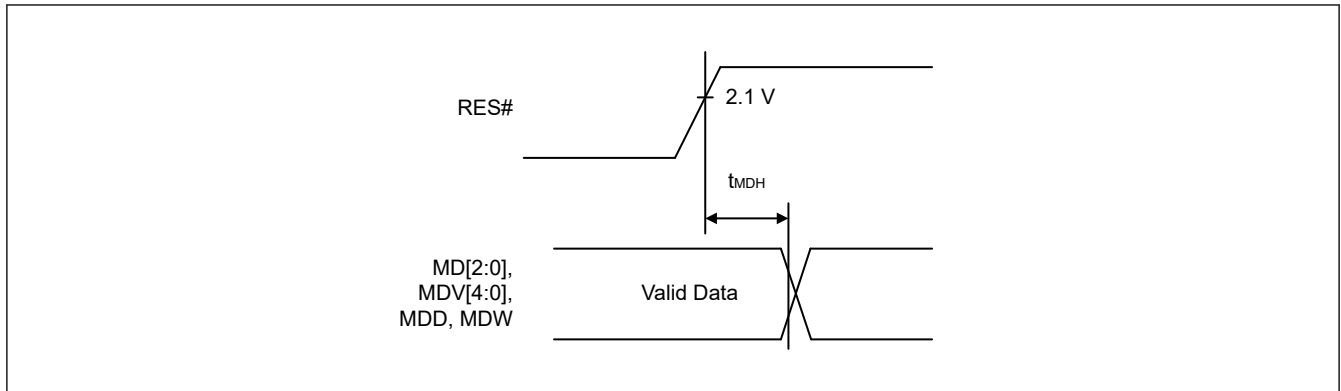


Figure 2.10 Mode input timing

### 2.5.3 Bus Timing

Table 2.21 Bus timing (1 of 2)

Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 15 \text{ pF}$  (CKIO),  $30 \text{ pF}$  (others),  $T_{jmin} = -40^\circ\text{C}$

Parameter	Symbol	CKIO = $1/t_{CKcyc}^{*1}$ (Max 66 MHz)		Unit	Reference Figure	
		Min.	Max.			
Address delay time 1	SDRAM <sup>*2</sup>	$t_{AD1}$	2	10.5	ns	Figure 2.11 to Figure 2.35
	Other than the above		0	10	ns	
Address delay time 2		$t_{AD2}$	$1/2t_{CKcyc}$	$1/2t_{CKcyc} + 10$	ns	Figure 2.18
Address setup time		$t_{AS}$	0	—	ns	Figure 2.11 to Figure 2.14, Figure 2.18
Chip enable setup time		$t_{CS}$	0	—	ns	Figure 2.11 to Figure 2.14, Figure 2.18
Address hold time		$t_{AH}$	0	—	ns	Figure 2.11 to Figure 2.14
BS delay time		$t_{BSD}$	—	10.5	ns	Figure 2.11 to Figure 2.32
CSn# delay time 1	SDRAM <sup>*2</sup>	$t_{CSD1}$	2	10.5	ns	Figure 2.11 to Figure 2.35
	Other than the above		0	10	ns	
Read/write delay time 1	SDRAM <sup>*2</sup>	$t_{RWD1}$	2	10.5	ns	Figure 2.11 to Figure 2.35
	Other than the above		0	10	ns	
Read strobe delay time		$t_{RSD}$	$1/2t_{CKcyc}$	$1/2t_{CKcyc} + 10$	ns	Figure 2.11 to Figure 2.18
Read data setup time 1 <sup>*3</sup>	High-drive output	$t_{RDS1}$	$1/2t_{CKcyc} + 4$	—	ns	Figure 2.11 to Figure 2.17
	Normal output		$1/2t_{CKcyc} + 7$	—	ns	
Read data setup time 2 <sup>*3</sup>	High-drive output	$t_{RDS2}$	6.6	—	ns	Figure 2.19 to Figure 2.22, Figure 2.27 to Figure 2.29
Read data setup time 3 <sup>*3</sup>	High-drive output	$t_{RDS3}$	$1/2t_{CKcyc} + 4$	—	ns	Figure 2.18
	Normal output		$1/2t_{CKcyc} + 7$	—	ns	
Read data hold time 1		$t_{RDH1}$	0	—	ns	Figure 2.11 to Figure 2.17
Read data hold time 2		$t_{RDH2}$	2	—	ns	Figure 2.19 to Figure 2.22, Figure 2.27 to Figure 2.29
Read data hold time 3		$t_{RDH3}$	0	—	ns	Figure 2.18
Write enable delay time 1		$t_{WED1}$	$1/2t_{CKcyc}$	$1/2t_{CKcyc} + 10$	ns	Figure 2.11 to Figure 2.16
Write enable delay time 2		$t_{WED2}$	—	10	ns	Figure 2.17
Write data delay time 1		$t_{WDD1}$	—	10	ns	Figure 2.11 to Figure 2.17

**Table 2.21 Bus timing (2 of 2)**Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 15$  pF (CKIO), 30 pF (others),  $T_{jmin} = -40^{\circ}\text{C}$ 

Parameter	Symbol	CKIO = $1/t_{CKcyc}^{*1}$ (Max 66 MHz)		Unit	Reference Figure
		Min.	Max.		
Write data delay time 2	$t_{WDD2}$	—	10.5	ns	Figure 2.23 to Figure 2.26, Figure 2.30 to Figure 2.32
Write data hold time 1	$t_{WDH1}$	1	—	ns	Figure 2.11 to Figure 2.17
Write data hold time 2	$t_{WDH2}$	2	—	ns	Figure 2.23 to Figure 2.26, Figure 2.30 to Figure 2.32
Write data hold time 4	$t_{WDH4}$	0	—	ns	Figure 2.11 to Figure 2.15
WAIT# setup time <sup>*3</sup>	High-drive output	$1/2t_{CKcyc} + 4.5$	—	ns	Figure 2.12 to Figure 2.18
	Normal output	$1/2t_{CKcyc} + 8$	—	ns	
WAIT# hold time	$t_{WTH}$	$1/2t_{CKcyc} + 3.5$	—	ns	Figure 2.12 to Figure 2.18
RAS# delay time 1	$t_{RASD1}$	2	10.5	ns	Figure 2.19 to Figure 2.35
CAS# delay time 1	$t_{CASD1}$	2	10.5	ns	Figure 2.19 to Figure 2.35
DQM delay time 1	$t_{DQMD1}$	2	10.5	ns	Figure 2.19 to Figure 2.32
CKE delay time 1	$t_{CKED1}$	2	10.5	ns	Figure 2.34
AH# delay time	$t_{AHD}$	$1/2t_{CKcyc}$	$1/2t_{CKcyc} + 10$	ns	Figure 2.15
Multiplex address delay time	$t_{MAD}$	—	10	ns	Figure 2.15
Multiplex address hold time	$t_{MAH}$	1	—	ns	Figure 2.15
Address setup time to AH#	$t_{AVVH}$	$1/2t_{CKcyc} - 2$	—	ns	Figure 2.15
DACK/TEND delay time	$t_{DACD}$	See section 2.5.4. DMAC Timing		ns	Figure 2.11 to Figure 2.32

Note: Notation of  $1/2t_{CKcyc}$  in the delay time, setup time, and hold time shows 1/2 cycles from the clock rising edge, that is, the reference of clock falling.

Note 1. Take the number of cycles of waiting that suits the system configuration into consideration with regard to the fmax value for CKIO (the external bus clock). When CKIO is running at 50 MHz or a higher frequency, select high drive output.

Note 2. These are values when SDRAM (CSnBCR.TYPE[2:0] = 100b) is selected in the CSn space bus control register (CSnBCR) and high-drive output is selected for CKIO.

Note 3. These are values when high-drive output and normal output are respectively selected for CKIO.

**Table 2.22 Bus timing (1 of 2)**Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 12$  pF (CKIO), 12 pF (others),  $T_{jmin} = -20^{\circ}\text{C}$ 

Parameter	Symbol	CKIO = $1/t_{CKcyc}^{*1}$ (Max 100 MHz)		Unit	Reference Figure	
		Min.	Max.			
Address delay time 1	SDRAM <sup>*2</sup>	$t_{AD1}$	1.3	8	ns	Figure 2.11 to Figure 2.35
	Other than the above		0	8		
Address delay time 2	$t_{AD2}$	$1/2t_{CKcyc} - 0.5$	$1/2t_{CKcyc} + 8$	ns	Figure 2.18	
Address setup time	$t_{AS}$	0	—	ns	Figure 2.11 to Figure 2.14, Figure 2.18	
Chip enable setup time	$t_{CS}$	0	—	ns	Figure 2.11 to Figure 2.14, Figure 2.18	
Address hold time	$t_{AH}$	0	—	ns	Figure 2.11 to Figure 2.14	
BS delay time	$t_{BSD}$	—	8	ns	Figure 2.11 to Figure 2.32	
CSn# delay time 1	SDRAM <sup>*2</sup>	$t_{CSD1}$	1.3	8	ns	Figure 2.11 to Figure 2.35
	Other than the above		0	8		

**Table 2.22 Bus timing (2 of 2)**Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 12$  pF (CKIO), 12 pF (others),  $T_{jmin} = -20^{\circ}\text{C}$ 

Parameter	Symbol	CKIO = $1/t_{CKcyc}^{*1}$ (Max 100 MHz)		Unit	Reference Figure	
		Min.	Max.			
Read/write delay time 1	SDRAM <sup>*2</sup>	t <sub>RWD1</sub>	1.3	8	ns	Figure 2.11 to Figure 2.35
	Other than the above		0	8	ns	
Read strobe delay time		t <sub>RSD</sub>	$1/2t_{CKcyc}$	$1/2t_{CKcyc} + 8$	ns	Figure 2.11 to Figure 2.18
Read data setup time 1 <sup>*3</sup>	High-drive output	t <sub>RDS1</sub>	$1/2t_{CKcyc} + 4.5$	—	ns	Figure 2.11 to Figure 2.17
	Normal output		$1/2t_{CKcyc} + 7$	—	ns	
Read data setup time 2 <sup>*3</sup>	High-drive output	t <sub>RDS2</sub>	6.6	—	ns	Figure 2.19 to Figure 2.22, Figure 2.27 to Figure 2.29
Read data setup time 3 <sup>*3</sup>	High-drive output	t <sub>RDS3</sub>	$1/2t_{CKcyc} + 4.5$	—	ns	Figure 2.18
	Normal output		$1/2t_{CKcyc} + 7$	—	ns	
Read data hold time 1		t <sub>RDH1</sub>	0	—	ns	Figure 2.11 to Figure 2.17
Read data hold time 2		t <sub>RDH2</sub>	2.5	—	ns	Figure 2.19 to Figure 2.22, Figure 2.27 to Figure 2.29
Read data hold time 3		t <sub>RDH3</sub>	0	—	ns	Figure 2.18
Write enable delay time 1		t <sub>WED1</sub>	$1/2t_{CKcyc}$	$1/2t_{CKcyc} + 8$	ns	Figure 2.11 to Figure 2.16
Write enable delay time 2		t <sub>WED2</sub>	—	9	ns	Figure 2.17
Write data delay time 1		t <sub>WDD1</sub>	—	8	ns	Figure 2.11 to Figure 2.17
Write data delay time 2		t <sub>WDD2</sub>	—	8	ns	Figure 2.23 to Figure 2.26, Figure 2.30 to Figure 2.32
Write data hold time 1		t <sub>WDH1</sub>	1	—	ns	Figure 2.11 to Figure 2.17
Write data hold time 2		t <sub>WDH2</sub>	1.3	—	ns	Figure 2.23 to Figure 2.26, Figure 2.30 to Figure 2.32
Write data hold time 4		t <sub>WDH4</sub>	0	—	ns	Figure 2.11 to Figure 2.15
WAIT# setup time <sup>*3</sup>	High-drive output	t <sub>WTS</sub>	$1/2t_{CKcyc} + 4.5$	—	ns	Figure 2.12 to Figure 2.18
	Normal output		$1/2t_{CKcyc} + 8$	—	ns	
WAIT# hold time		t <sub>WTH</sub>	$1/2t_{CKcyc} + 3.5$	—	ns	Figure 2.12 to Figure 2.18
RAS# delay time 1		t <sub>RASD1</sub>	1.3	8	ns	Figure 2.19 to Figure 2.35
CAS# delay time 1		t <sub>CASD1</sub>	1.3	8	ns	Figure 2.19 to Figure 2.35
DQM delay time 1		t <sub>DQMD1</sub>	1.3	8	ns	Figure 2.19 to Figure 2.32
CKE delay time 1		t <sub>CKED1</sub>	1.3	8	ns	Figure 2.34
AH# delay time		t <sub>AHD</sub>	$1/2t_{CKcyc}$	$1/2t_{CKcyc} + 8$	ns	Figure 2.15
Multiplex address delay time		t <sub>MAD</sub>	—	8	ns	Figure 2.15
Multiplex address hold time		t <sub>MAH</sub>	1	—	ns	Figure 2.15
Address setup time to AH#		t <sub>AVVH</sub>	$1/2t_{CKcyc} - 2$	—	ns	Figure 2.15
DACK/TEND delay time		t <sub>DACD</sub>	See section 2.5.4. DMAC Timing		ns	Figure 2.11 to Figure 2.32

Note: Notation of  $1/2t_{CKcyc}$  in the delay time, setup time, and hold time shows 1/2 cycles from the clock rising edge, that is, the reference of clock falling.

Note 1. Take the number of cycles of waiting that suits the system configuration into consideration with regard to the f<sub>max</sub> value for CKIO (the external bus clock). When CKIO is running at 50 MHz or a higher frequency, select high drive output.

Note 2. These are values when SDRAM (CSnBCR.TYPE[2:0] = 100b) is selected in the CSn space bus control register (CSnBCR) and high-drive output is selected for CKIO.

Note 3. These are values when high-drive output and normal output are respectively selected for CKIO.

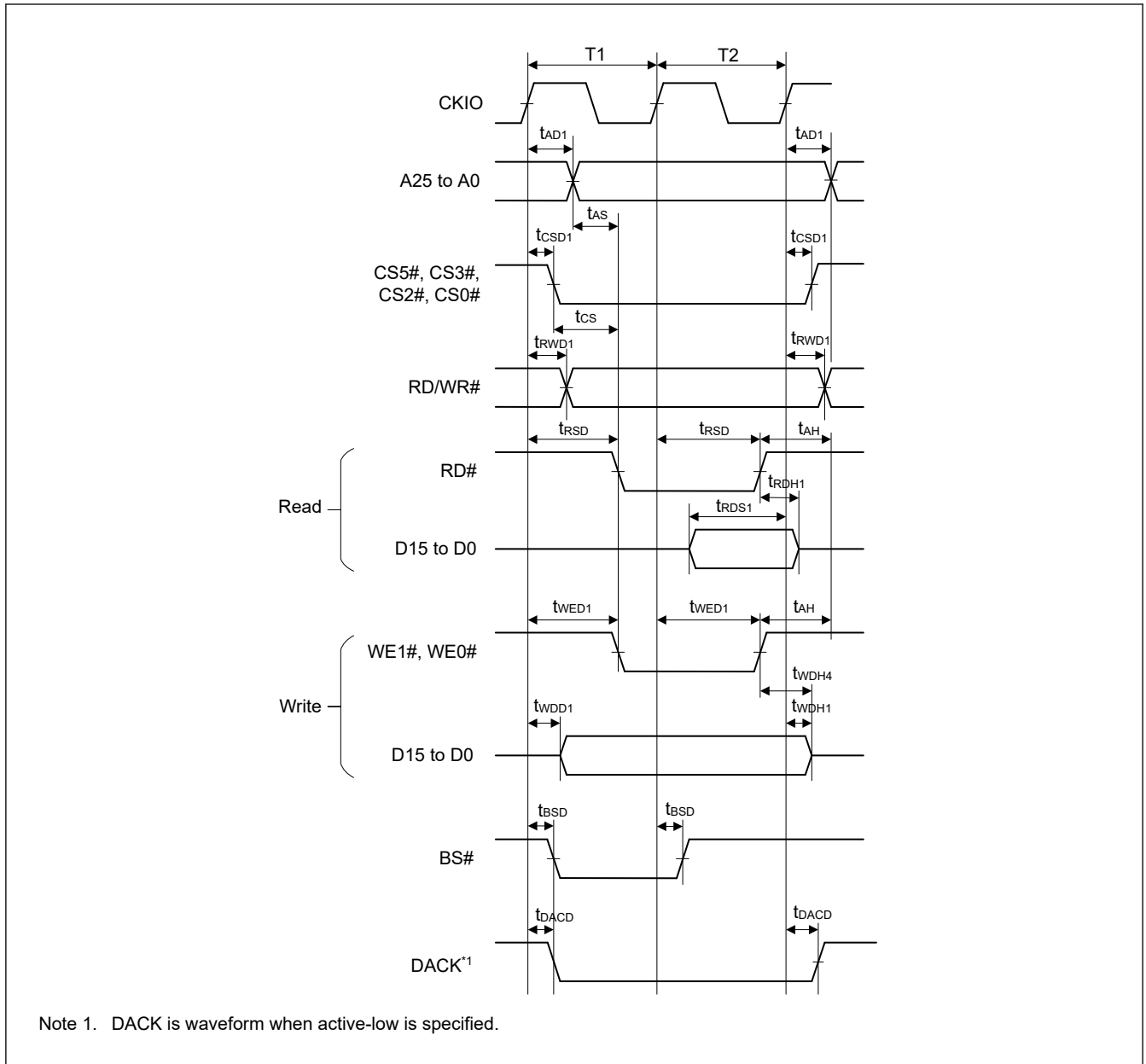


Figure 2.11 SRAM interface basic bus cycle (no wait)

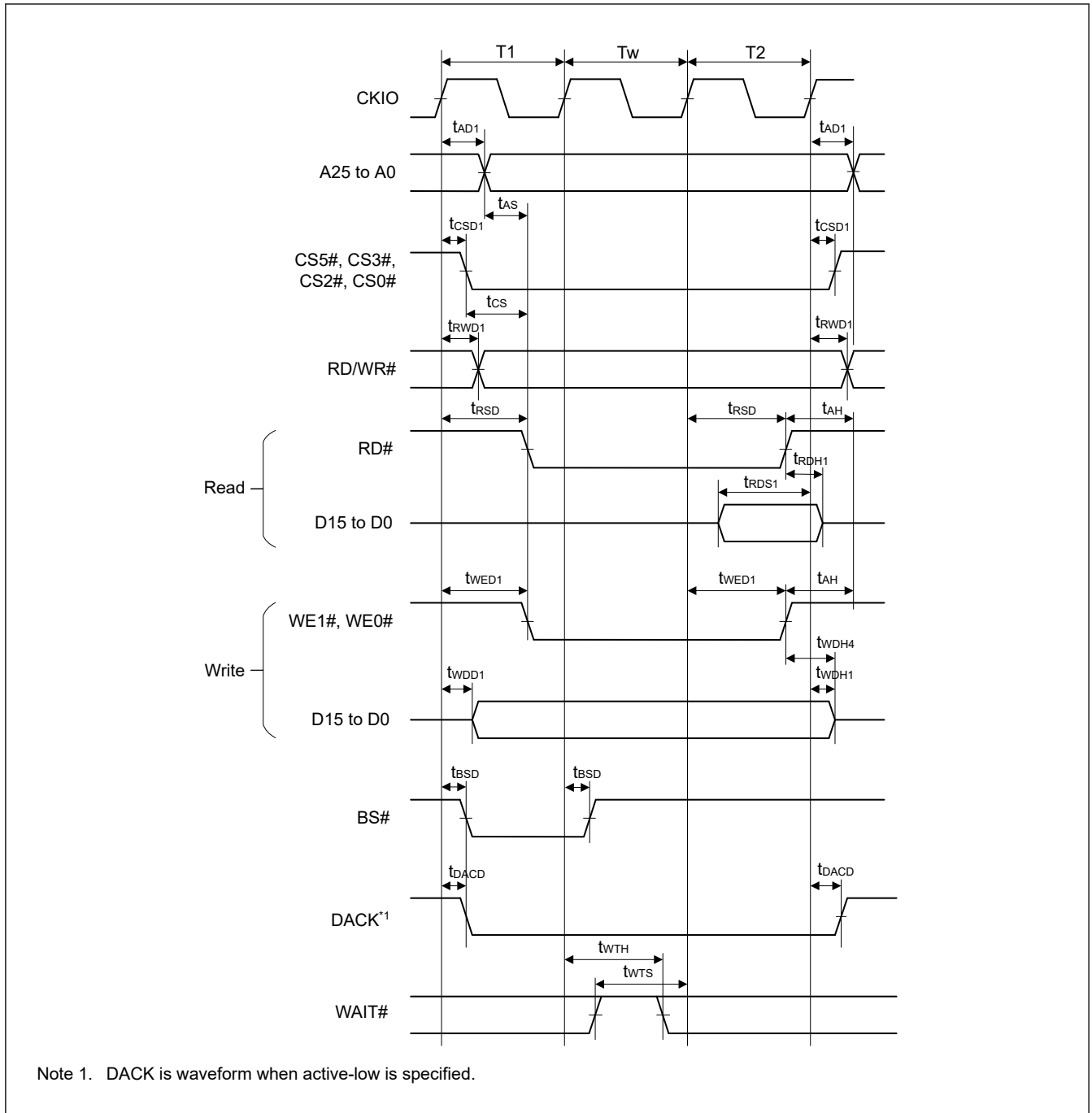


Figure 2.12 SRAM interface basic bus cycle (software wait 1)



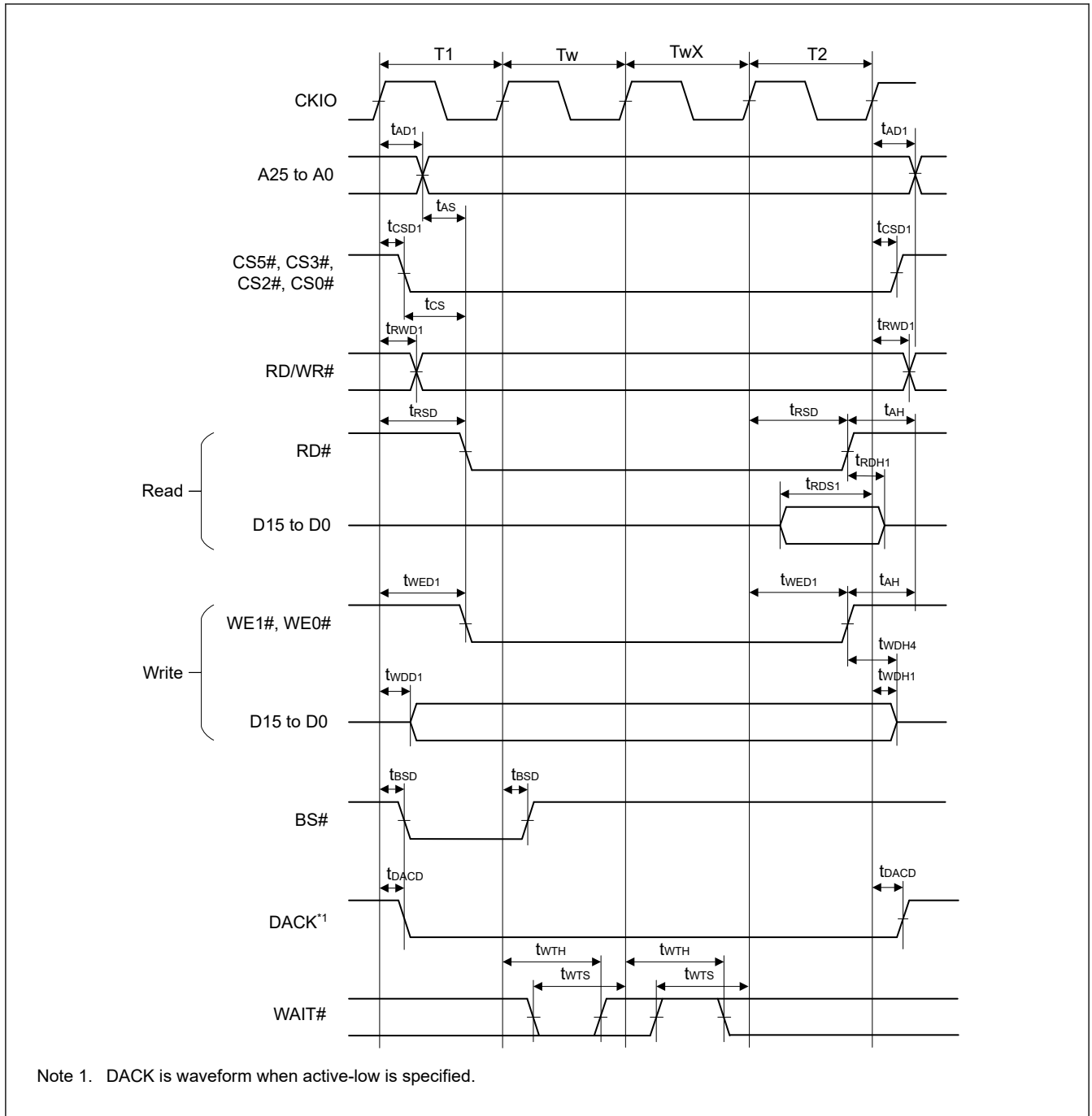


Figure 2.13 SRAM interface basic bus cycle (software wait 1, external wait 1 inserted)

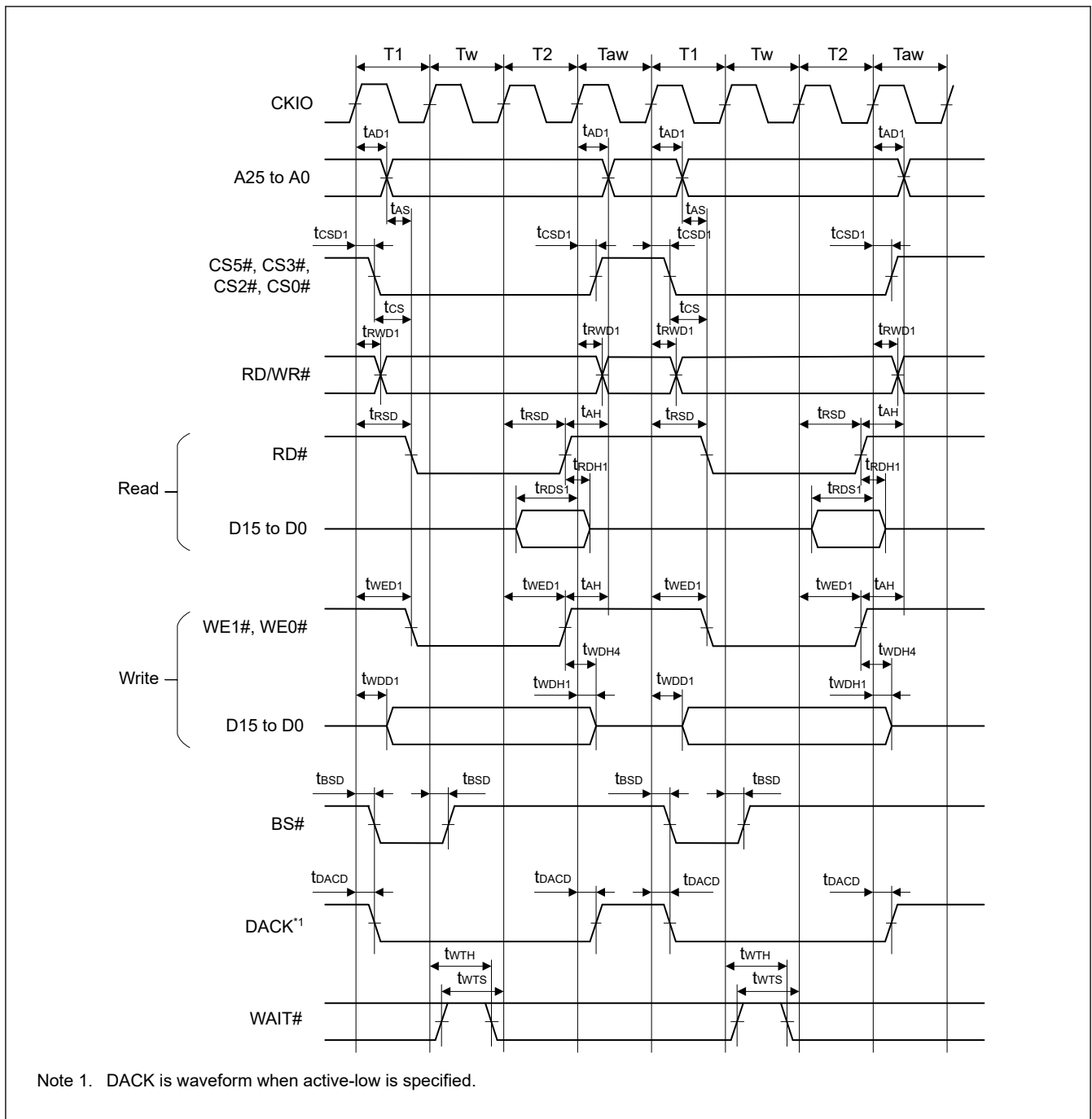


Figure 2.14 SRAM interface basic bus cycle (software wait 1, external wait enabled (WM = 0), no idle cycle)

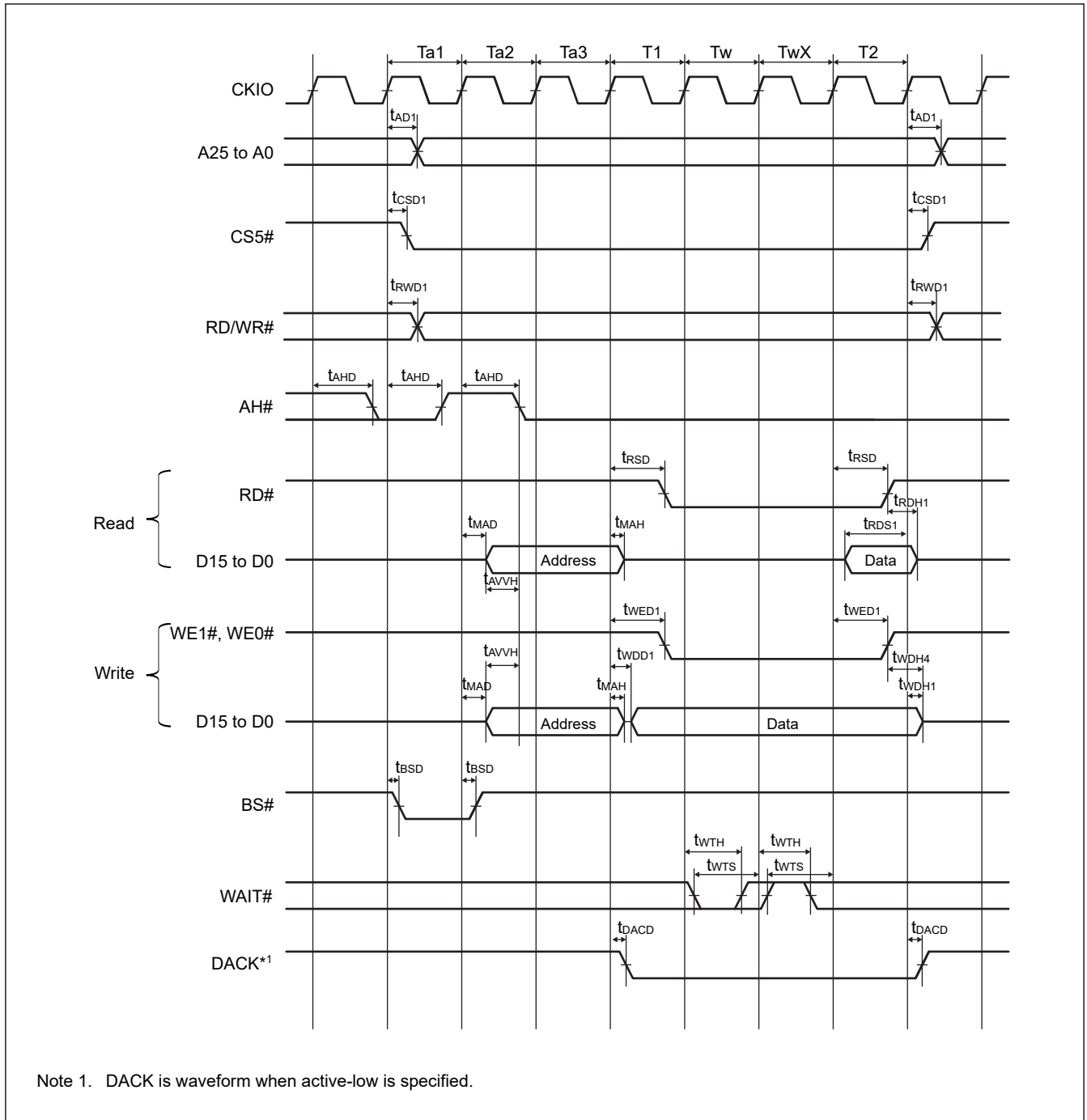
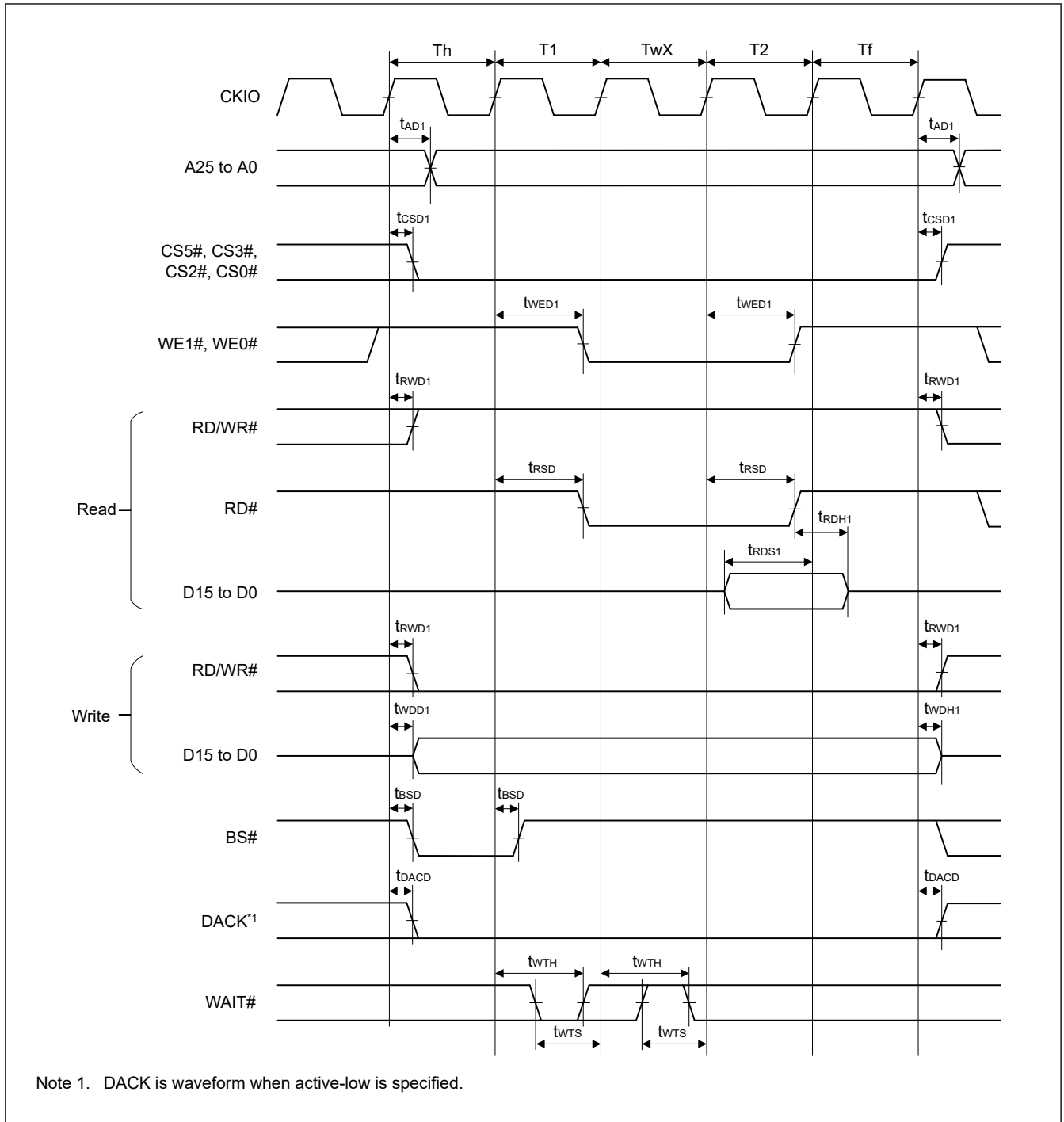
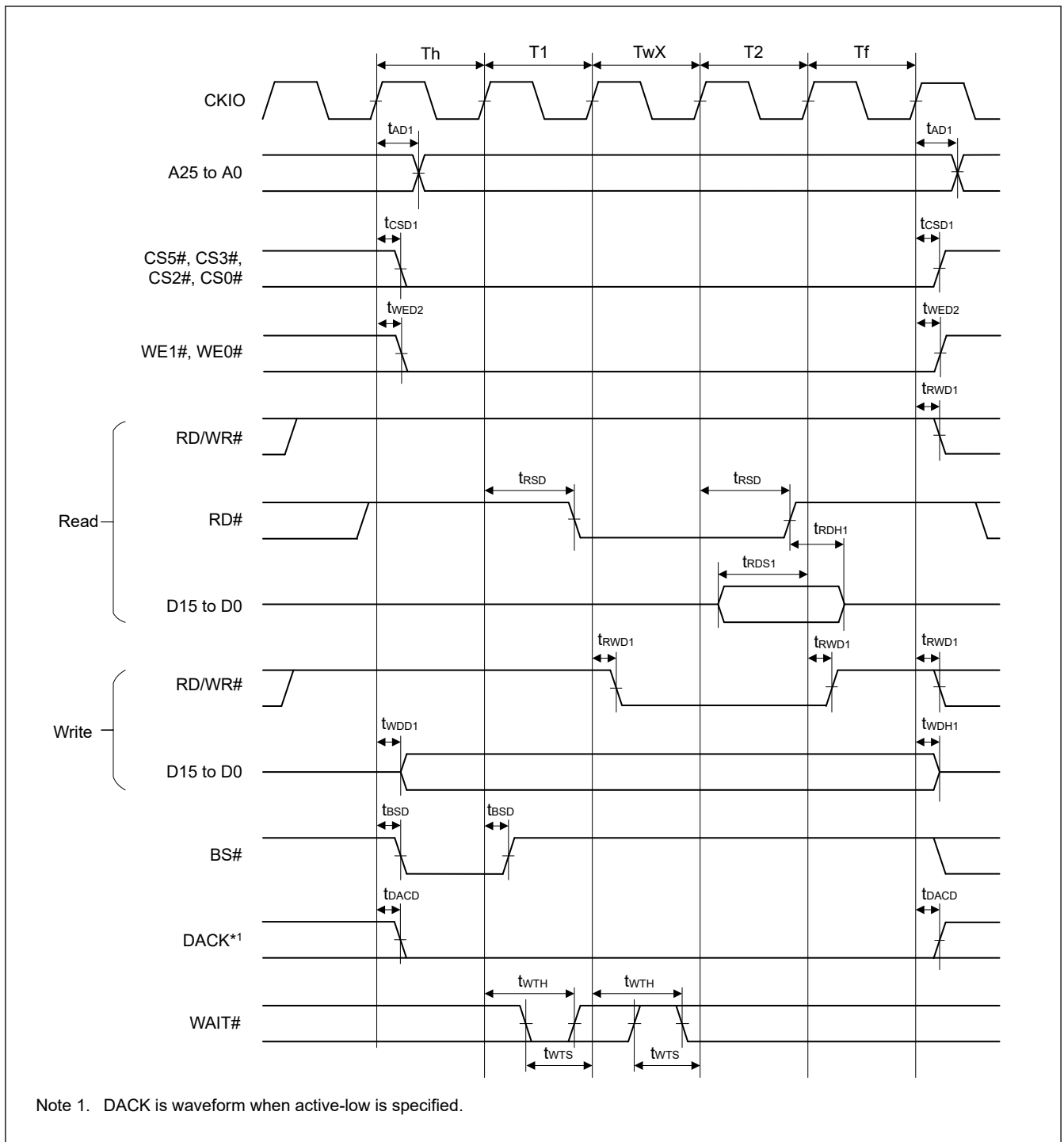


Figure 2.15 MPX-I/O interface bus cycle (address cycle 3, software wait 1, external wait 1 inserted)



**Figure 2.16 SRAM bus cycle with byte selection (SW = 1 cycle, HW = 1 cycle, asynchronous external wait 1 inserted, BAS = 0 (write cycle UB/LB control))**



**Figure 2.17 SRAM bus cycle with byte selection (SW = 1 cycle, HW = 1 cycle, asynchronous external wait 1 inserted, BAS = 1 (write cycle WE control))**

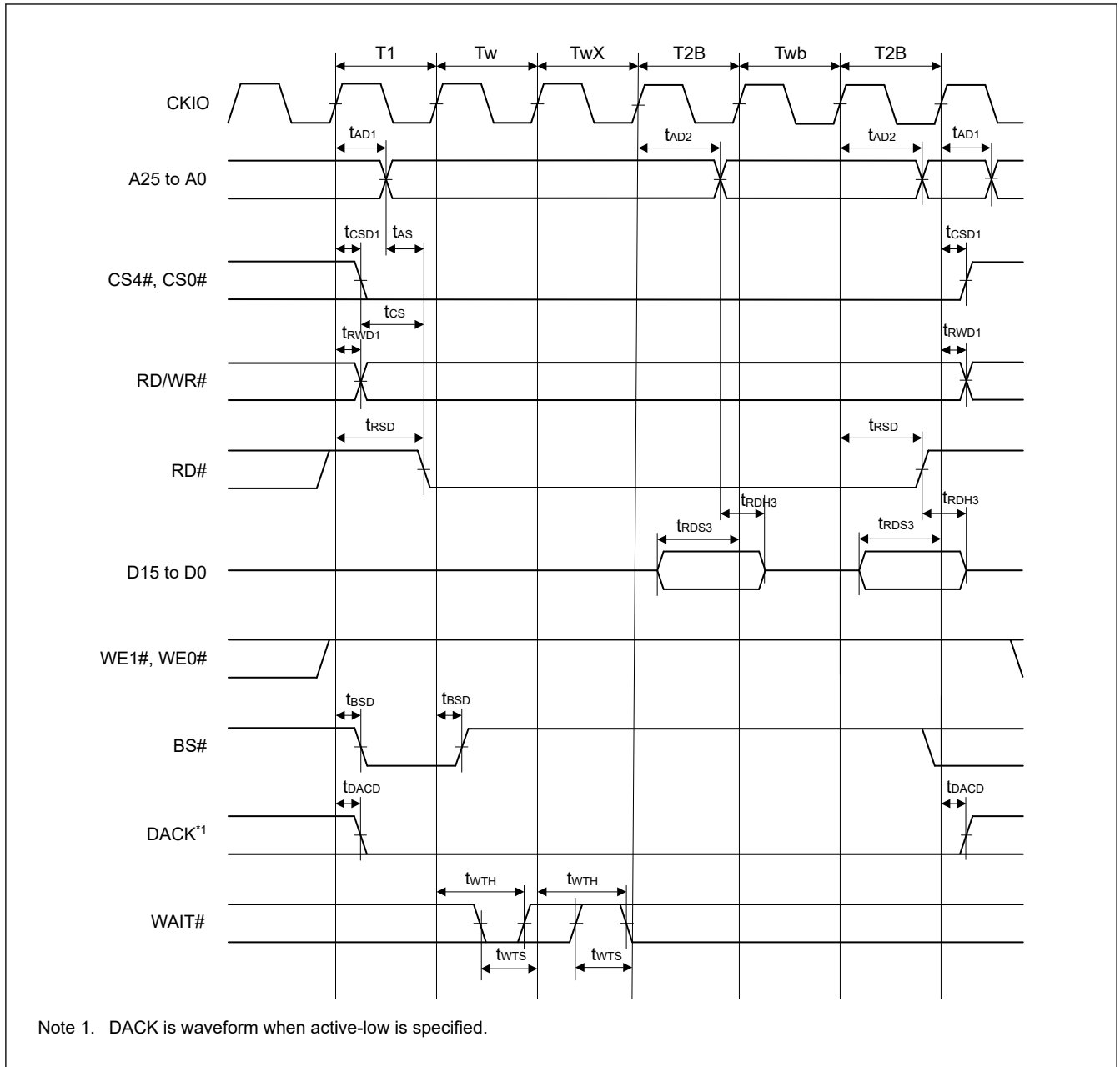
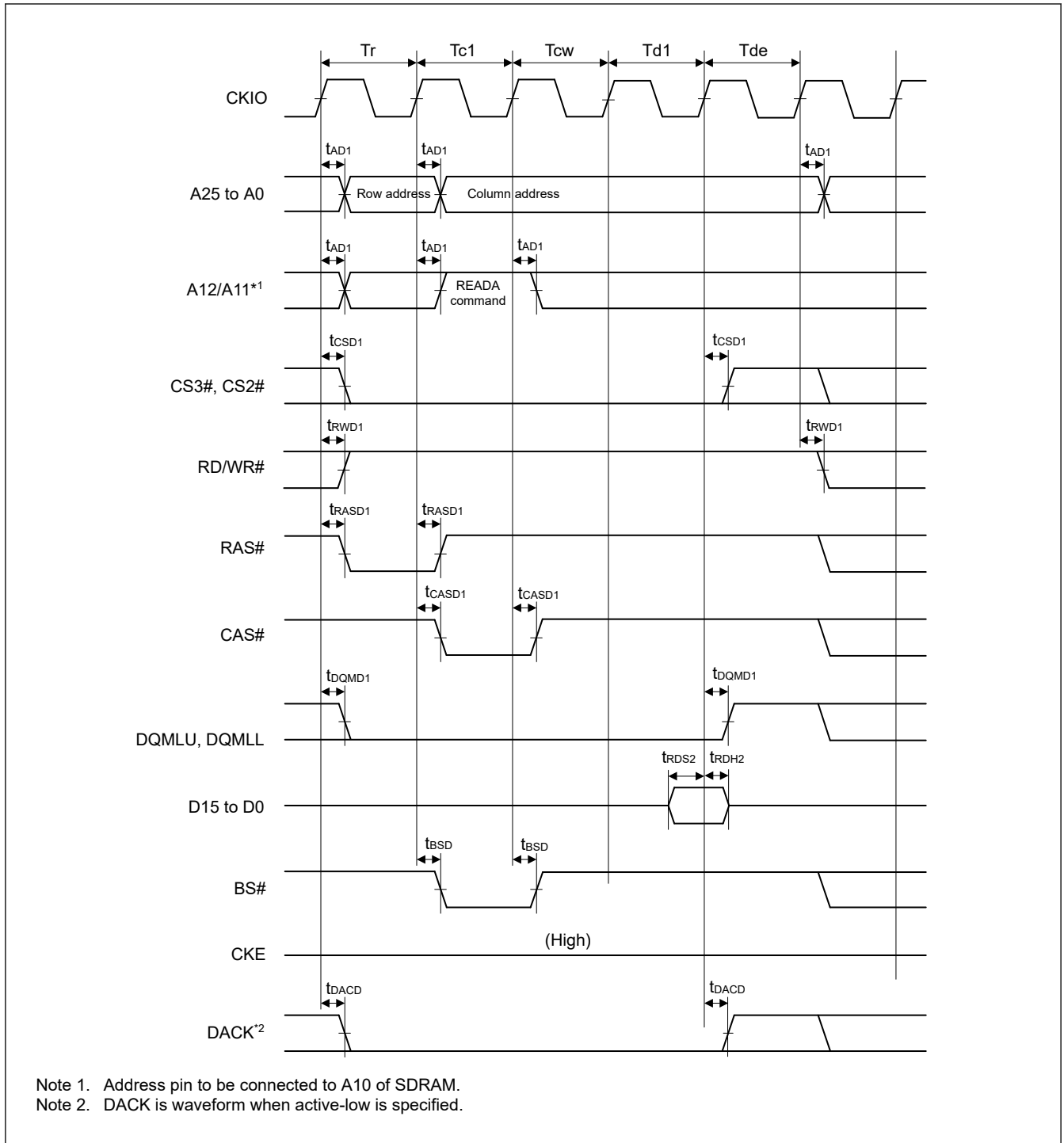
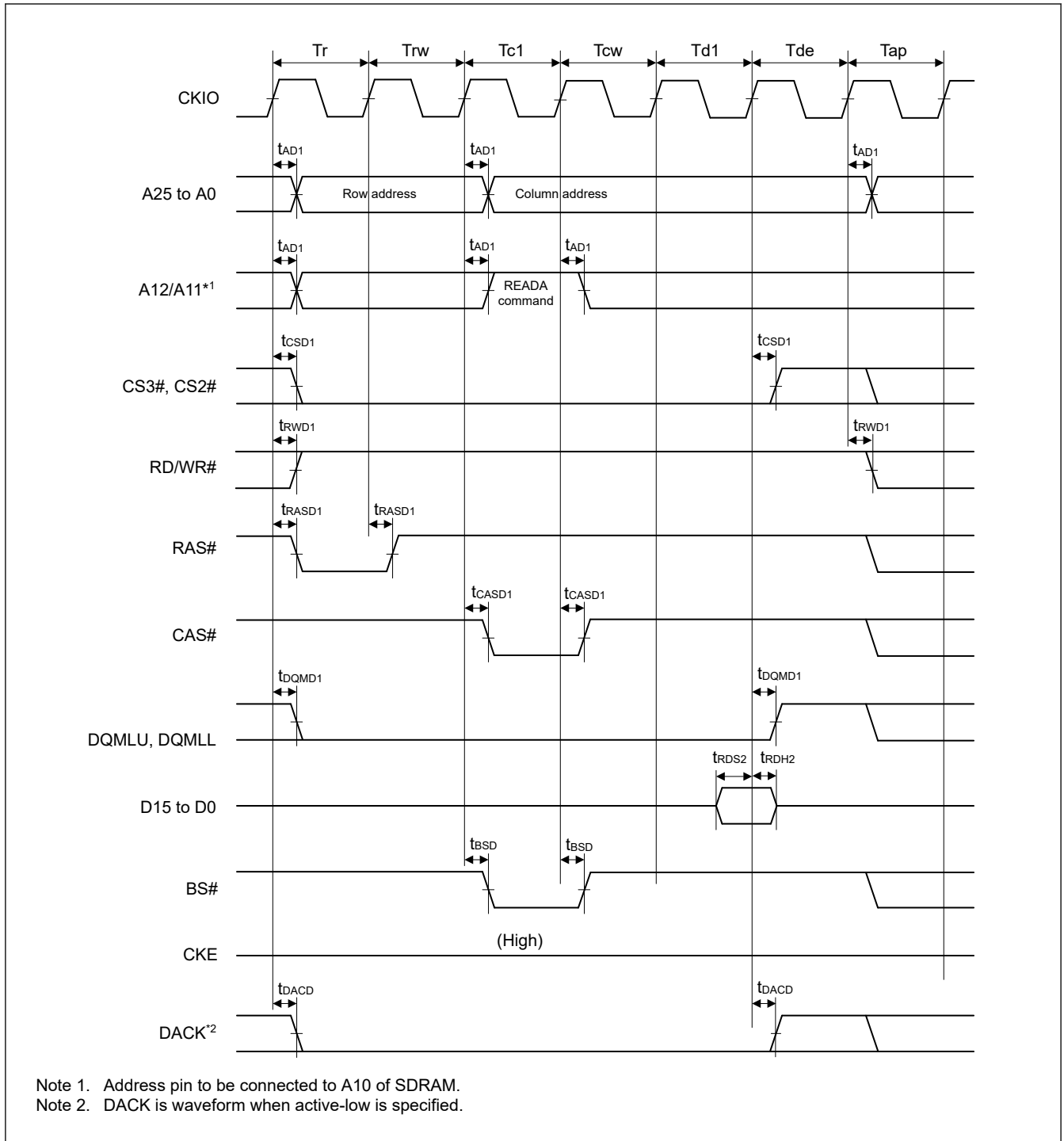


Figure 2.18 Burst ROM read cycle (software wait 1, asynchronous external wait 1 inserted, burst wait 1, 2)

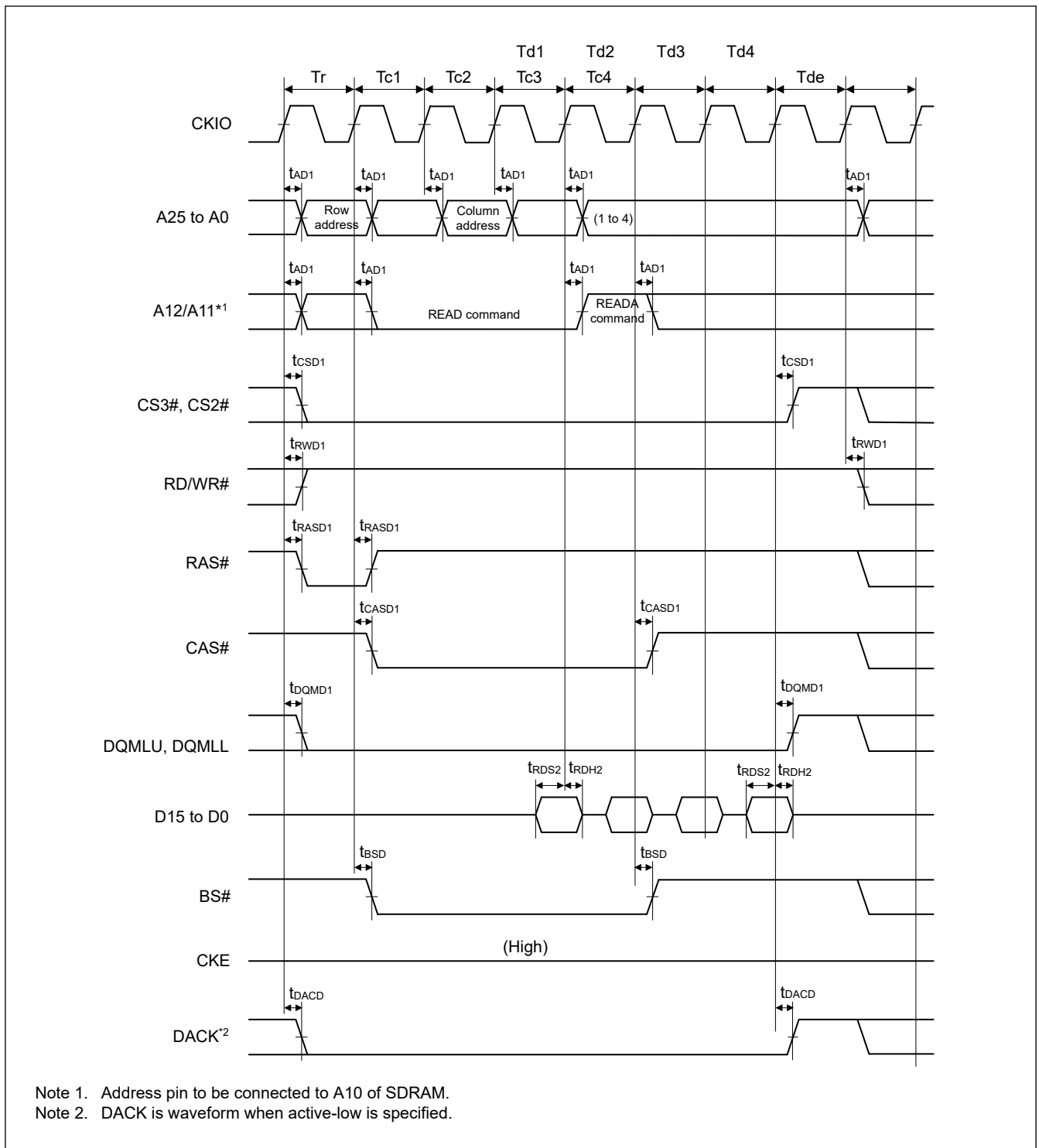


**Figure 2.19 Synchronous DRAM single-read bus cycle (with auto precharge, CAS latency 2, WTRCD = 0 cycles, WTRP = 0 cycles)**

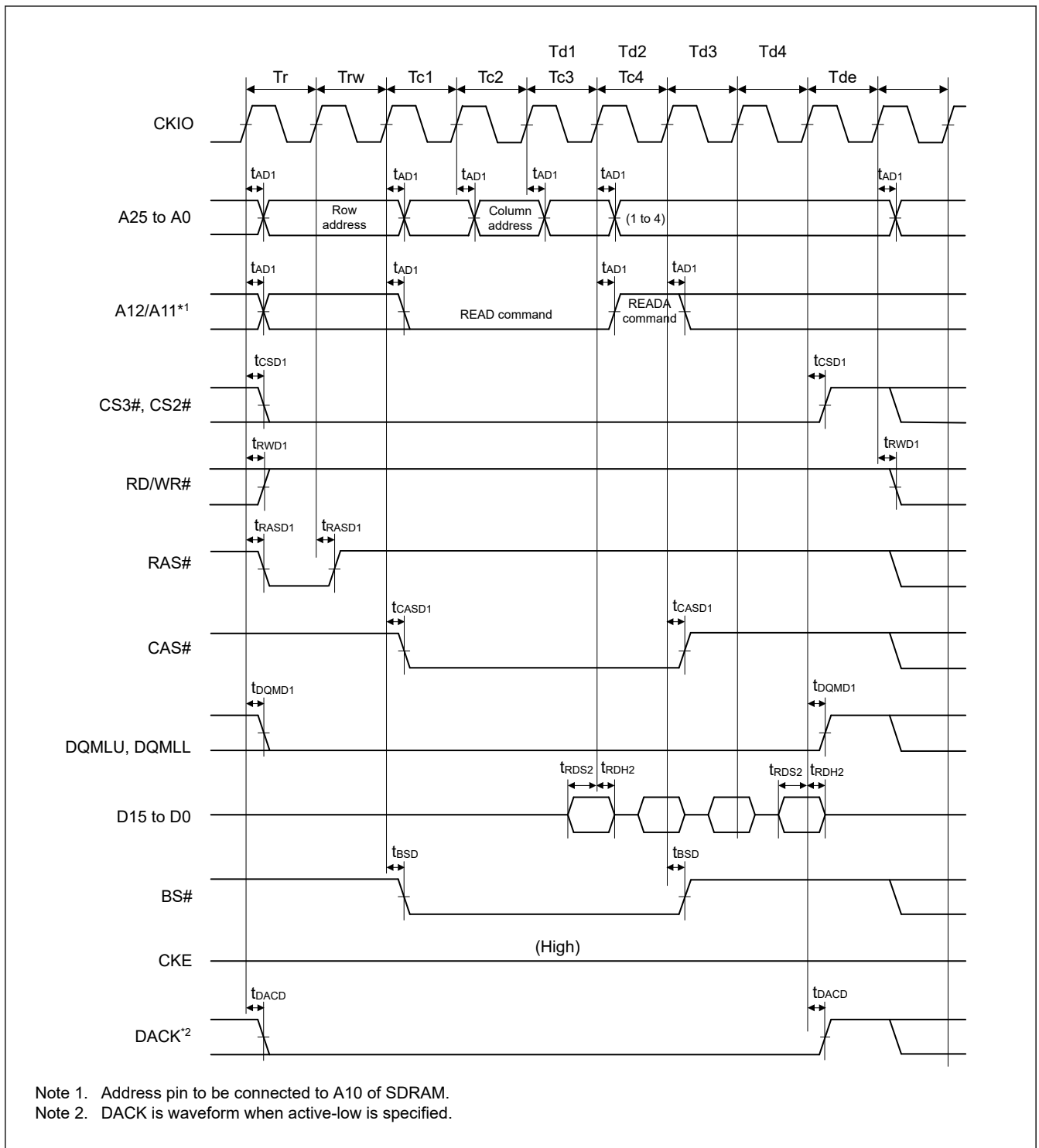


**Figure 2.20 Synchronous DRAM single-read bus cycle (with auto precharge, CAS latency 2, WTRCD = 1 cycle, WTRP = 1 cycle)**

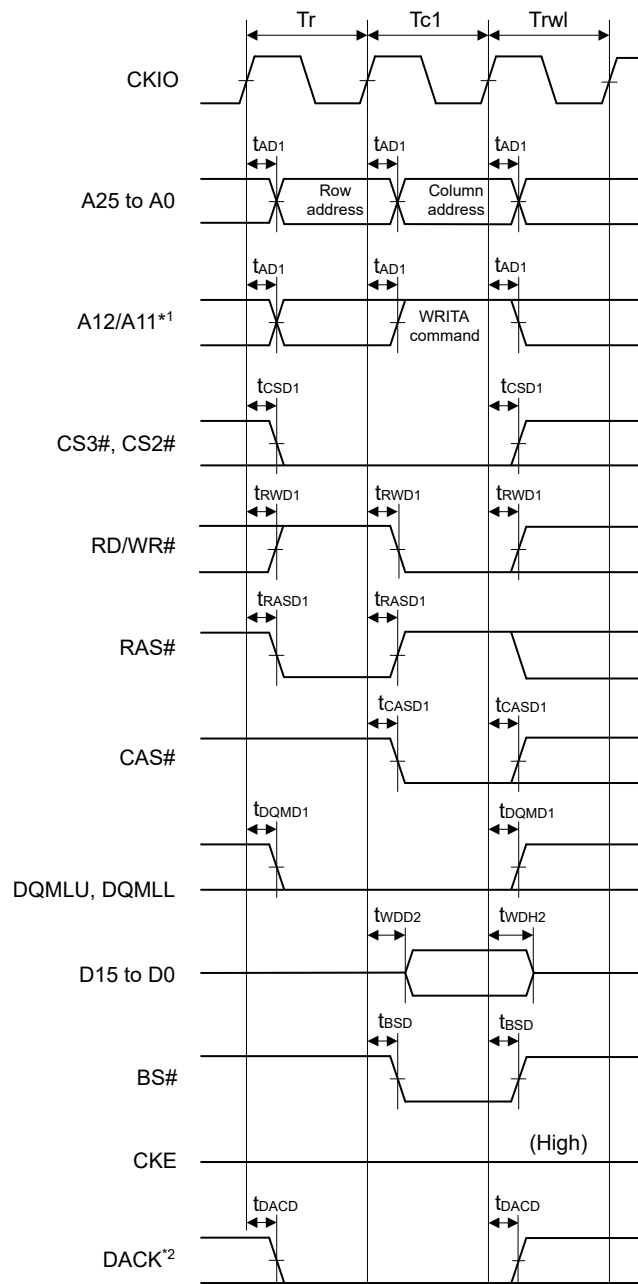




**Figure 2.21 Synchronous DRAM burst-read bus cycle (read for 4 cycles) (with auto precharge, CAS latency 2, WTRCD = 0 cycles, WTRP = 1 cycle)**

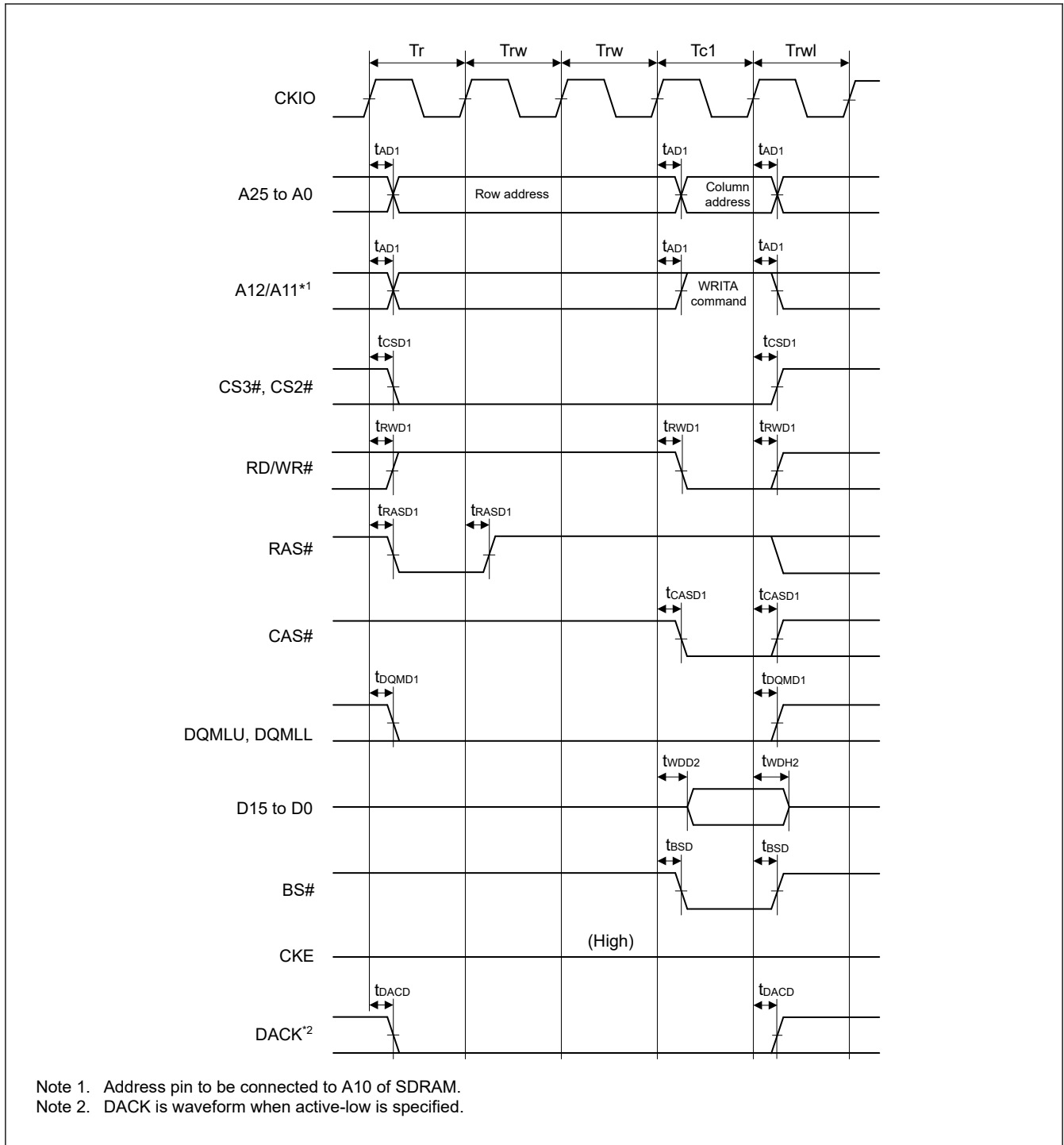


**Figure 2.22 Synchronous DRAM burst-read bus cycle (read for 4 cycles) (with auto precharge, CAS latency 2, WTRCD = 1 cycle, WTRP = 0 cycles)**

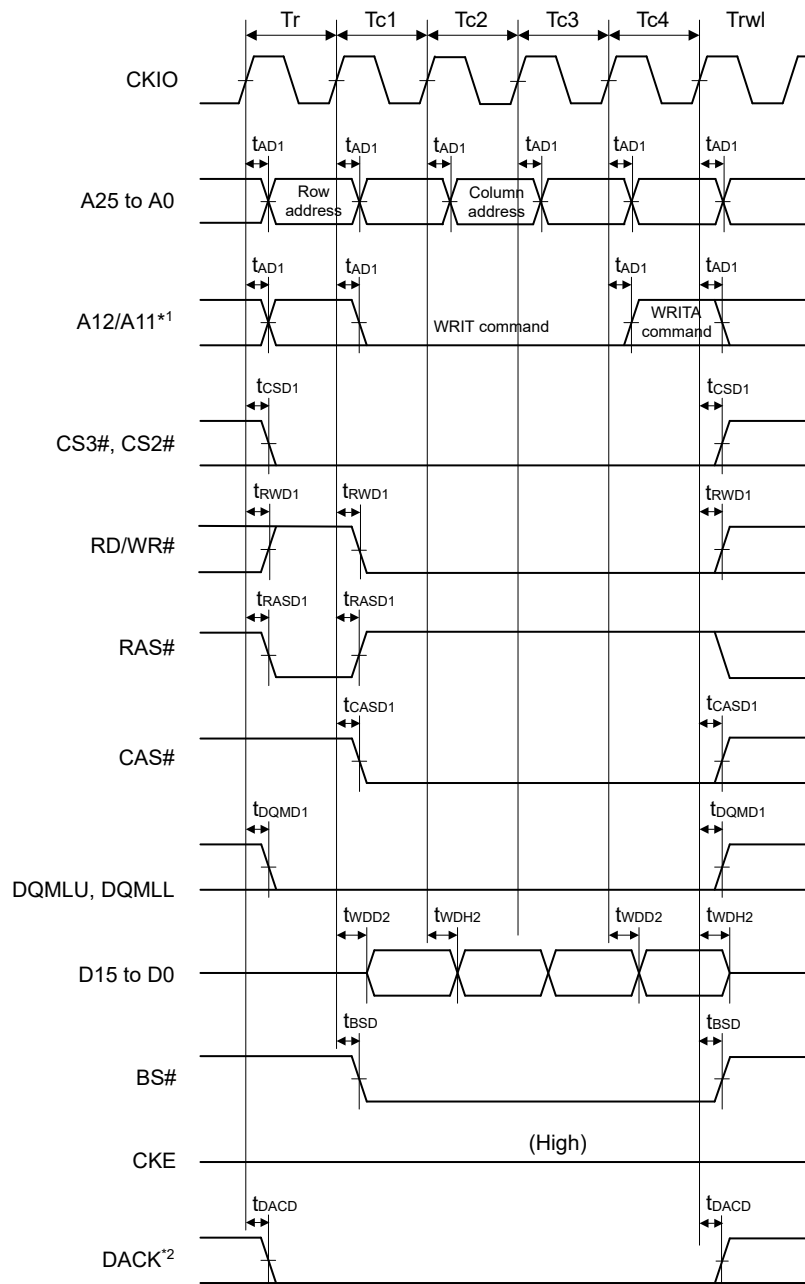


Note 1. Address pin to be connected to A10 of SDRAM.  
 Note 2. DACK is waveform when active-low is specified.

Figure 2.23 Synchronous DRAM single-write bus cycle (with auto precharge, TRWL = 1 cycle)

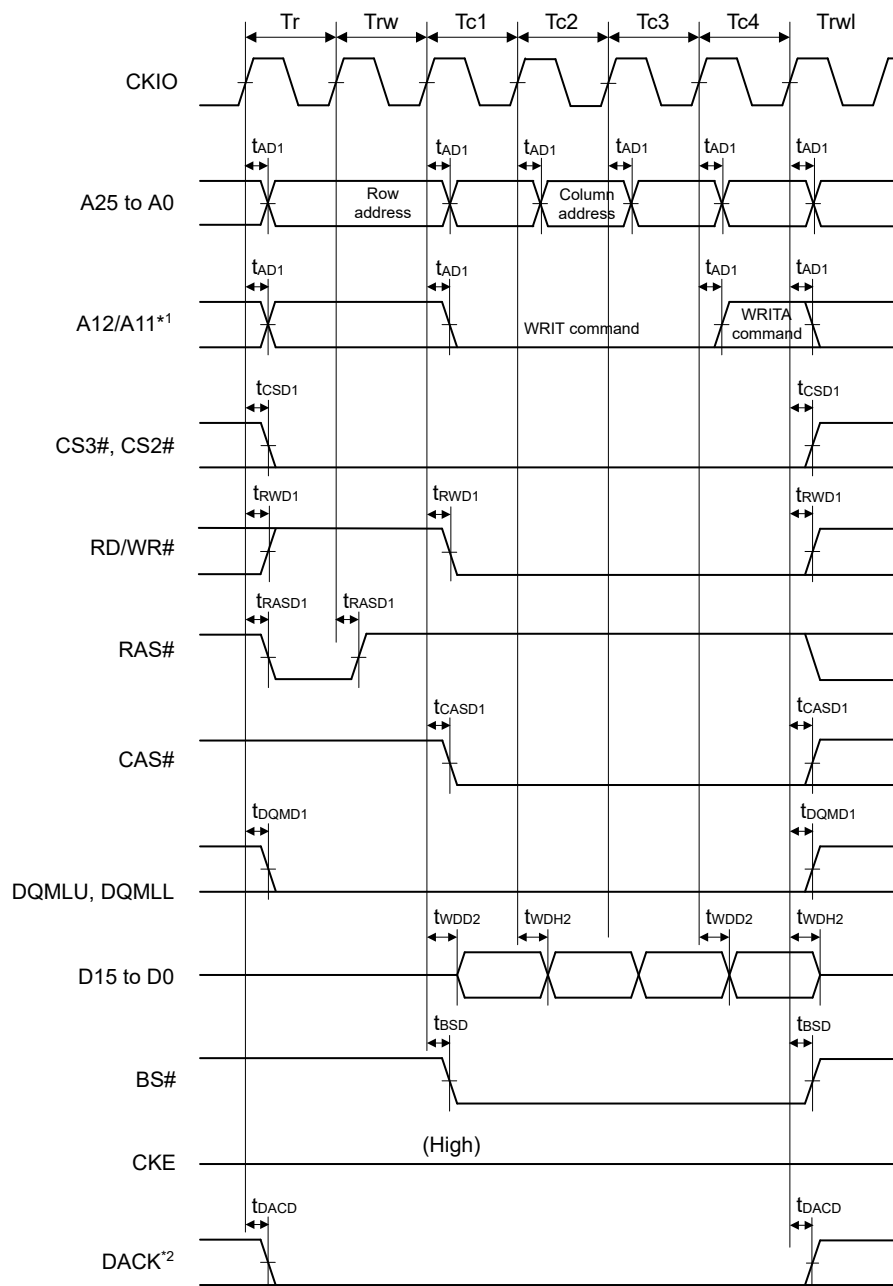


**Figure 2.24 Synchronous DRAM single-write bus cycle (with auto precharge, WTRCD = 2 cycles, TRWL = 1 cycle)**



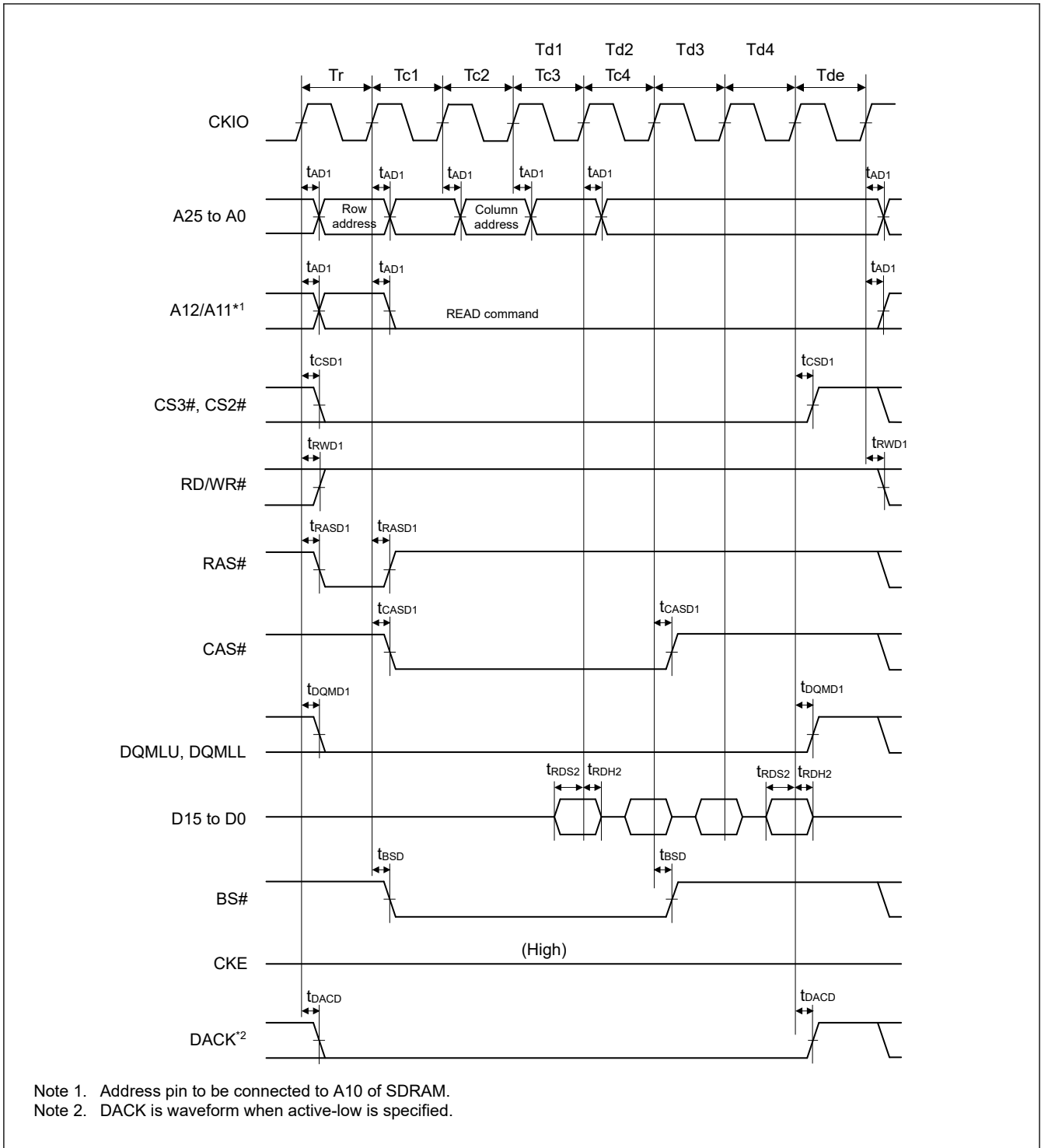
Note 1. Address pin to be connected to A10 of SDRAM.  
 Note 2. DACK is waveform when active-low is specified.

**Figure 2.25 Synchronous DRAM burst-write bus cycle (write for 4 cycles) (with auto precharge, WTRCD = 0 cycles, TRWL = 1 cycle)**

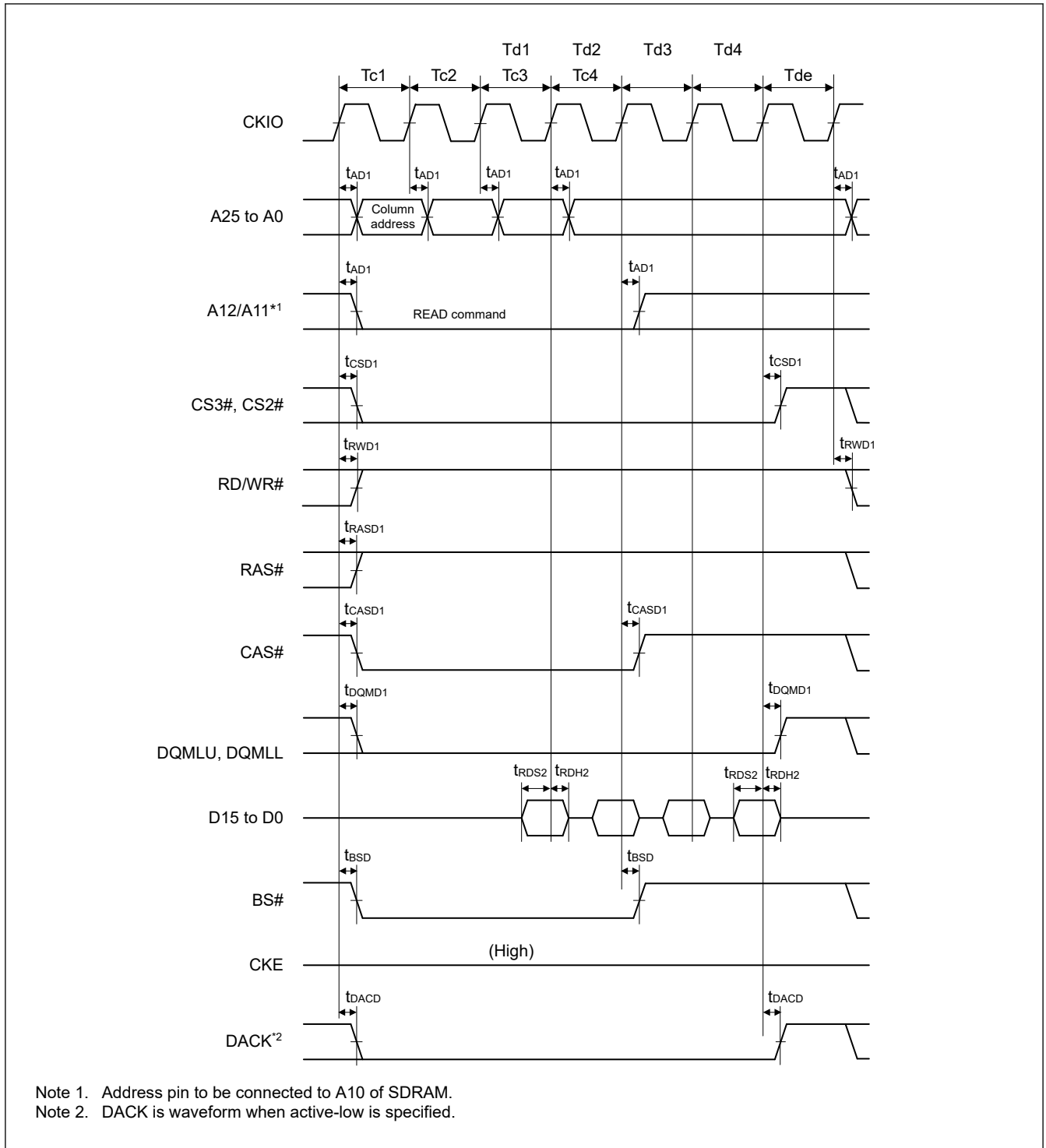


Note 1. Address pin to be connected to A10 of SDRAM.  
 Note 2. DACK is waveform when active-low is specified.

**Figure 2.26 Synchronous DRAM burst-write bus cycle (write for 4 cycles) (with auto precharge, WTRCD = 1 cycle, TRWL = 1 cycle)**

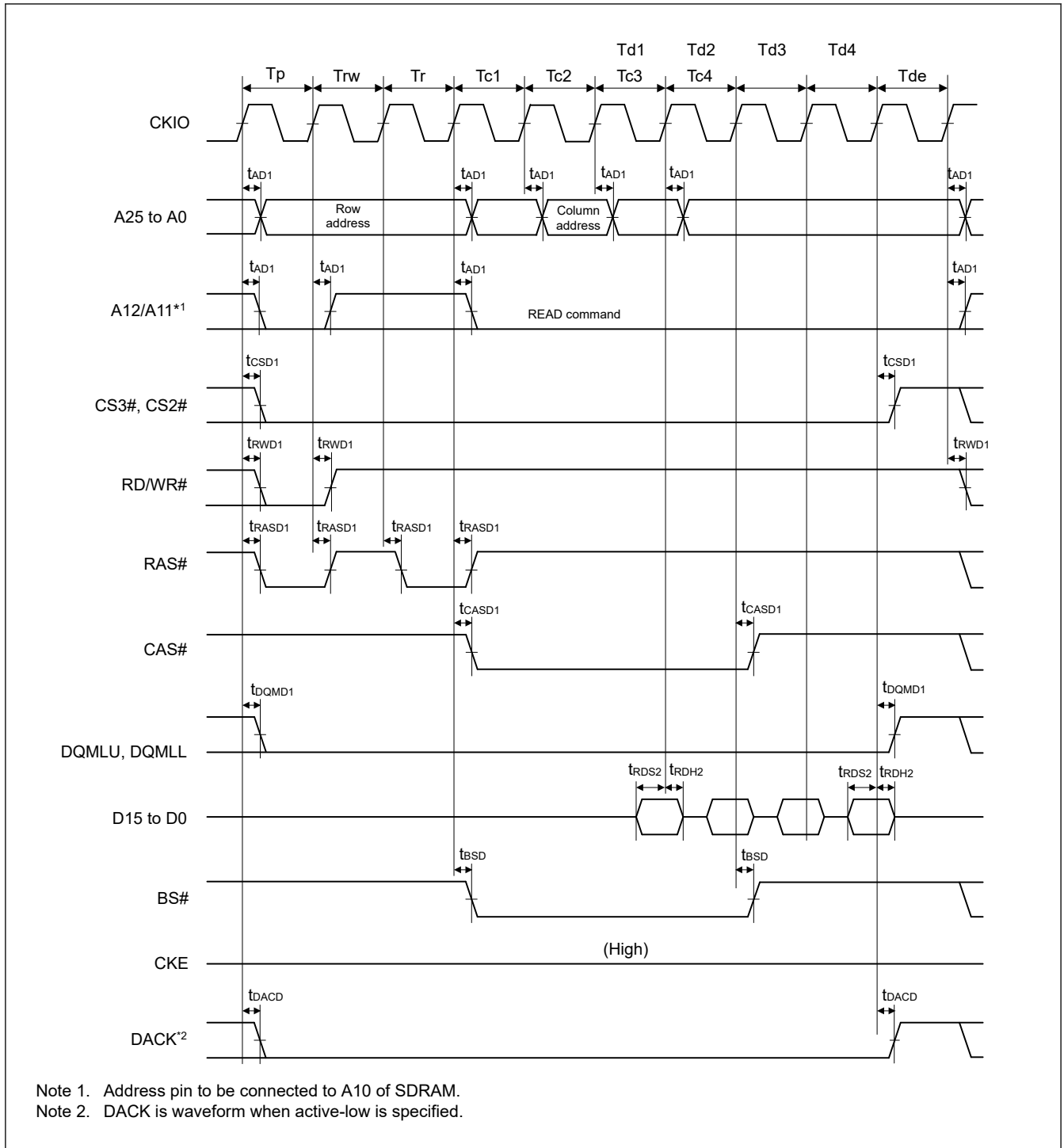


**Figure 2.27 Synchronous DRAM burst-read bus cycle (read for 4 cycles) (bank active mode: ACT + READ command, CAS latency 2, WTRCD = 0 cycles)**

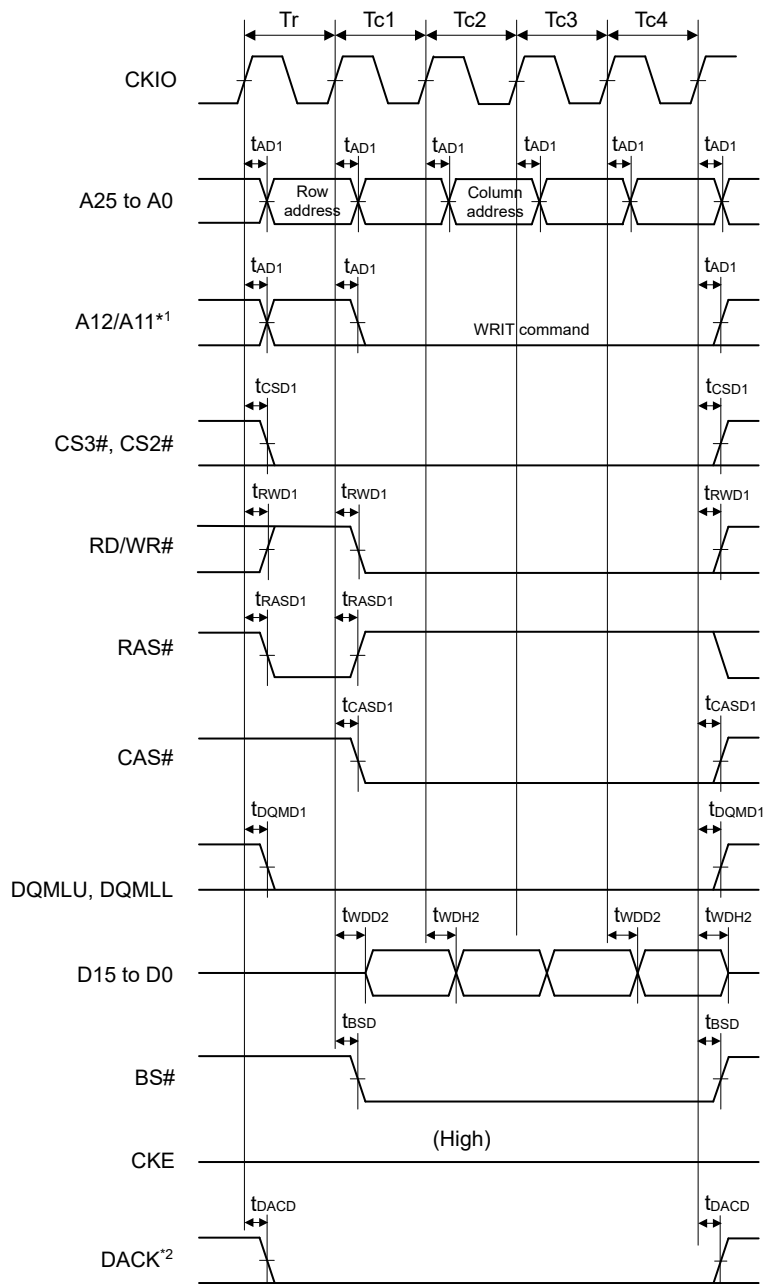


**Figure 2.28 Synchronous DRAM burst-read bus cycle (read for 4 cycles) (bank active mode: READ command, same row address, CAS latency 2, WTRCD = 0 cycles)**



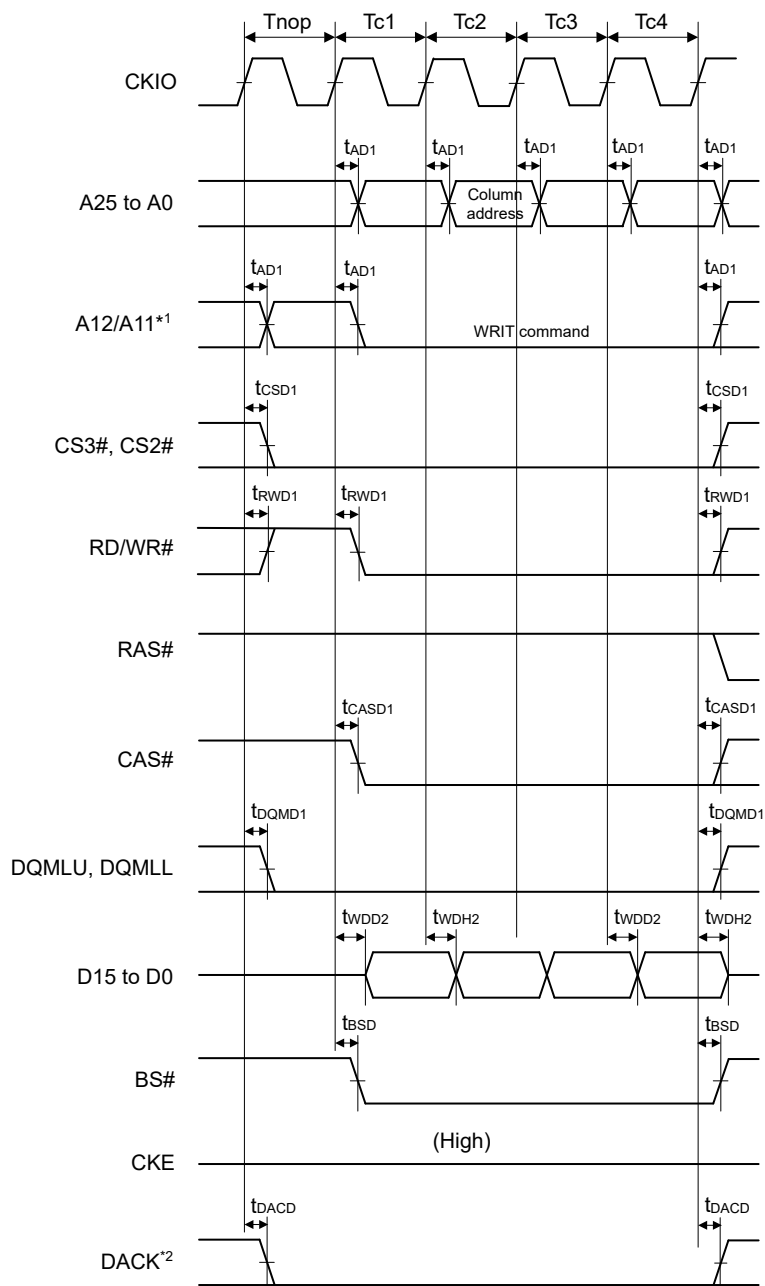


**Figure 2.29 Synchronous DRAM burst-read bus Cycle (read for 4 cycles) (bank active mode: PRE + ACT + READ command, different row address, CAS latency 2, WTRCD = 0 cycles)**



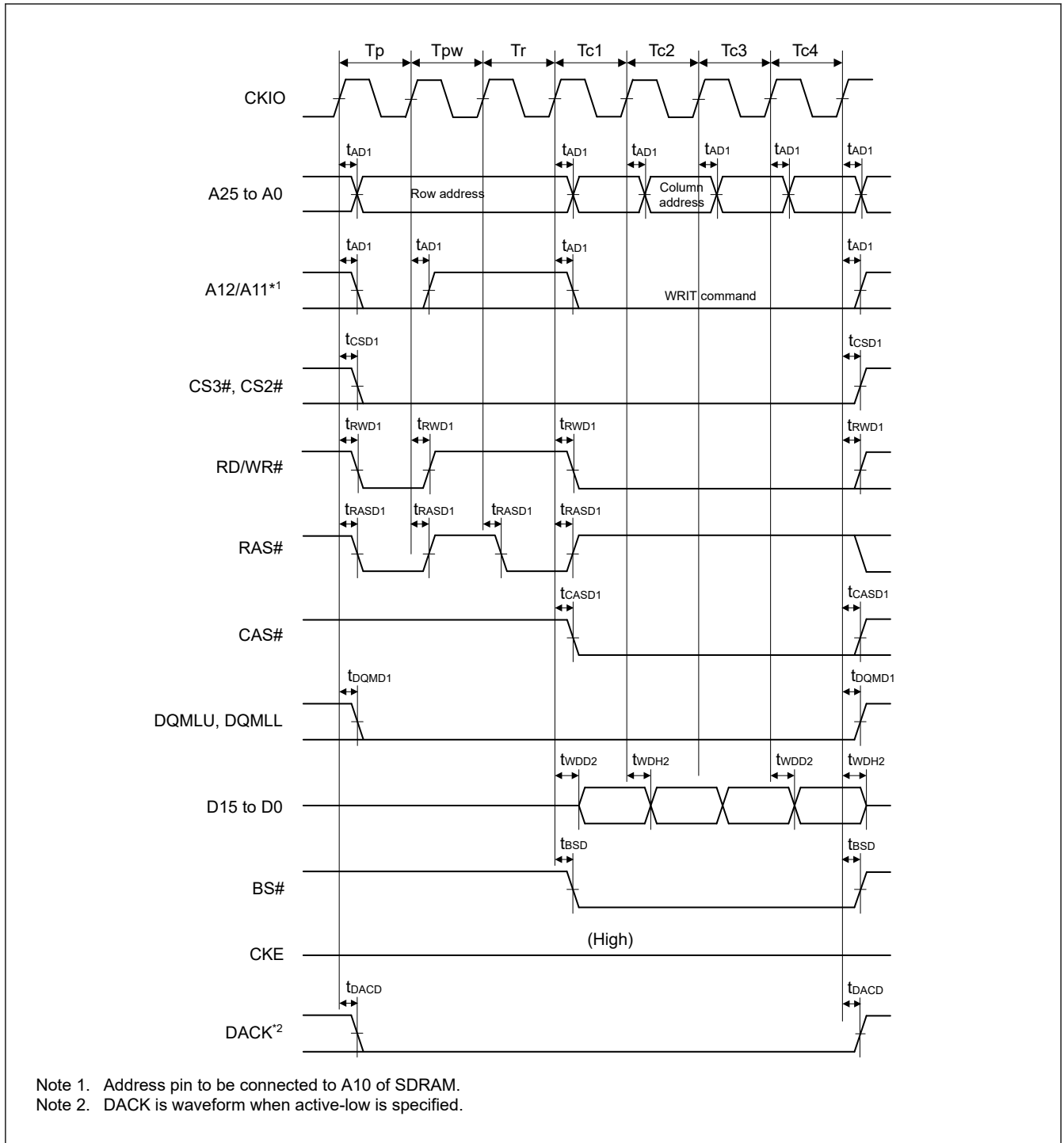
Note 1. Address pin to be connected to A10 of SDRAM.  
 Note 2. DACK is waveform when active-low is specified.

**Figure 2.30 Synchronous DRAM burst-write bus cycle (write for 4 cycles) (bank active mode: ACT + WRITE command, WTRCD = 0 cycles, TRWL = 0 cycles)**



Note 1. Address pin to be connected to A10 of SDRAM.  
 Note 2. DACK is waveform when active-low is specified.

**Figure 2.31 Synchronous DRAM burst-write bus cycle (write for 4 cycles) (bank active mode: WRITE command, same row address, WTRCD = 0 cycles, TRWL = 0 cycles)**



**Figure 2.32 Synchronous DRAM burst-write bus cycle (write for 4 cycles) (bank active mode: PRE + ACT + WRITE command, different row address, WTRCD = 0 cycles, TRWL = 0 cycles)**

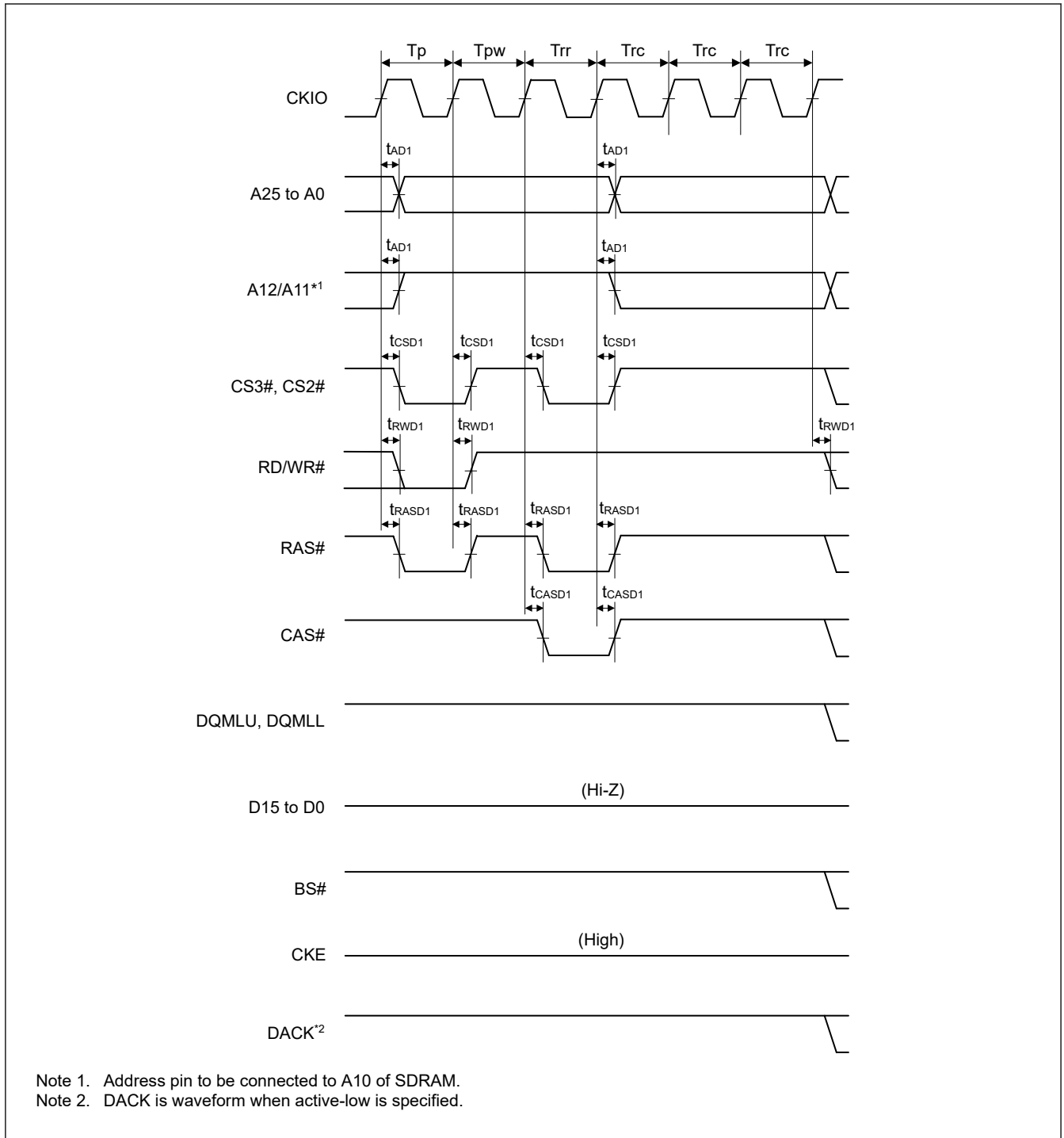


Figure 2.33 Synchronous DRAM auto-refresh timing (WTRP = 1 cycle, WTRC = 3 cycles)

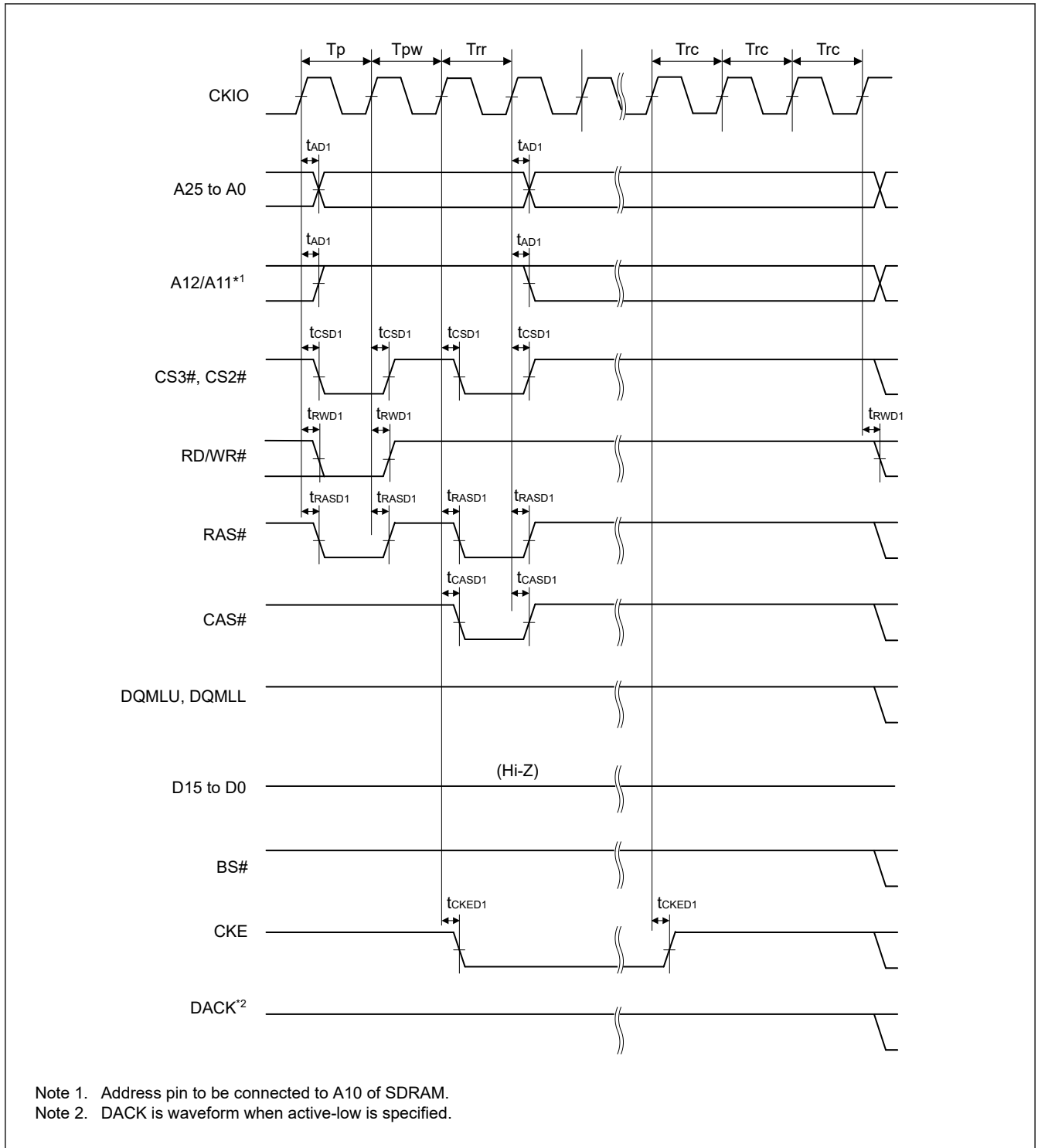


Figure 2.34 Synchronous DRAM self-refresh timing (WTRP = 1 cycle)

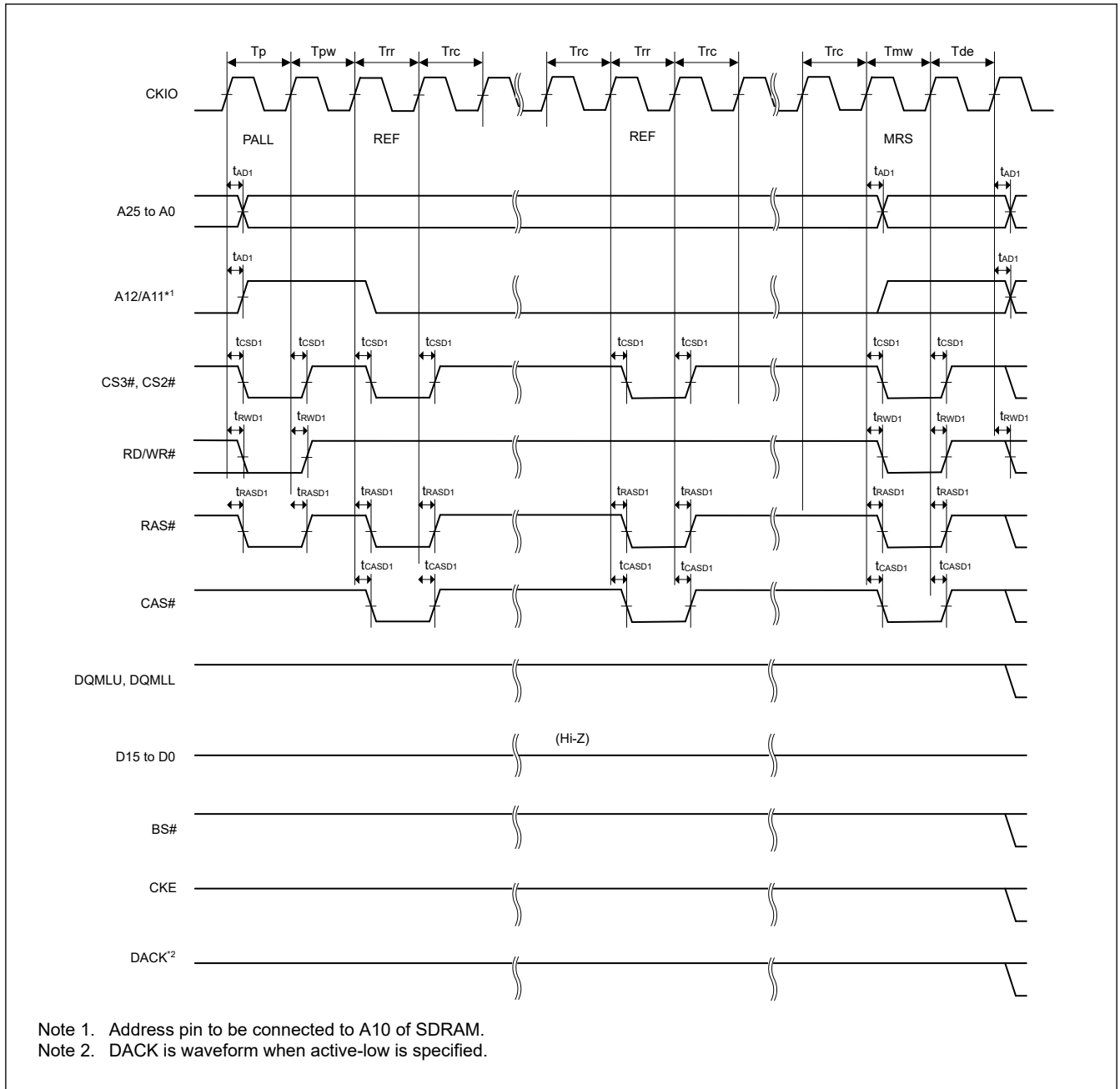


Figure 2.35 Synchronous DRAM mode register set timing (WTRP = 1 cycle)

### 2.5.4 DMAC Timing

Table 2.23 DMAC timing

Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 15 \text{ pF}$  (CKIO),  $30 \text{ pF}$  (others),  $T_{jmin} = -40^\circ\text{C}$

Parameter	Symbol	Min.*1	Max.	Unit	Reference figure
DMAC	DREQ pulse width	$t_{DRQW}$	$t_{PLCyc} \times 2$	ns	Figure 2.36
	DACK and TEND delay time	$t_{DACD}$	10	ns	Figure 2.37

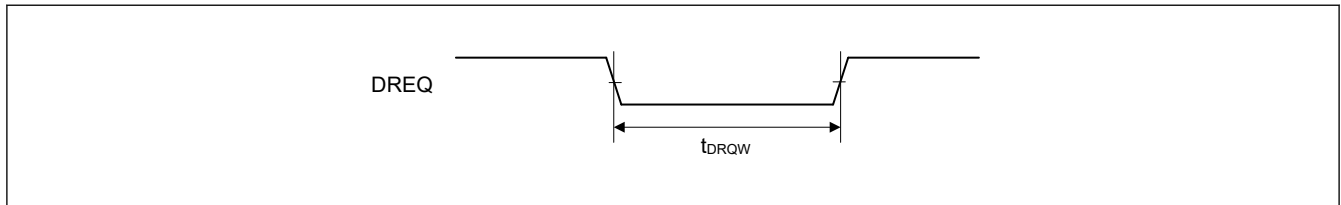
Note 1.  $t_{PLCyc}$ : PCLKL cycle

**Table 2.24 DMAC timing**

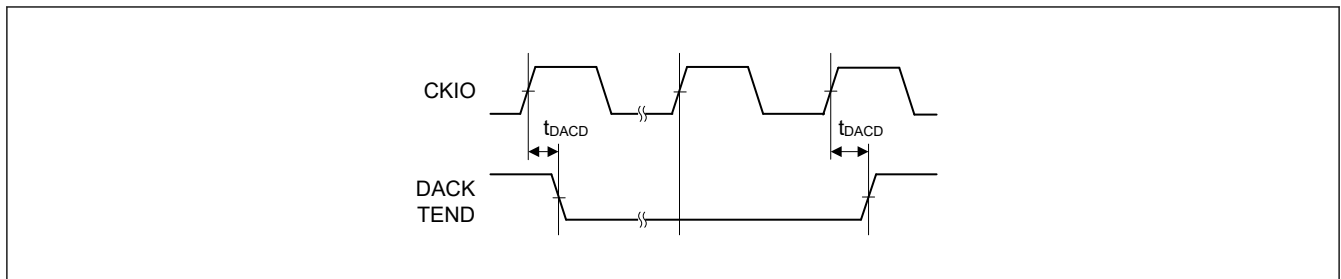
Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 12 \text{ pF}$  (CKIO),  $12 \text{ pF}$  (others),  $T_{jmin} = -20^\circ\text{C}$

Parameter		Symbol	Min.*1	Max.	Unit	Reference figure
DMAC	DREQ pulse width	$t_{DRQW}$	$t_{PLcyc} \times 2$	—	ns	<a href="#">Figure 2.36</a>
	DACK and TEND delay time	$t_{DACD}$	-0.5	8	ns	<a href="#">Figure 2.37</a>

Note 1.  $t_{PLcyc}$ : PCLKL cycle



**Figure 2.36 DREQ input timing**



**Figure 2.37 DACK and TEND output timing**

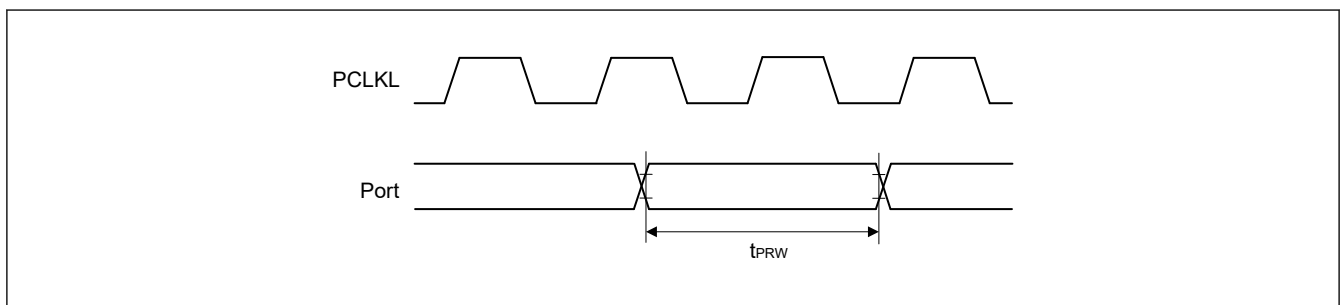
## 2.5.5 On-Chip Peripheral Module Timing

### 2.5.5.1 I/O Port Timing

**Table 2.25 I/O port timing**

Parameter		Symbol	Min.	Max.	Unit*1	Reference figure
I/O port	Input data pulse width	$t_{PRW}$	1.5	—	$t_{PLcyc}$	<a href="#">Figure 2.38</a>

Note 1.  $t_{PLcyc}$ : PCLKL cycle



**Figure 2.38 I/O port input timing**

### 2.5.5.2 CMTW Timing

**Table 2.26 CMTW timing**

Parameter		Symbol	Min.	Max.	Unit*1	Reference figure
CMTW	Input capture input pulse width	Single-edge setting	1.5	—	$t_{PLcyc}$	<a href="#">Figure 2.39</a>
		Both-edge setting	2.5	—		

Note 1.  $t_{PLcyc}$ : PCLKL cycle



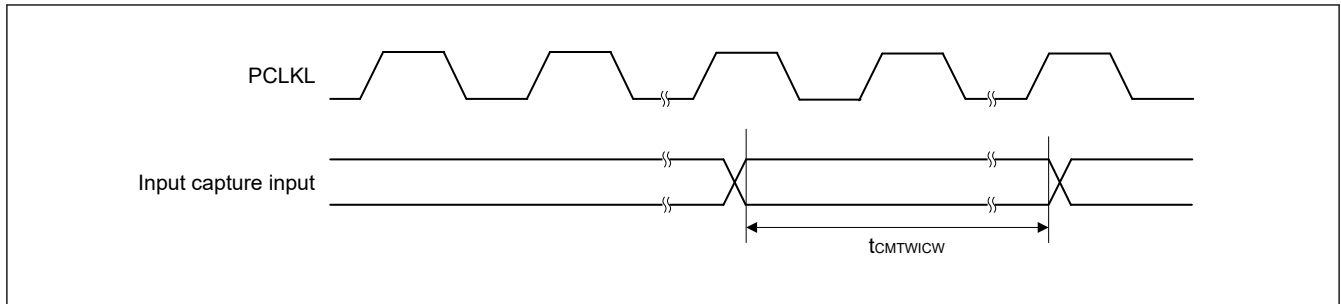


Figure 2.39 CMTW input capture input timing

### 2.5.5.3 MTU3 Timing

Table 2.27 MTU3 timing

Parameter		Symbol	Min.	Max.	Unit*1	Reference figure	
MTU3	Input capture input pulse width	Single-edge setting	t <sub>MTICW</sub>	2.5	—	t <sub>PHcyc</sub>	Figure 2.40
		Both-edge setting		3.5	—		
	Timer clock pulse width	Single-edge setting	t <sub>MTCKWH</sub>	2.5	—	t <sub>PHcyc</sub>	Figure 2.41
	Both-edge setting	t <sub>MTCKWL</sub>	3.5	—			
	Phase counting mode		3.5	—			

Note 1. t<sub>PHcyc</sub>: PCLKH cycle

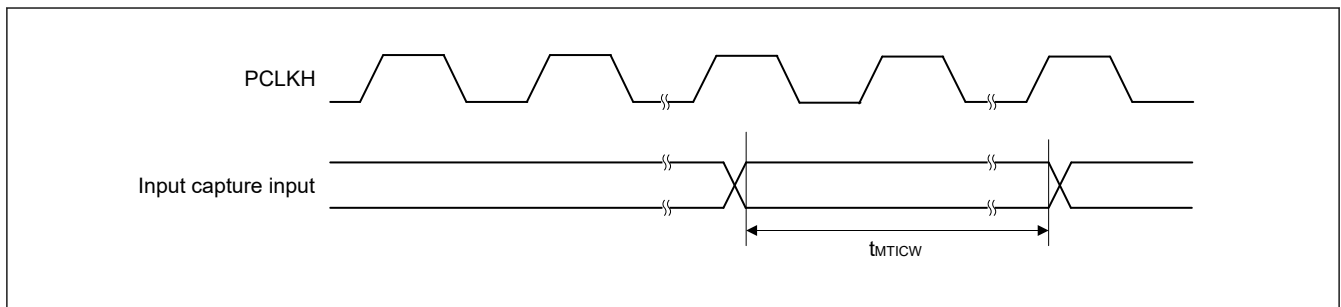


Figure 2.40 MTU3 input capture input timing

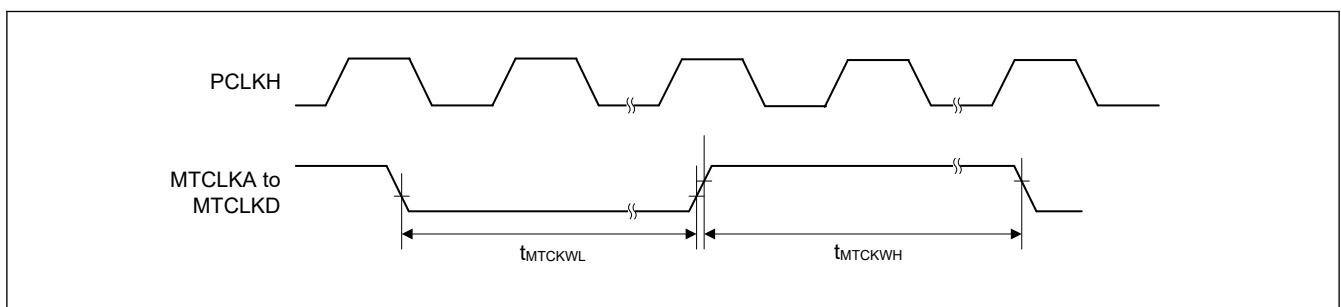


Figure 2.41 MTU3 clock input timing

2.5.5.4 POE3 Timing

Table 2.28 POE3 timing

Parameter		Symbol	Min.	Max.	Unit*1	Reference figure	
POE3	POEn# input pulse width	$t_{POEW}$	2.5	—	$t_{PHcyc}$	Figure 2.42	
	Output disable time	Transition of the POEn# signal level	$t_{POEDI}$	—	$5 \times PCLKH + 0.1$	$\mu s$	Figure 2.43
		Simultaneous conduction of output pins	$t_{POEDO}$	—	$3 \times PCLKH + 0.1$	$\mu s$	Figure 2.44
		Register setting	$t_{POEDS}$	—	$PCLKH + 0.1$	$\mu s$	Figure 2.45
		Oscillation stop detection	$t_{POEDOS}$	—	74	$\mu s$	Figure 2.46

Note 1.  $t_{PHcyc}$ : PCLKH cycle

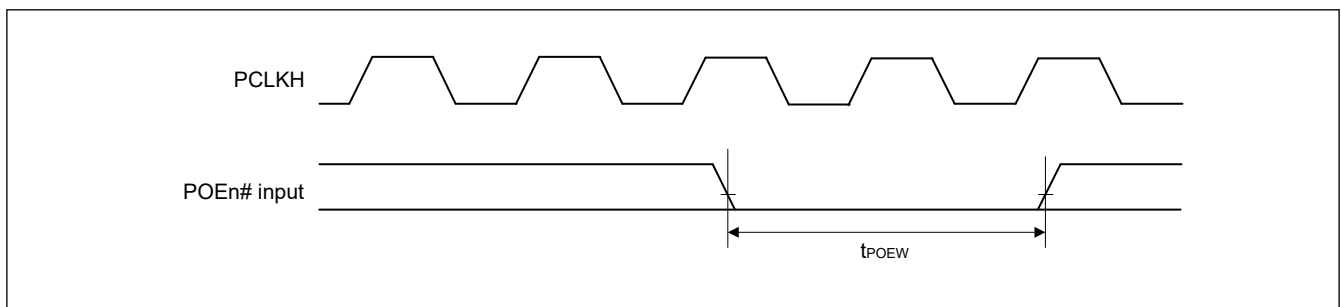


Figure 2.42 POEn# input pulse timing

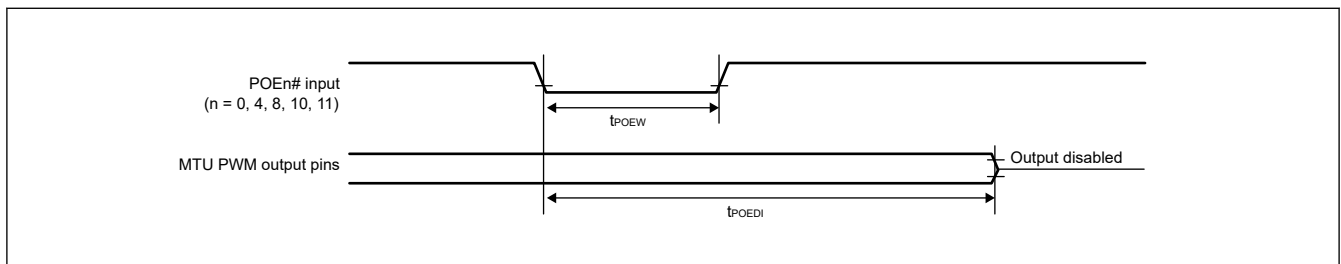
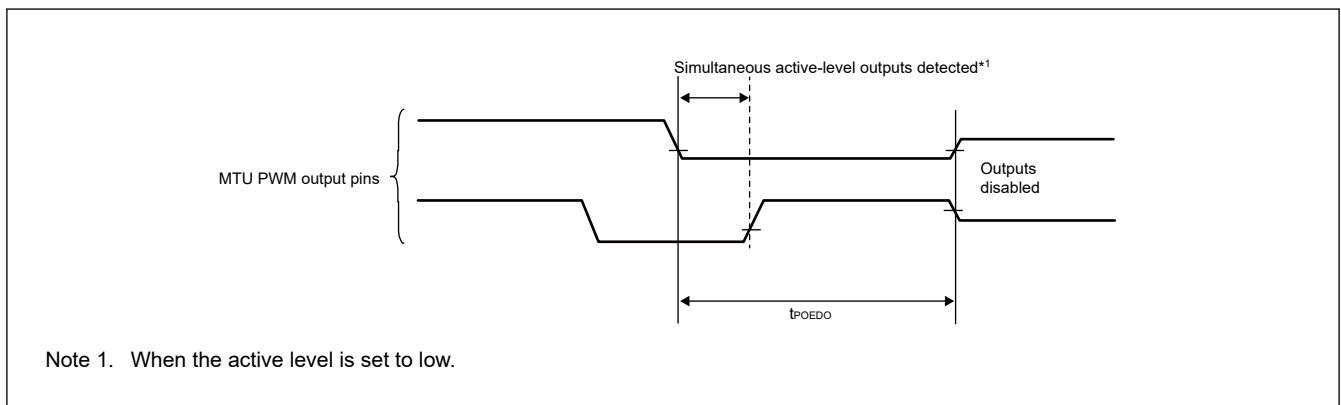


Figure 2.43 Output disable time for POE in response to transition of the POEn# signal level



Note 1. When the active level is set to low.

Figure 2.44 Output disable time for POE in response to the simultaneous conduction of output pins

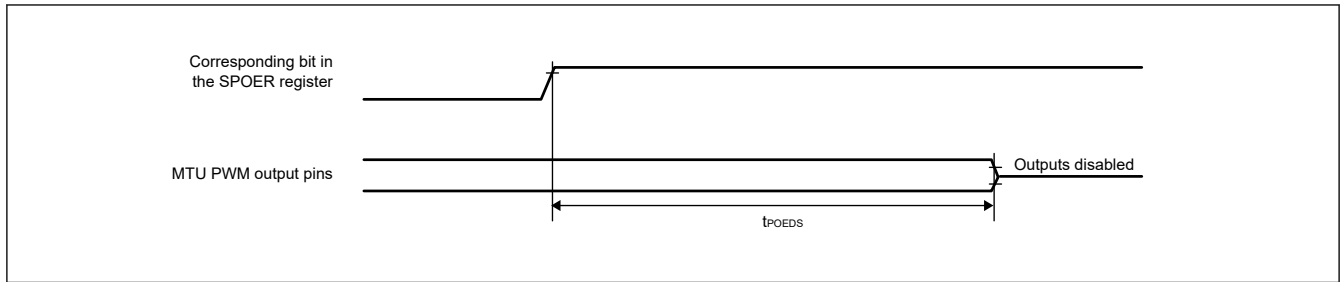


Figure 2.45 Output disable time for POE in response to the register setting

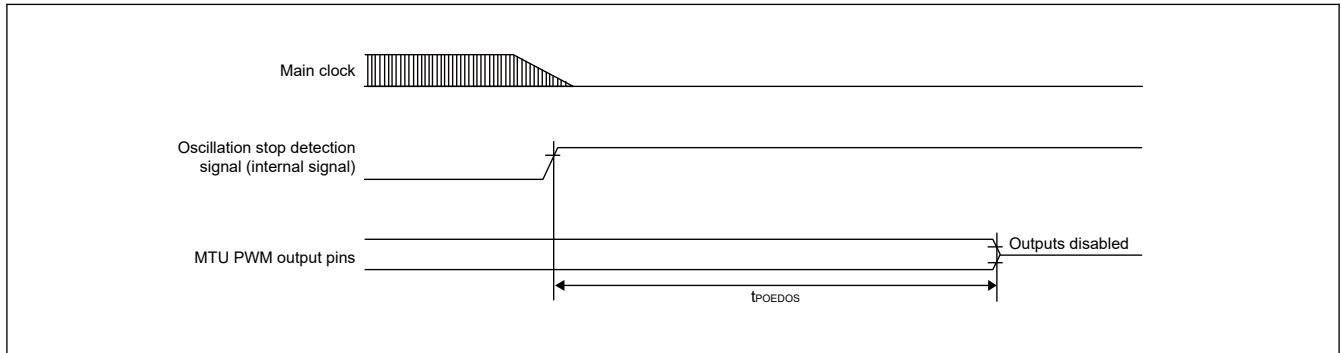


Figure 2.46 Output disable time for POE in response to the oscillation stop detection

### 2.5.5.5 GPT Timing

Table 2.29 GPT timing

Parameter		Symbol	Min.	Max.	Unit*1	Reference figure
GPT	Input capture input pulse width	Single-edge setting	2.5	—	$t_{PHcyc}$	Figure 2.47
		Both-edge setting				
GPT	External trigger input pulse width	Single-edge setting	2.5	—	$t_{PHcyc}$	Figure 2.48
		Both-edge setting				

Note 1.  $t_{PHcyc}$ : PCLKH cycle (LLPP channels), PCLKM cycle (Other channels)

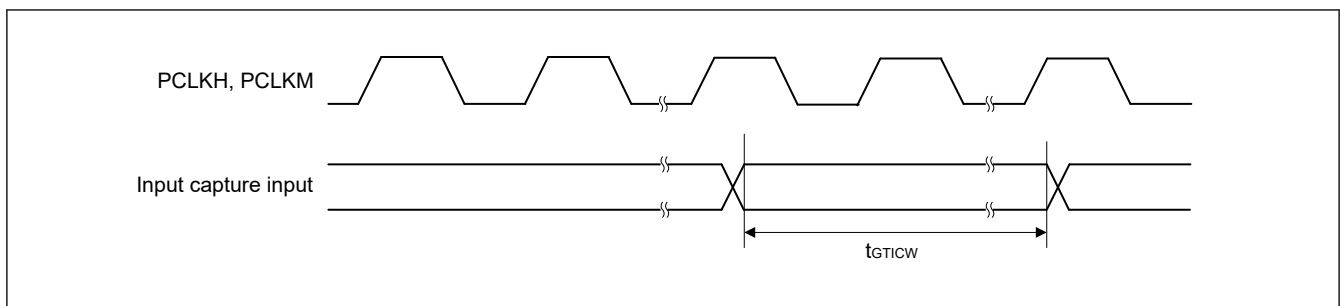


Figure 2.47 GPT input capture input timing

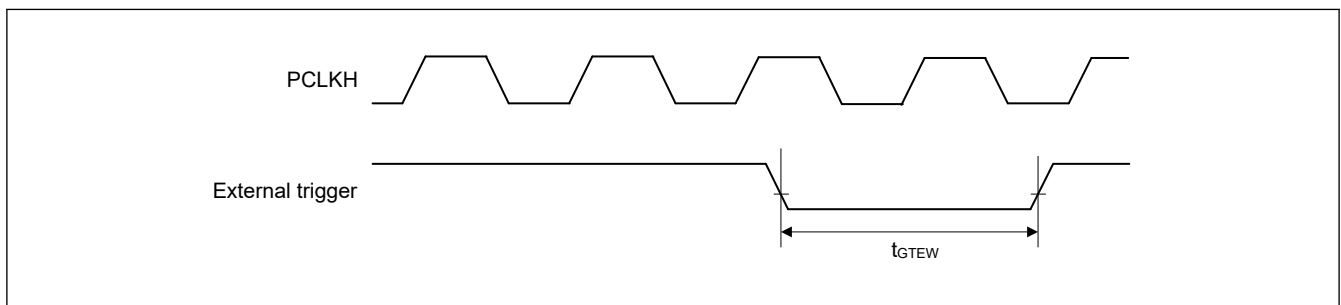


Figure 2.48 GPT external trigger input timing

2.5.5.6 POEG Timing

Table 2.30 POEG timing

Parameter		Symbol	Min.	Max.	Unit*1	Reference figure	
POEG	GTETRn input pulse width (n = A to D)	$t_{POEGW}$	2.5	—	$t_{PHcyc}$	Figure 2.49	
	Output disable time	Input level detection of the GTETRn pin (via flag)	$t_{POEGDI}$	—	$3 \times PCLKH + 0.1$	$\mu s$	Figure 2.50
		Detection of the output stopping signal from GPT (dead time error, simultaneous high output, or simultaneous low output)	$t_{POEGDO}$	—	0.1	$\mu s$	Figure 2.51
		Register setting	$t_{POEGDS}$	—	$PCLKH + 0.1$	$\mu s$	Figure 2.52
		Oscillation stop detection	$t_{POEGDOS}$	—	74	$\mu s$	Figure 2.53

Note 1.  $t_{PHcyc}$ : PCLKH cycle (LLPP channels), PCLKL cycle (Other channels)

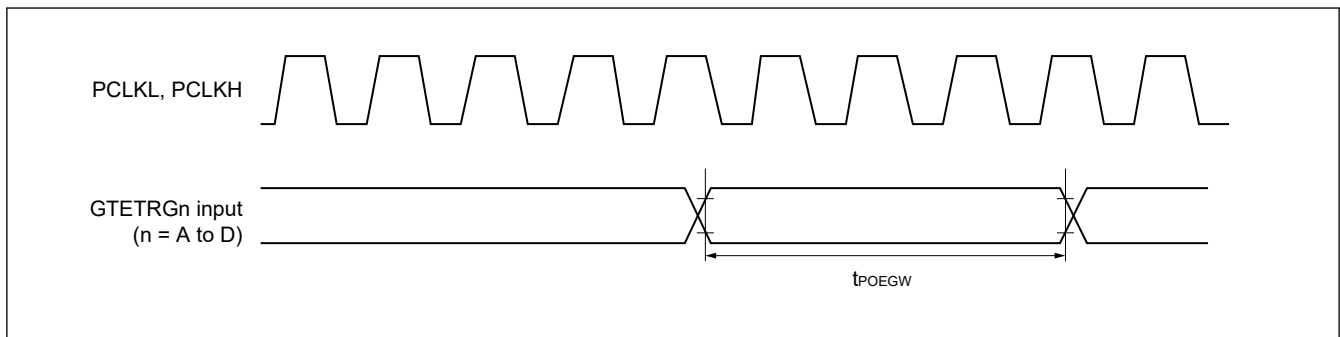


Figure 2.49 POEG input timing

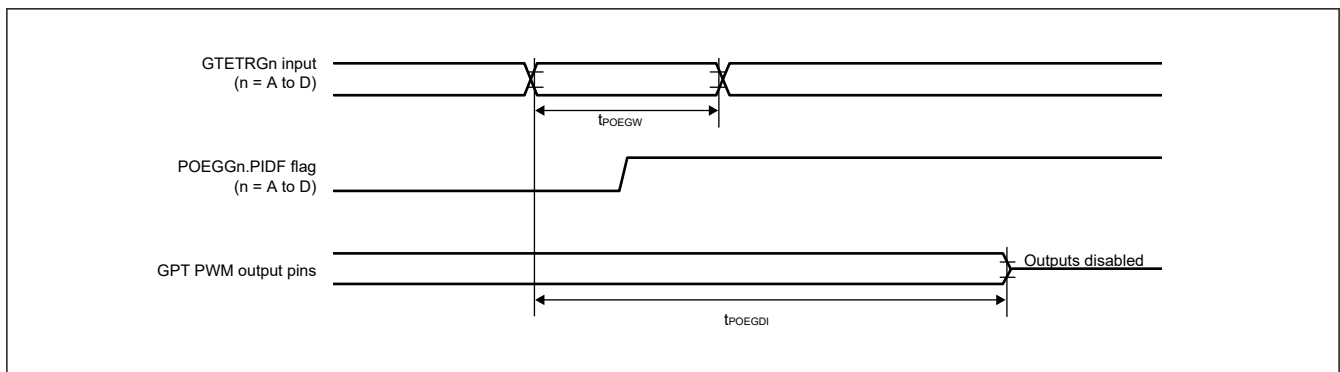
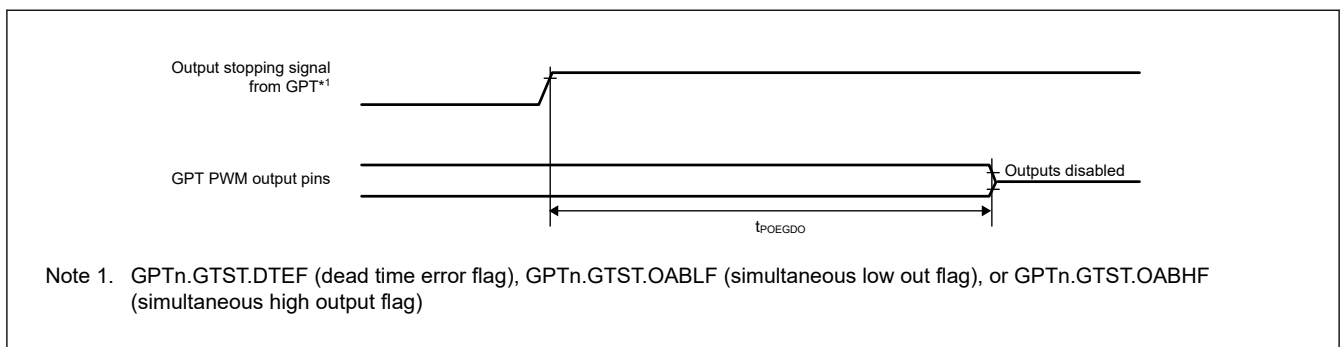


Figure 2.50 Output disable time for POEG via detection flag in response to the input level detection of the GTETRn pin



Note 1. GPTn.GTST.DTEF (dead time error flag), GPTn.GTST.OABLF (simultaneous low out flag), or GPTn.GTST.OABHF (simultaneous high output flag)

Figure 2.51 Output disable time for POEG in response to detection of the output stopping signal from GPT

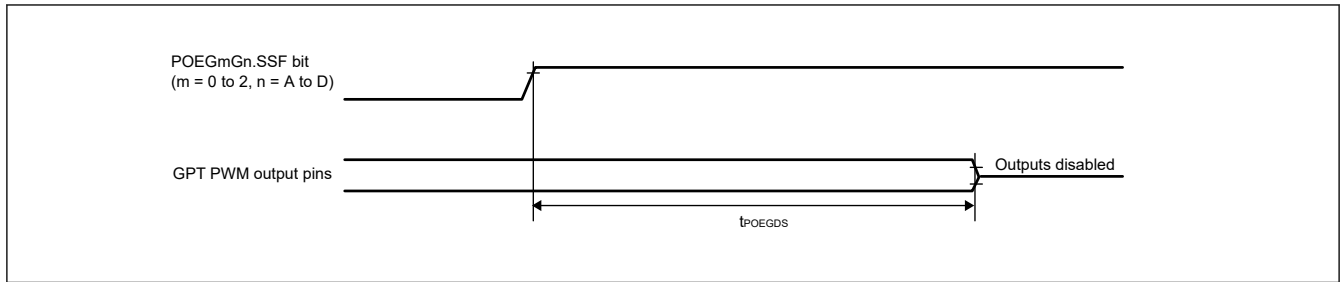


Figure 2.52 Output disable time for POEG in response to the register setting

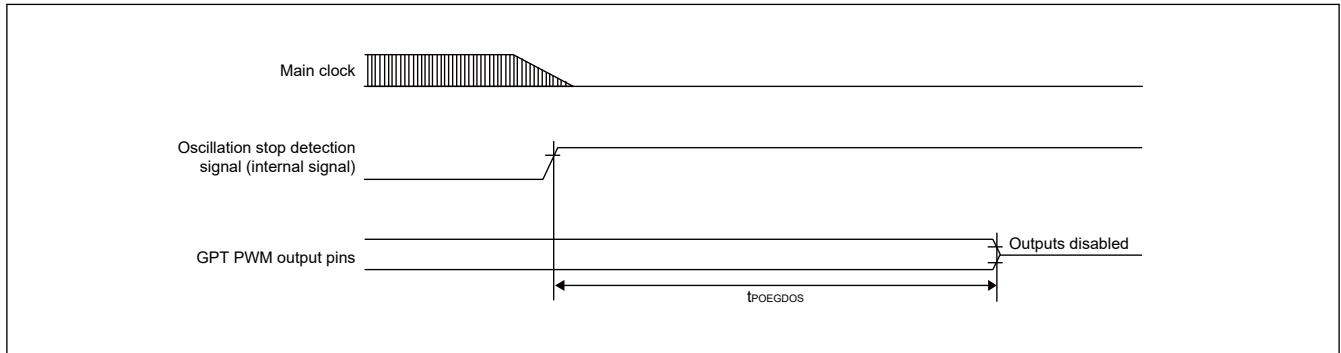


Figure 2.53 Output disable time for POEG in response to the oscillation stop detection

### 2.5.5.7 A/D Converter Trigger Timing

Table 2.31 A/D converter trigger timing

Parameter			Symbol	Min.	Max.	Unit*1	Reference figure
A/D converter	A/D converter trigger input pulse width	ADTRG0#, ADTRG1#	t <sub>TRGW</sub>	1.5	—	t <sub>PADCcyc</sub>	Figure 2.54

Note 1. t<sub>PADCcyc</sub>: PCLKADC cycle

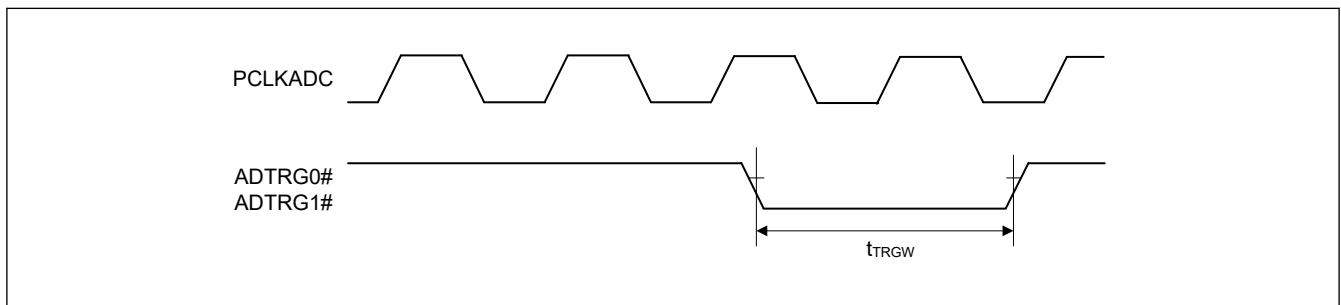


Figure 2.54 A/D converter trigger input timing (ADTRG0#, ADTRG1#)

### 2.5.5.8 SCI Timing

Conditions: V<sub>OH</sub> = VCC33 × 0.5, V<sub>OL</sub> = VCC33 × 0.5, C = 30 pF (except Simple I2C)

**Table 2.32 SCI timing (1 of 2)**

Parameter		Symbol	Min.	Max.	Unit	Reference figure
SCI (Asynchronous)	Input clock cycle	$t_{Scyc}$	4	—	$t_{PSClCyc}$	Figure 2.55
	Input clock pulse width	$t_{SCKW}$	0.4	0.6	$t_{Scyc}$	
	Input clock rise time	$t_{SCKr}$	—	3	ns	
	Input clock fall time	$t_{SCKf}$	—	3	ns	
	Output clock cycle	$t_{Scyc}$	6	—	$t_{PSClCyc}$	
	Output clock pulse width	$t_{SCKW}$	0.4	0.6	$t_{Scyc}$	
	Output clock rise time	$t_{SCKr}$	—	3	ns	
	Output clock fall time	$t_{SCKf}$	—	3	ns	
SCI (Simple I2C, Standard mode)	SDA input rise time	$t_{Sr}$	—	1000	ns	Figure 2.56
	SDA input fall time	$t_{Sf}$	—	300	ns	
	SCL, SDA input spike pulse removal time	$t_{SP}$	0	$2 \times NF_{cyc}^{*1}$	ns	
	Data input setup time	$t_{SDAS}$	250	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load	$C_b$	—	400	pF	
SCI (Simple I2C, Fast mode)	SDA input rise time	$t_{Sr}$	—	300	ns	Figure 2.56
	SDA input fall time	$t_{Sf}$	—	300	ns	
	SCL, SDA input spike pulse removal time	$t_{SP}$	0	$2 \times NF_{cyc}^{*1}$	ns	
	Data input setup time	$t_{SDAS}$	100	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load	$C_b$	—	400	pF	

**Table 2.32 SCI timing (2 of 2)**

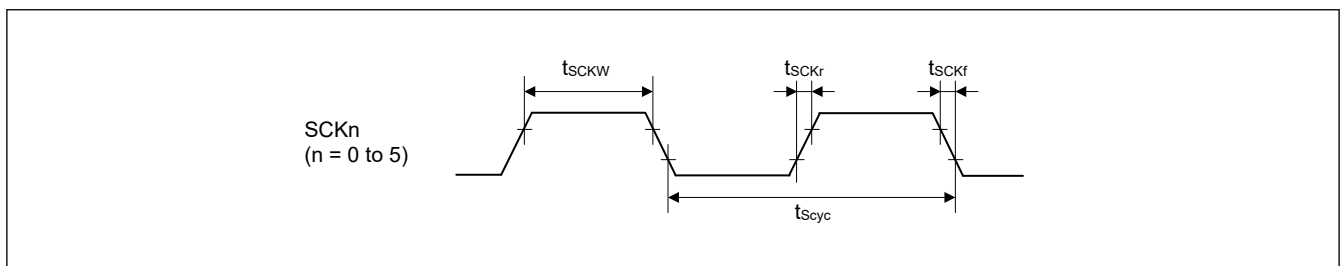
Parameter		Symbol	Min.	Max.	Unit	Reference figure	
SCI (Clock sync, Simple SPI)	SCK output clock cycle (master)	$t_{SPcyc}$	2	65536	$t_{PSClcyc}$	Figure 2.57 to Figure 2.62	
	SCK input clock cycle (slave)		2	65536			
	SCK clock high pulse width	$t_{SPCKWH}$	0.4	0.6	$t_{SPcyc}$		
	SCK clock low pulse width	$t_{SPCKWL}$	0.4	0.6	$t_{SPcyc}$		
	SCK clock rise/fall time	$t_{SPCKR}$ , $t_{SPCKF}$	—	3	ns		
	Data input setup time	Internal clock	$t_{SU}$	7	—		ns
		External clock		3	—		
	Data input hold time	Internal clock	$t_H$	3	—		ns
		External clock		3	—		
	Data output delay time	Internal clock	$t_{OD}$	—	3		ns
		External clock		—	12		
	Data output hold time	Internal clock	$t_{OH}$	0	—		ns
		External clock		0	—		
Data rise/fall time		$t_{DR}$ , $t_{DF}$	—	3	ns		
Slave access time	Internal clock	$t_{SA}$	—	$3 \times t_{PSClcyc} + 12$	ns		
	External clock		—	$3 \times t_{PSClcyc} + 12$			
Slave output release time	Internal clock	$t_{REL}$	—	$3 \times t_{PSClcyc} + 12$	ns		
	External clock		—	$3 \times t_{PSClcyc} + 12$			
SCI (Simple SPI)	SS input setup time	$t_{LEAD}$	1	—	$t_{SPcyc}$		
	SS input hold time	$t_{LAG}$	1	—	$t_{SPcyc}$		
	SS input rise/fall time	$t_{SSR}$ , $t_{SSF}$	—	3	ns		

Note:  $t_{PSClcyc}$ : PCLKSCIn cycle

Note 1.  $N_{Fcy} = 4^n \times 2^{m-1} \times t_{PSClcyc}$

n: CCR2.CKS[1:0] (n = 0, 1, 2, 3)

m: CCR1.NFCS[2:0] (m = 1, 2, 3, 4)

**Figure 2.55 SCK clock input/output timing**

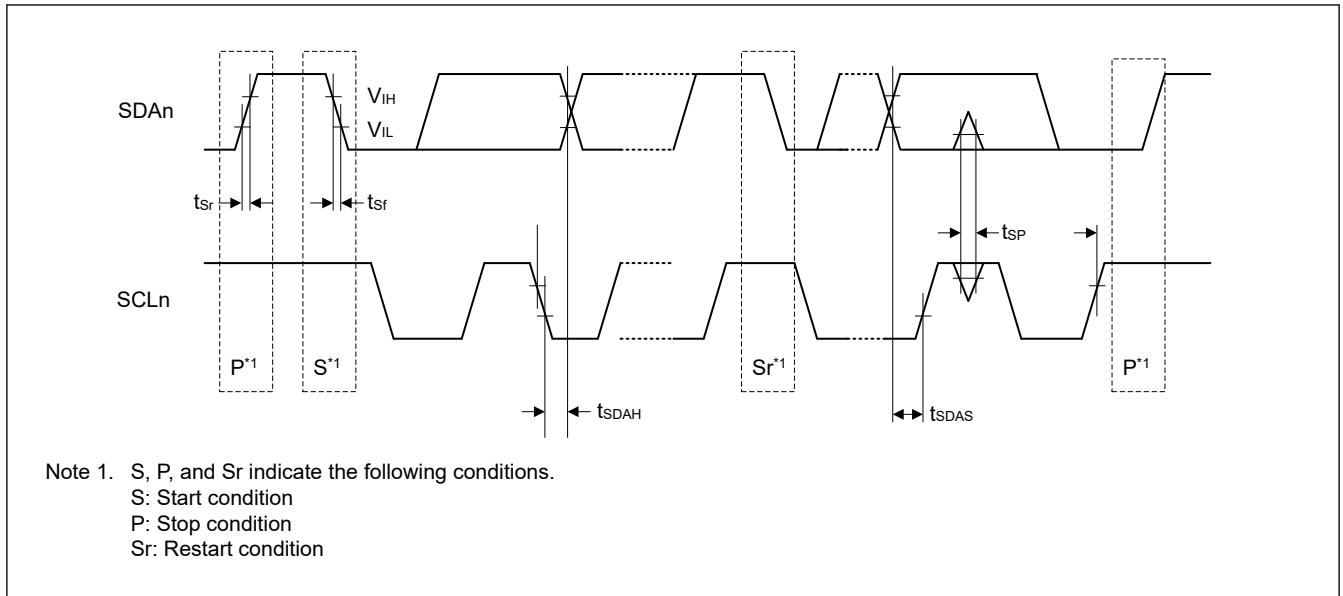


Figure 2.56 SCI simple I2C mode timing

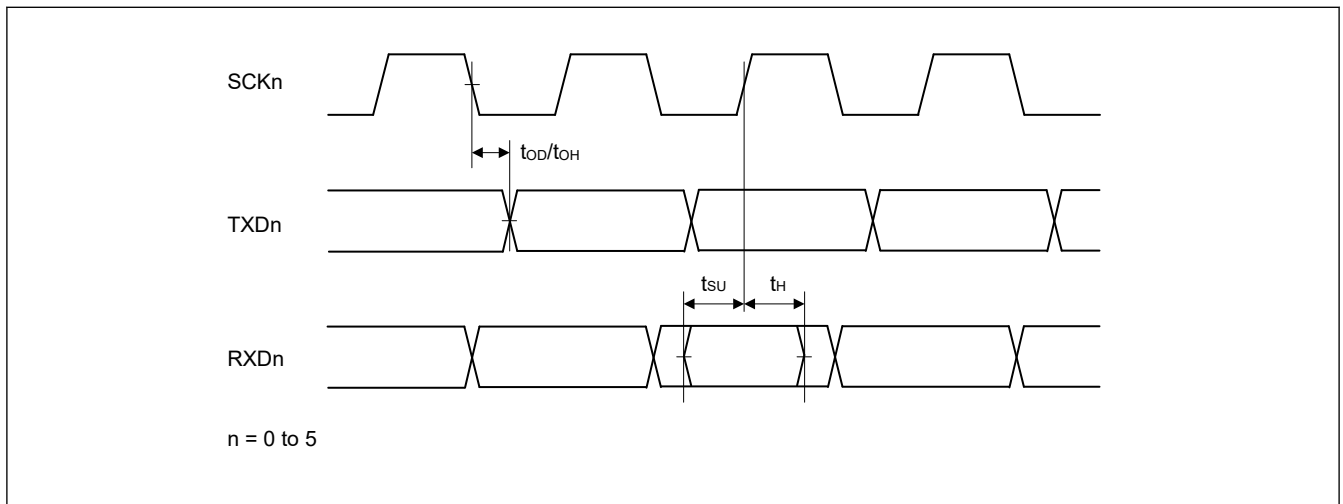


Figure 2.57 SCI input/output timing in clock synchronous mode

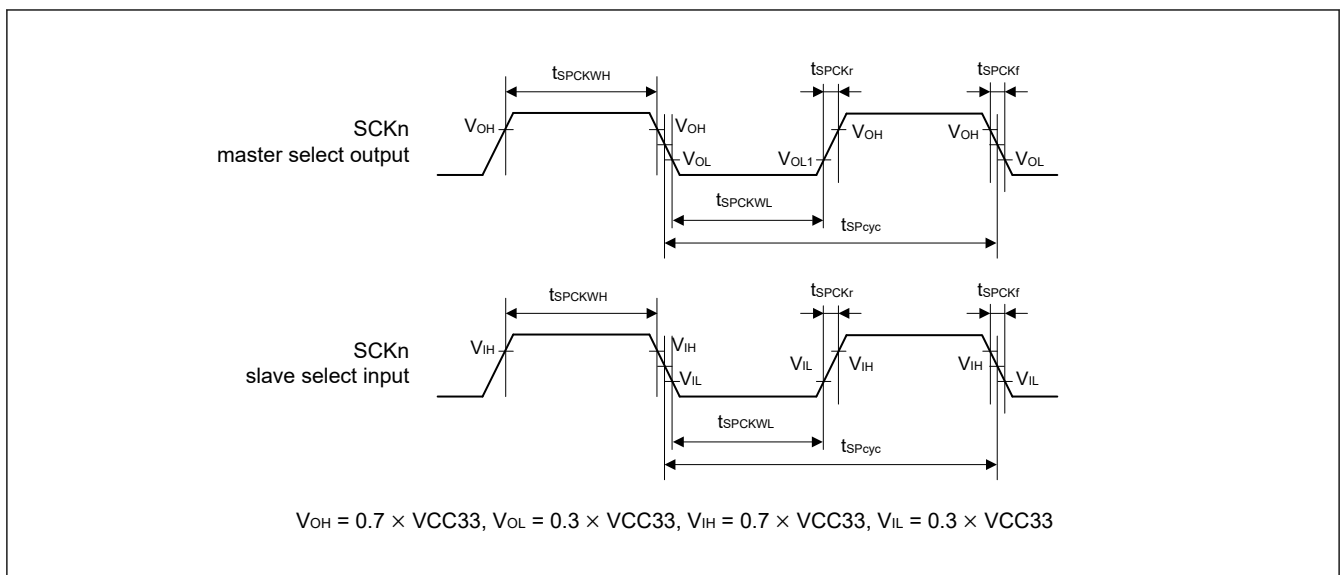


Figure 2.58 SCI simple SPI mode clock timing



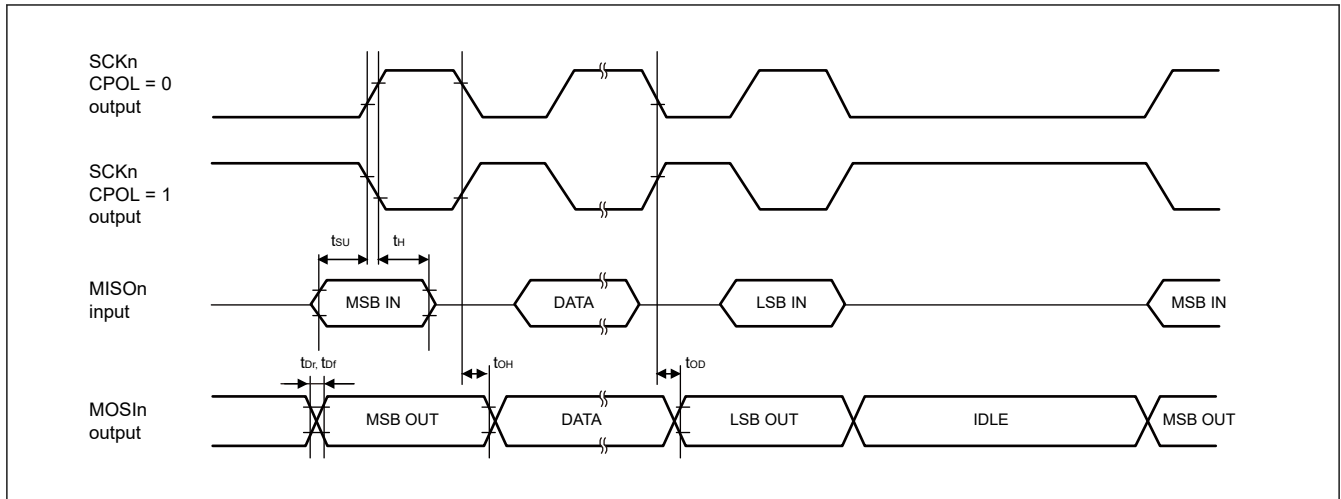


Figure 2.59 SCI simple SPI mode timing for master when CPHA = 0

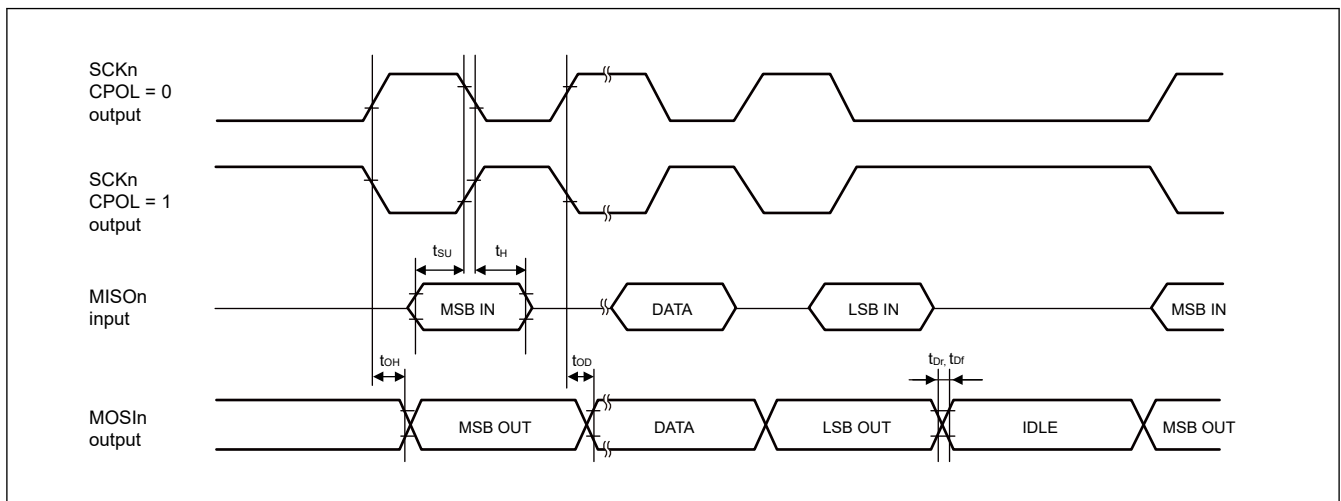


Figure 2.60 SCI simple SPI mode timing for master when CPHA = 1

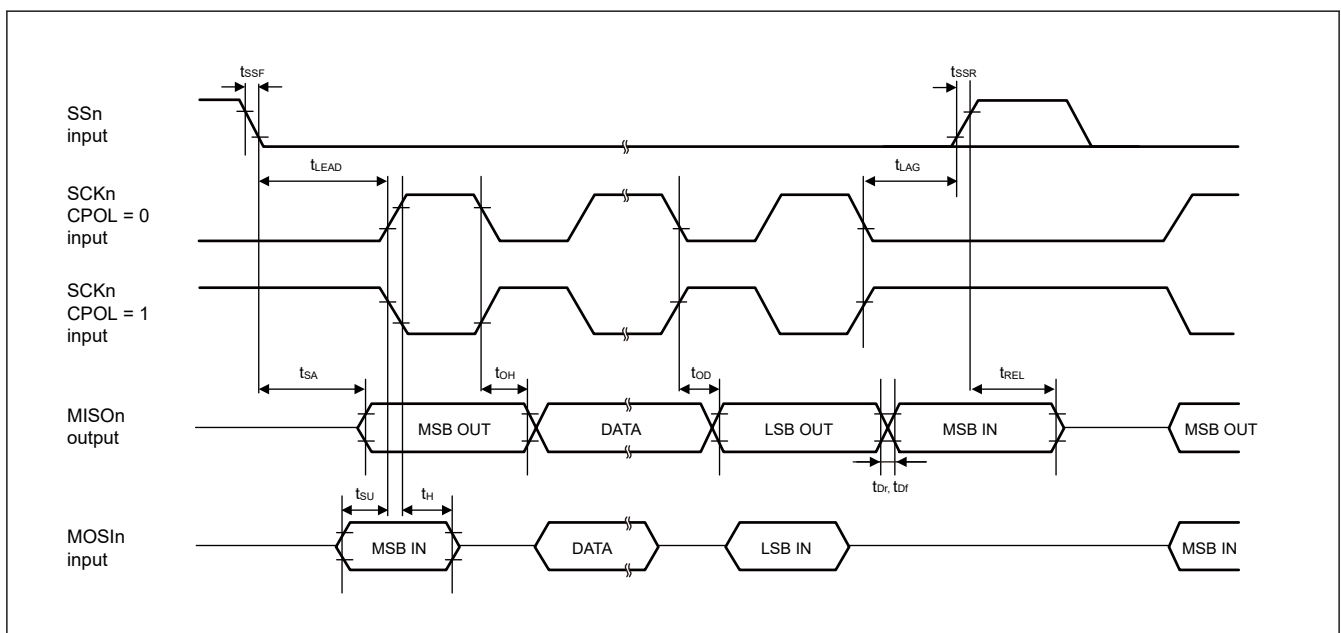


Figure 2.61 SCI simple SPI mode timing for slave when CPHA = 0

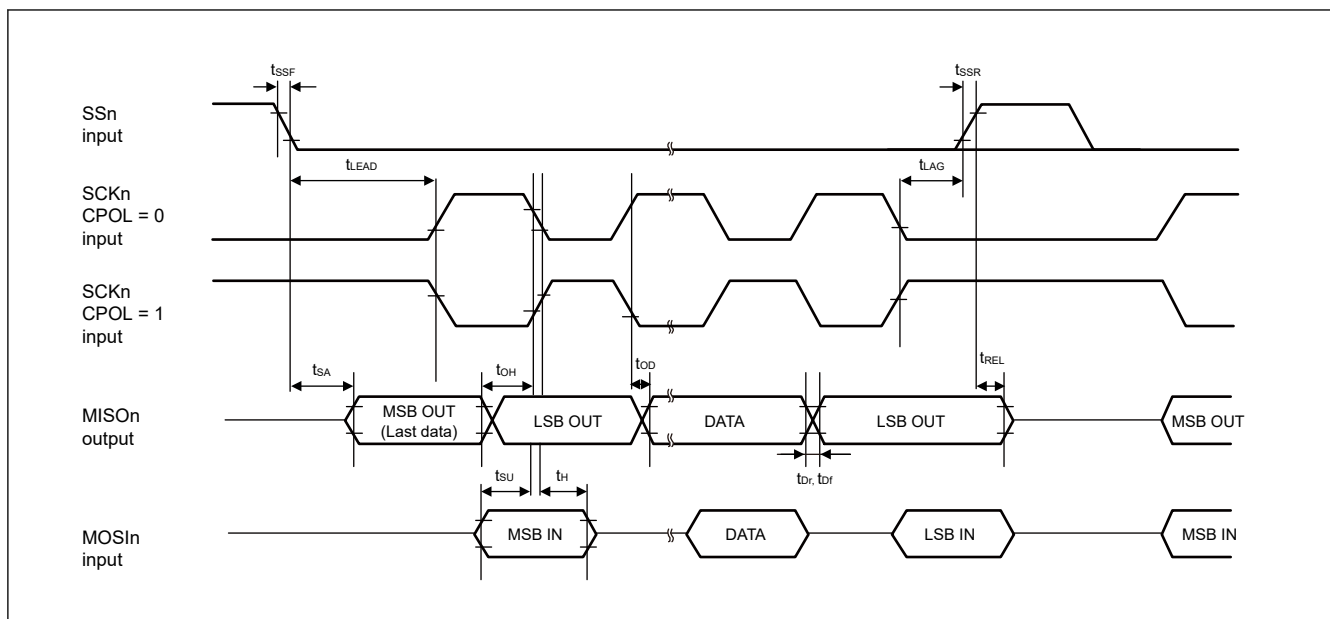


Figure 2.62 SCI simple SPI mode timing for slave when CPHA = 1

### 2.5.5.9 IIC Timing

Conditions:  $V_{OL} = 0.4\text{ V}$ ,  $I_{OL} = 4\text{ mA}$

Table 2.33 IIC timing

Parameter		Symbol	Min.*1 *2	Max.*1 *2	Unit	Reference figure
IIC (Standard-mode)	SCL input cycle time	$t_{SCL}$	$6(12) \times t_{IICcyc} + 1300$	—	ns	Figure 2.63
	SCL input high pulse width	$t_{SCLH}$	$3(6) \times t_{IICcyc} + 300$	—	ns	
	SCL input low pulse width	$t_{SCLL}$	$3(6) \times t_{IICcyc} + 300$	—	ns	
	SCL, SDA input rising time	$t_{sr}$	—	1000	ns	
	SCL, SDA input falling time	$t_{sf}$	—	300	ns	
	SCL, SDA input spike pulse removal time	$t_{SP}$	0	$1(4) \times t_{IICcyc}$	ns	
	SDA input bus free time	$t_{BUF}$	$3(6) \times t_{IICcyc} + 300$	—	ns	
	Start condition input hold time	$t_{STAH}$	$t_{IICcyc} + 300$	—	ns	
	Restart condition input setup time	$t_{STAS}$	1000	—	ns	
	Stop condition input setup time	$t_{STOS}$	1000	—	ns	
	Data input setup time	$t_{SDAS}$	$t_{IICcyc} + 50$	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load	$C_b$	—	400	pF	
IIC (Fast-mode)	SCL input cycle time	$t_{SCL}$	$6(12) \times t_{IICcyc} + 600$	—	ns	
	SCL input high pulse width	$t_{SCLH}$	$3(6) \times t_{IICcyc} + 300$	—	ns	
	SCL input low pulse width	$t_{SCLL}$	$3(6) \times t_{IICcyc} + 300$	—	ns	
	SCL, SDA input rising time	$t_{sr}$	—*4	300	ns	
	SCL, SDA input falling time	$t_{sf}$	—*4	300	ns	
	SCL, SDA input spike pulse removal time	$t_{SP}$	0	$1(4) \times t_{IICcyc}$	ns	
	SDA input bus free time	$t_{BUF}$	$3(6) \times t_{IICcyc} + 300$	—	ns	
	Start condition input hold time	$t_{STAH}$	$t_{IICcyc} + 300$	—	ns	
	Restart condition input setup time	$t_{STAS}$	300	—	ns	
	Stop condition input setup time	$t_{STOS}$	300	—	ns	
	Data input setup time	$t_{SDAS}$	$t_{IICcyc} + 50$	—	ns	
	Data input hold time	$t_{SDAH}$	0	—	ns	
	SCL, SDA capacitive load*3	$C_b$	—	400	pF	

Note 1.  $t_{IICcyc}$ : IIC internal reference clock (PCLKL) cycle

Note 2. The value out of parentheses is applicable when the value of the ICMR3.NF[1:0] bits is 00b while the digital filter is enabled by setting ICFER.NFE = 1. The value within parentheses is applicable when the value of the ICMR3.NF[1:0] bits is 11b while the digital filter is enabled by setting ICFER.NFE = 1.

Note 3.  $C_b$  is the total capacitance of the bus lines.

Note 4. The minimum values are not specified for  $t_{sr}$  and  $t_{sf}$  in Fast-mode.



## 2.5.5.11 SPI Timing

Table 2.35 SPI timing (1 of 2)

Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 30$  pF

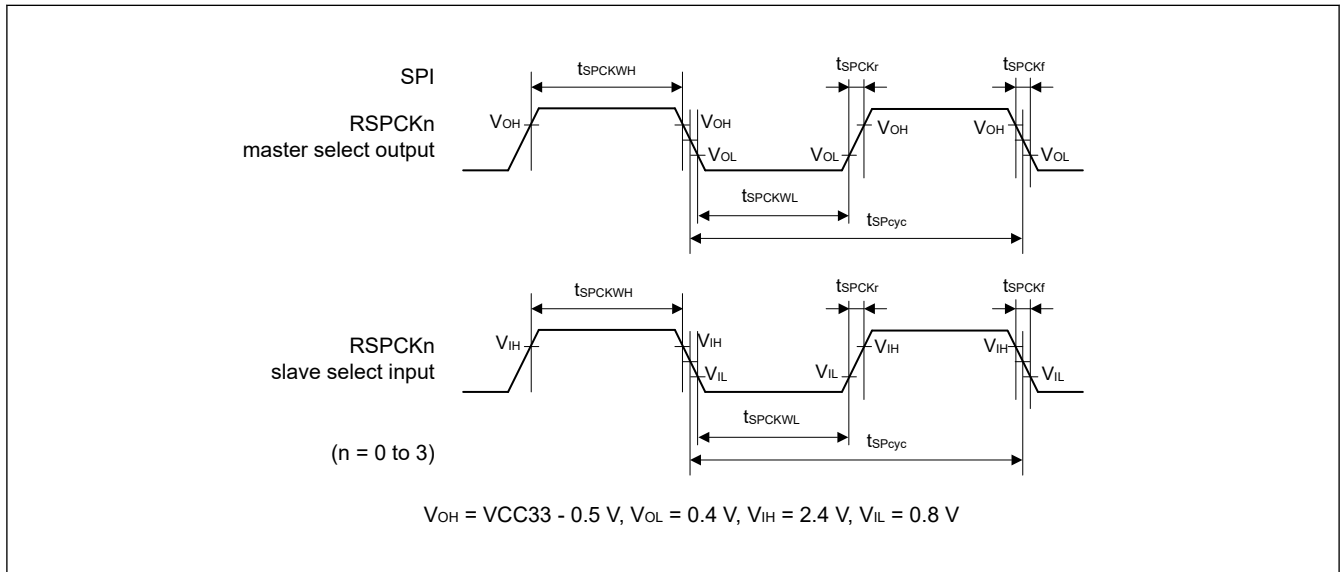
Parameter		Symbol	Min.*1	Max.*1	Unit*1	Reference figure	
RSPCK clock cycle	Master	$t_{SPCyc}$	2	4096	$t_{SPICyc}$	Figure 2.65	
	Slave		2	4096			
RSPCK clock high level pulse width	Master	$t_{SPCKWH}$	$(t_{SPCyc} - t_{SPCKr} - t_{SPCKf}) / 2 - 2.5$	—	ns		
	Slave		1	—	$t_{SPICyc}$		
RSPCK clock low level pulse width	Master	$t_{SPCKWL}$	$(t_{SPCyc} - t_{SPCKr} - t_{SPCKf}) / 2 - 2.5$	—	ns		
	Slave		1	—	$t_{SPICyc}$		
RSPCK clock rising/falling time	Output	$t_{SPCKr}$	—	3	ns		
	Input	$t_{SPCKf}$	—	1	ns		
Data input setup time	Master	$t_{SU}$	5	—	ns		Figure 2.66 to Figure 2.72
	Slave		3	—			
Data input hold time	Master	$t_H$	3	—	ns		
	Slave		3	—			
SSL setup time	Master	$t_{LEAD}$	$N \times t_{SPCyc} - 3^{*2}$	$N \times t_{SPCyc} + 3^{*2}$	ns	Figure 2.66 to Figure 2.69	
	Slave		4	—	$t_{SPICyc}$		
SSL hold time	Master	$t_{LAG}$	$N \times t_{SPCyc} - 3^{*3}$	$N \times t_{SPCyc} + 3^{*3}$	ns		
	Slave		4	—	$t_{SPICyc}$		
Continuous transmission delay	Master	$t_{TD}$	$t_{SPCyc} + 2 \times t_{SPICyc}$	$8 \times t_{SPCyc} + 2 \times t_{SPICyc}$	ns		
	Slave		$t_{SPCyc} + 5 \times t_{SPICyc}$	—			
TI-SSP SS input setup time		$t_{TISS}$	3	—	ns	Figure 2.70 to Figure 2.72	
TI-SSP SS input hold time		$t_{TISH}$	3	—	ns		
TI-SSP next access time		$t_{TIND}$	$M^{*4}$	—	$t_{SPICyc}$		
TI-SSP Master SS output delay		$t_{TISSOD}$	-3	3	ns		
TI-SSP Master OE delay 1		$t_{TIMOED1}$	—	2	ns		
TI-SSP Master OE delay 2		$t_{TIMOED2}$	—	2	ns		
TI-SSP Slave OE delay 1		$t_{TISOED1}$	—	12	ns		
TI-SSP Slave OE delay 2		$t_{TISOED2}$	—	8	ns		
Data output delay time	Master	$t_{OD}$	—	3	$t_{SPICyc}$		Figure 2.66 to Figure 2.72
	Slave		—	12	ns		
Data output hold time	Master	$t_{OH}$	-3	—	ns		
	Slave		3	—			
MOSI, MISO rising/falling time	Output	$t_{Dr}, t_{Df}$	—	3	ns		
	Input		—	1	$\mu s$		
SSL rising/falling time	Output	$t_{SSLr}, t_{SSLf}$	—	3	ns	Figure 2.66, Figure 2.67	
	Input		—	1	$\mu s$		

**Table 2.35 SPI timing (2 of 2)**

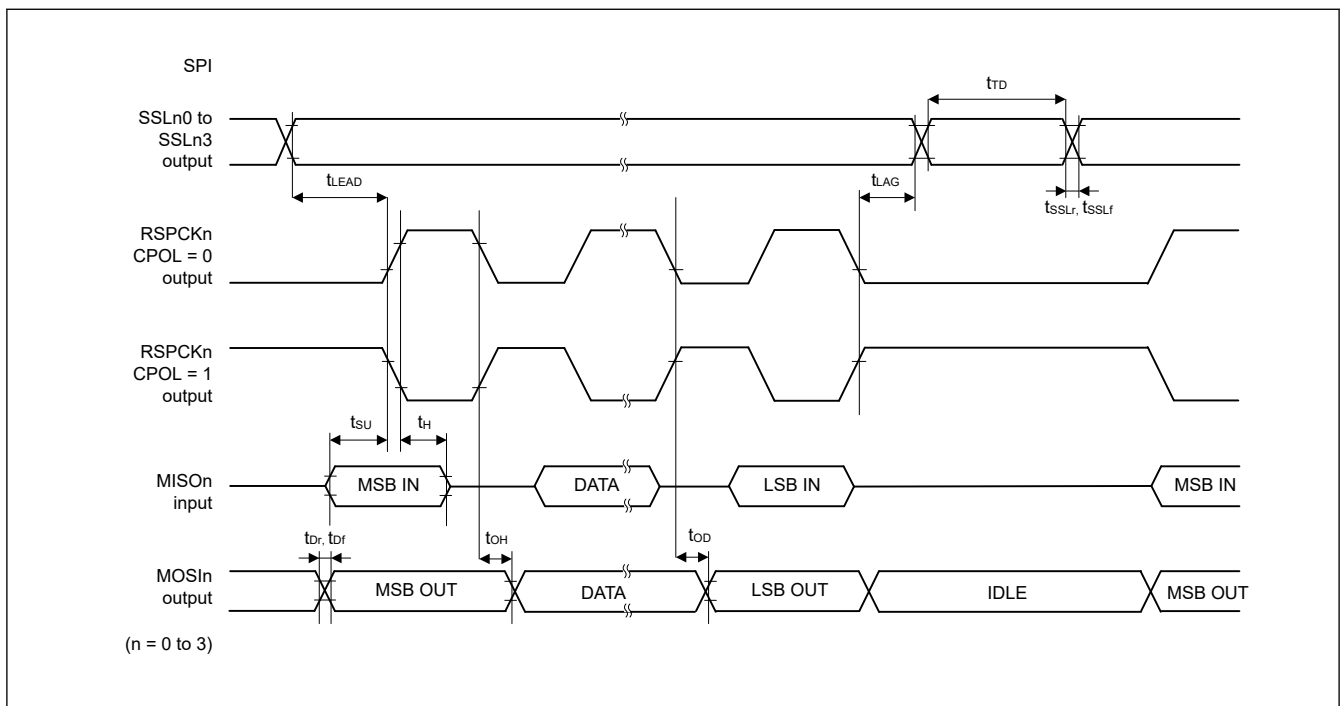
Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 30$  pF

Parameter	Symbol	Min.*1	Max.*1	Unit*1	Reference figure
Slave access time	$t_{SA}$	—	12	ns	Figure 2.68, Figure 2.69
Slave output release time	$t_{REL}$	—	12	ns	

- Note 1.  $t_{SP1cyc}$ : PCLKSPI $_n$  cycle
- Note 2. SPCKD set value + 1 (1 to 8)
- Note 3. SSLND set value + 1 (1 to 8)
- Note 4. SSLND set value + 2 (2 to 9)



**Figure 2.65 SPI clock timing**



**Figure 2.66 SPI timing (Master, Motorola SPI, CPHA = 0)**

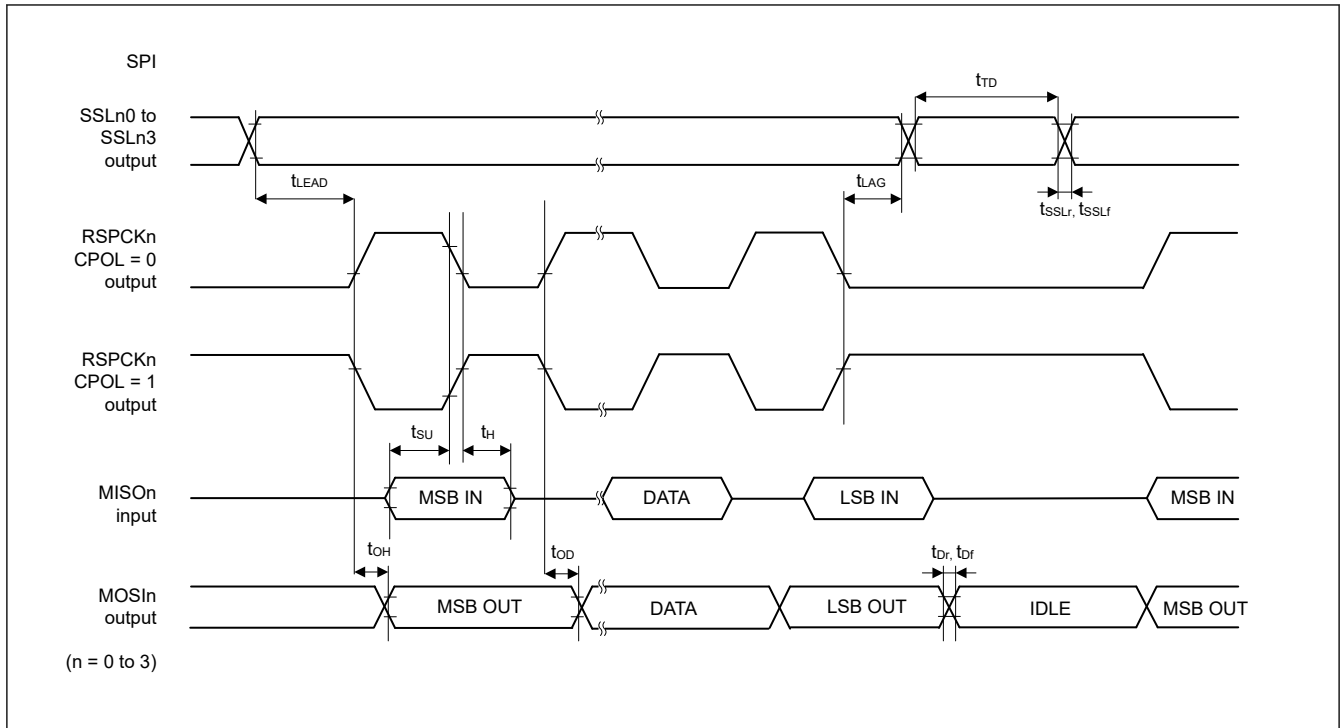


Figure 2.67 SPI timing (Master, Motorola SPI, CPHA = 1)

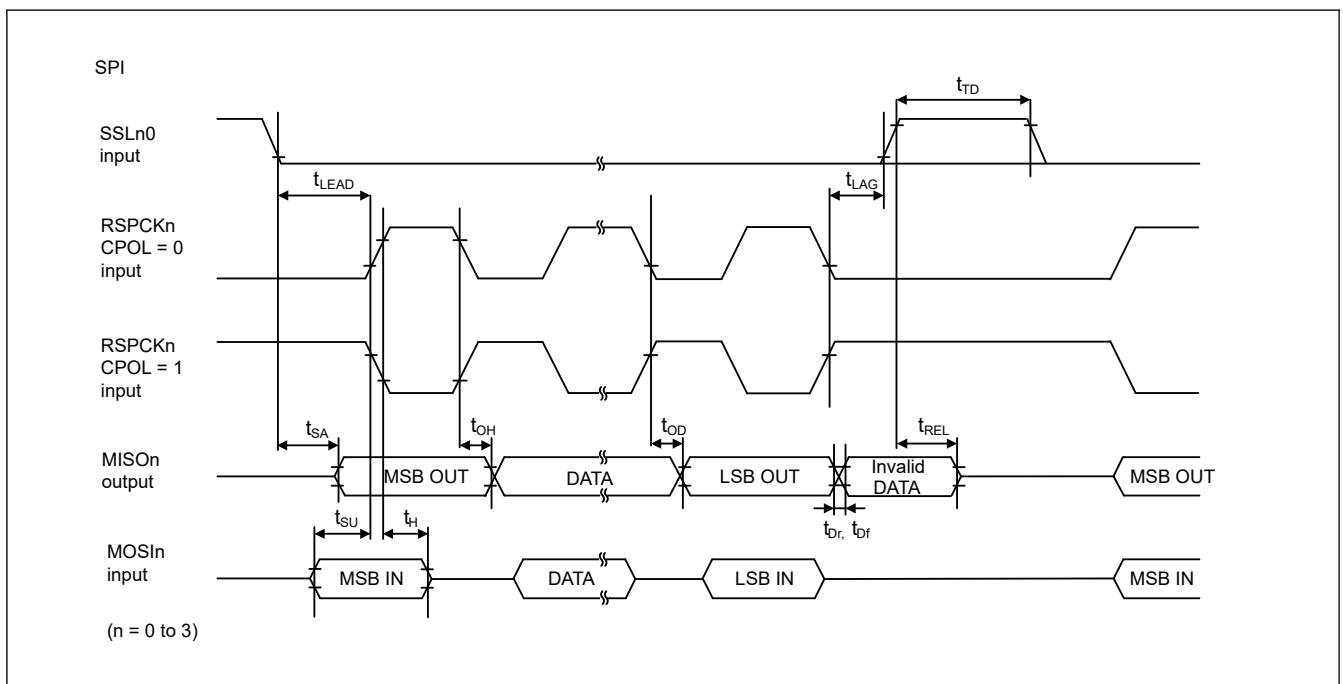


Figure 2.68 SPI timing (Slave, Motorola SPI, CPHA = 0)

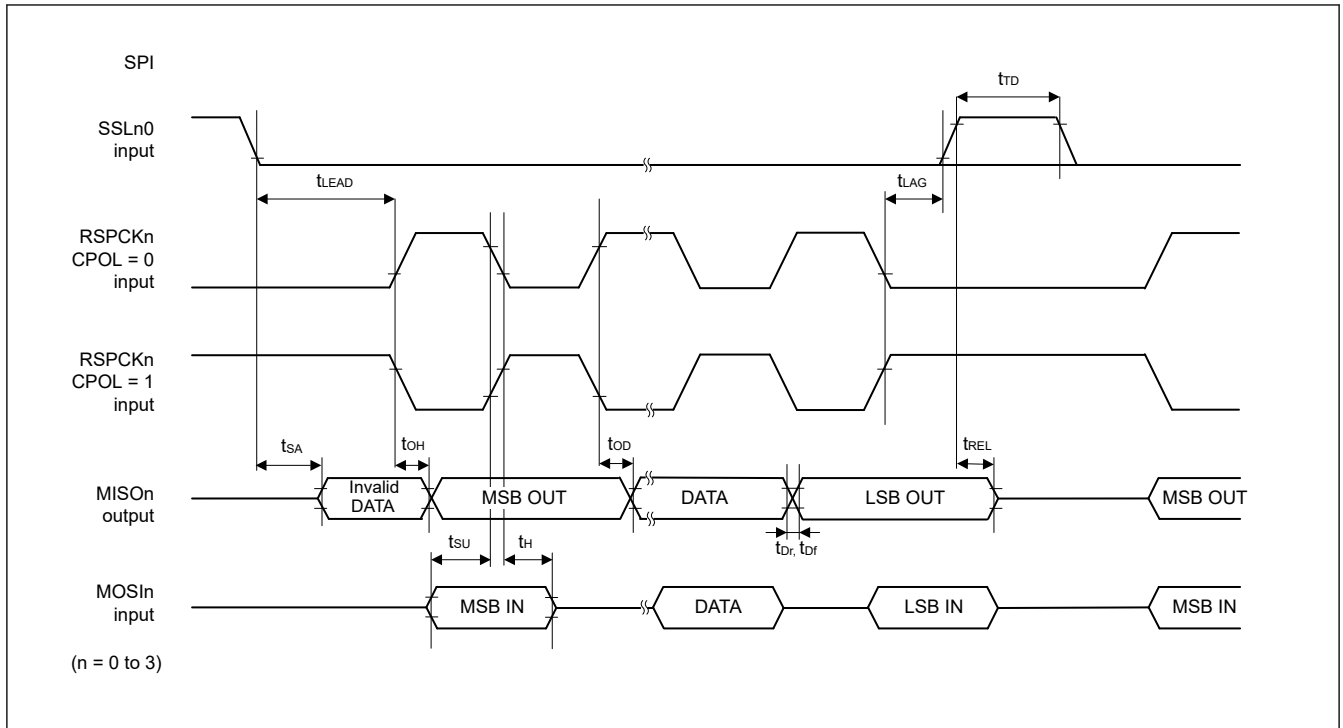


Figure 2.69 SPI timing (Slave, Motorola SPI, CPHA = 1)

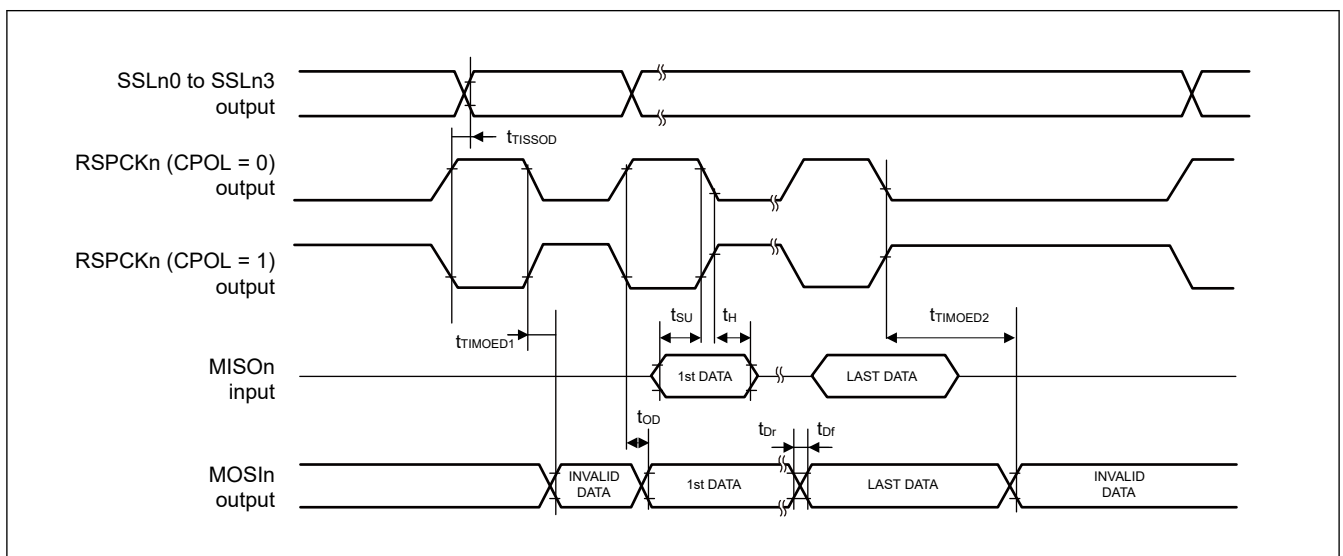


Figure 2.70 SPI timing (Master, TI SSP)



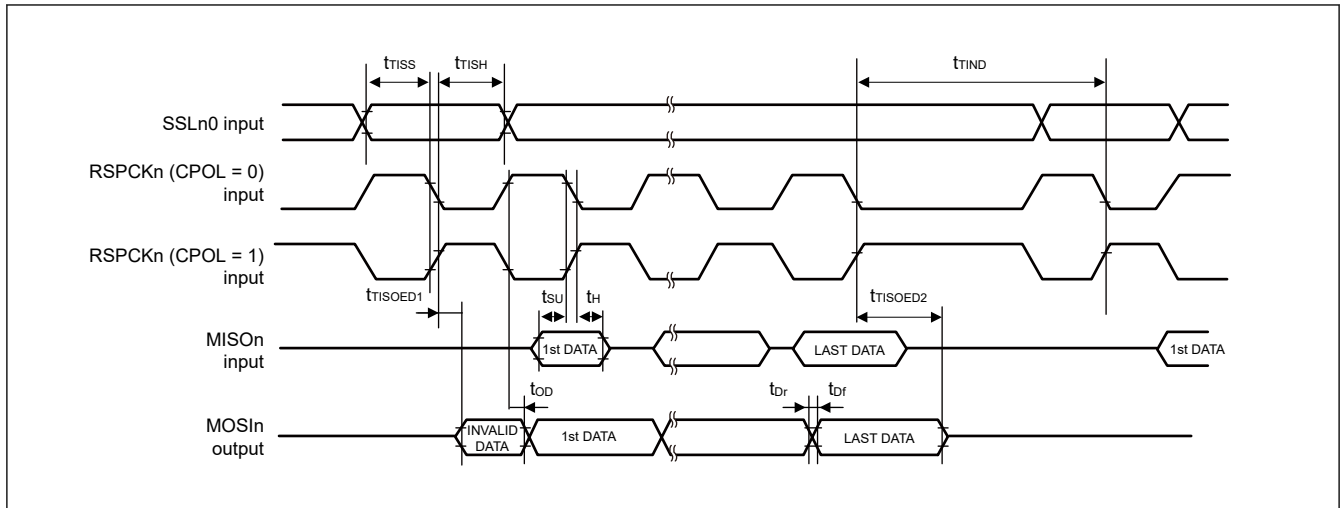


Figure 2.71 SPI timing (Slave, TI-SSP, with delay in burst transfer)

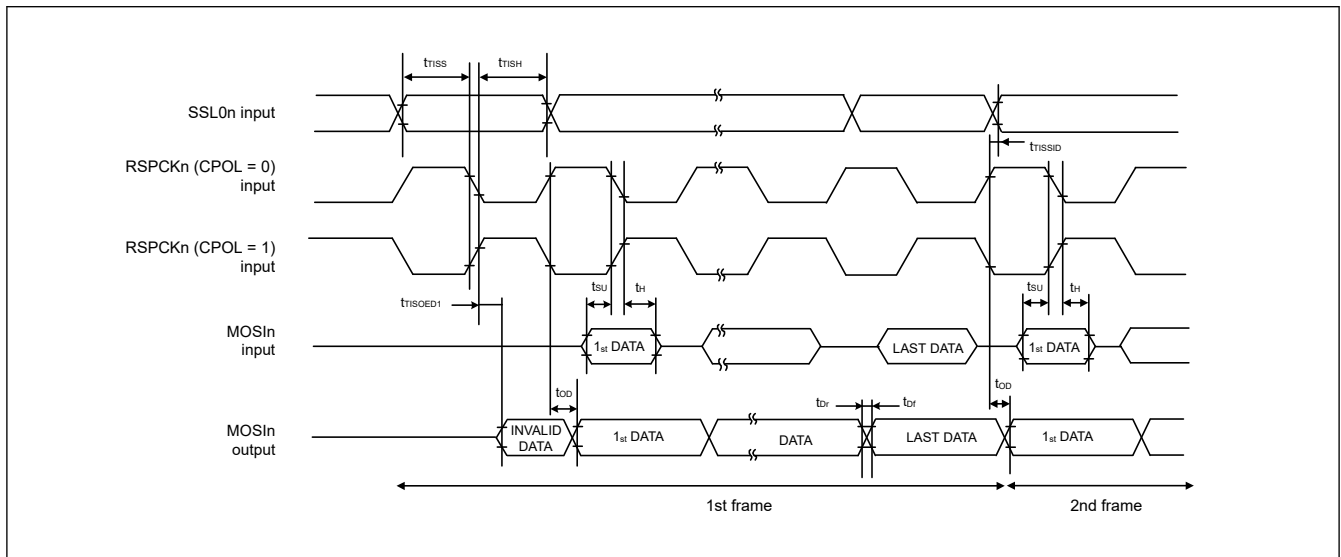


Figure 2.72 SPI timing (Slave, TI-SSP, without delay in burst transfer)

### 2.5.5.12 xSPI Timing

Conditions:

Single end Clock

$$V_{OH} = V_{CC18} \times 0.5, V_{OL} = V_{CC18} \times 0.5, C = 15 \text{ pF (1.8 V)}$$

$$V_{OH} = V_{CC33} \times 0.5, V_{OL} = V_{CC33} \times 0.5, C = 15 \text{ pF (3.3 V)}$$

Data

$$V_{OH} = V_{CC18} \times 0.5, V_{OL} = V_{CC18} \times 0.5, C = 15 \text{ pF (1.8 V)}$$

$$V_{OH} = V_{CC33} \times 0.5, V_{OL} = V_{CC33} \times 0.5, C = 15 \text{ pF (3.3 V)}$$

Table 2.36 xSPI timing

Parameter	Symbol	1.8 V		3.3 V		Unit	Reference figure	
		Min.	Max.	Min.	Max.			
Cycle time	SDR	$t_{PERIOD}$	7.5	—	13.3	—	ns	Figure 2.73
	DDR		10.0	—	13.3	—	ns	
Clock output slew rate		$t_{SRck}$	0.75/0.56 <sup>*2</sup>	—	0.56	—	V/ns	
Clock Duty cycle distortion		$t_{CKDCD}$	0.0	$t_{PERIOD} \times 0.05$	0.0	$t_{PERIOD} \times 0.05$	ns	
Clock Minimum Pulse width		$t_{CKMPW}$	$t_{PERIOD} \times 0.45$	—	$t_{PERIOD} \times 0.45$	—	ns	
Differential clock crossing voltage		$V_{OX(AC)}$	$0.4 \times VCC18$	$0.6 \times VCC18$	—	—	V	
DS Duty cycle distortion		$t_{DSDCD}$	0.0	$t_{PERIOD} \times 0.04$	0.0	$t_{PERIOD} \times 0.04$	ns	
DS Minimum Pulse width		$t_{DSMPW}$	$t_{PERIOD} \times 0.41$	—	$t_{PERIOD} \times 0.41$	—	ns	
Data input/output slew rate		$t_{SR}$	0.75/0.56 <sup>*2</sup>	—	0.56	—	V/ns	
Data input setup time (to CK)	SDR	$t_{SU}$	2.0	—	2.4	—	ns	Figure 2.74
Data input hold time (to CK)		$t_H$	1.0	—	1.0	—	ns	
Data output delay time		$t_{OD}$	—	1.0 <sup>*3</sup>	—	1.4 <sup>*3</sup>	ns	
Data output hold time		$t_{OH}$	-1.0	—	-2.3	—	ns	
Data output buffer off time		$t_{BOFF}$	-1.0	—	-2.3	—	ns	
Data input setup time (to DS)	DDR <sup>*1</sup> <sup>*3</sup>	$t_{SU}$	-0.8	—	-0.8	—	ns	Figure 2.75, Figure 2.76
Data input hold time (to DS)		$t_H$	$t_{PERIOD} \times 0.41 - 0.8$	—	$t_{PERIOD} \times 0.41 - 0.8$	—	ns	
Data output setup time (to CK)		$t_{SUO}$	1.0	—	1.0	—	ns	
Data output hold time (to CK)		$t_{HO}$	1.0	—	1.0	—	ns	
CS Low to Clock High		$t_{CSLCKH}$	$6.0/8.0^{*2} \text{ } ^*4$	—	$8.0^{*4}$	—	ns	Figure 2.74 to Figure 2.76
Clock Low to CS High		$t_{CKLCSH}$	$6.0/8.0^{*2}$	—	8.0	—	ns	
CS High time		$t_{CSTD}$	1	16	1	16	$t_{PERIOD}$	
DS Low to CS High		$t_{DSLCSH}$	$6.0/8.0^{*2}$	—	10.6	—	ns	Figure 2.77
CS High to DS Tri-State		$t_{CSHDST}$	0.0	$t_{PERIOD}$	0.0	$t_{PERIOD}$	ns	
CS Low to DS Low		$t_{CSLDSL}$	0.0	—	0.0	—	ns	
DS Tri-State to CS Low		$t_{DSTCSL}$	0.0	—	0.0	—	ns	

Note 1. The DS shift setting (WRAPCFG.DSSFTCSx[4:0]) is 01000b for xSPI200.

Note 2. Specification at 133 MHz / Specification at 100 MHz

Note 3. These are values when the OEN assertion is extended in the Output Enable Asserting extension bit (COMCFG.OEASTEX = 1).

Note 4. These are the values when the CS assertion is extended in the CS asserting extension bit (LIOCFGCSn.CSASTEX = 1).

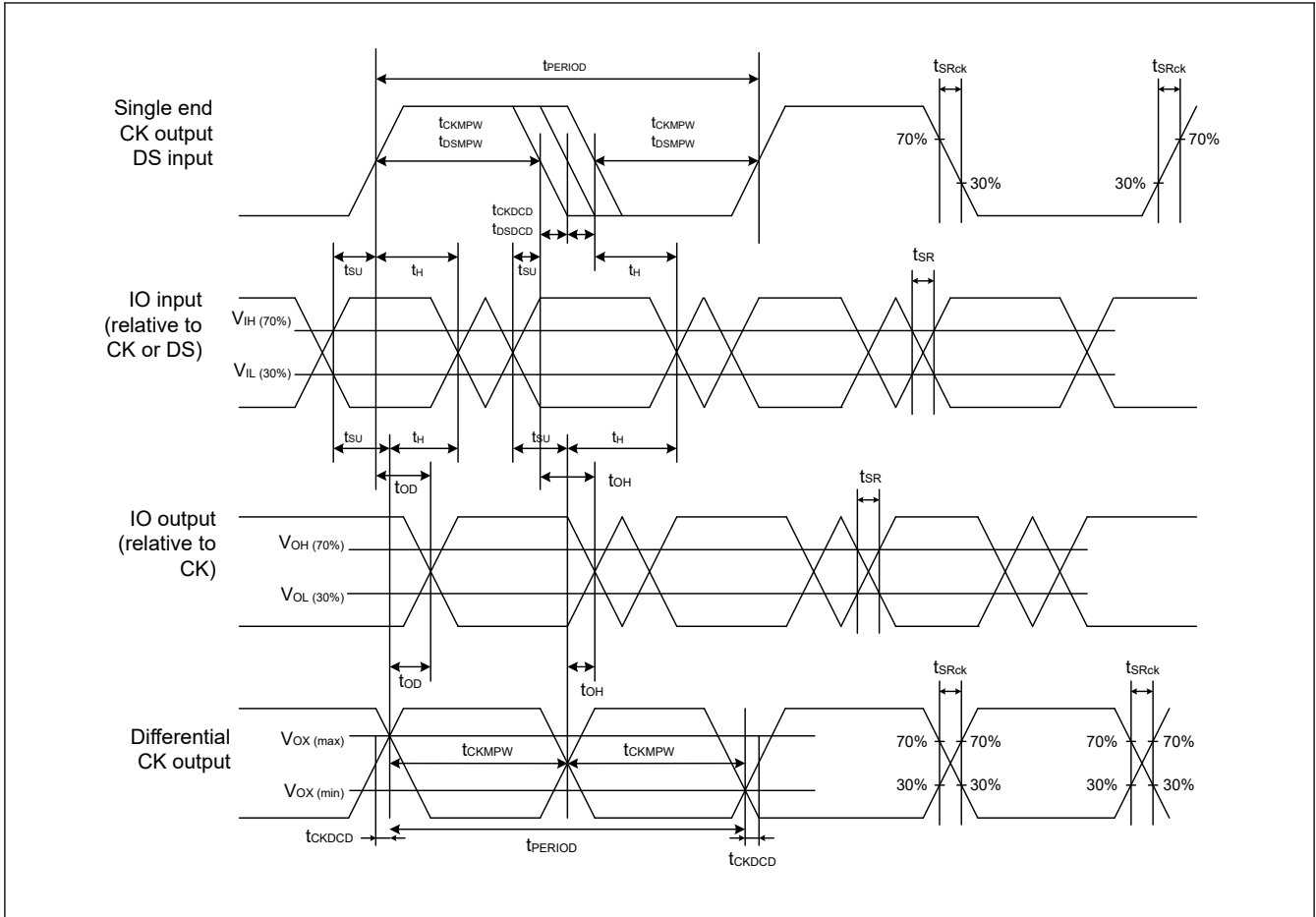


Figure 2.73 xSPI clock / DS timing

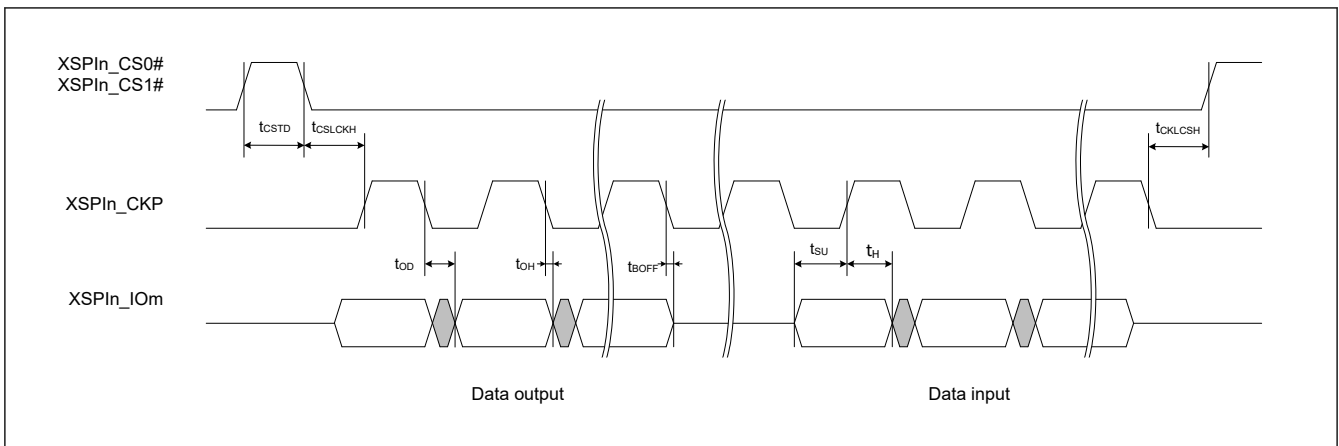


Figure 2.74 SDR transmit/receive timing (1S-1S-1S, 1S-2S-2S, 2S-2S-2S, 1S-4S-4S, 4S-4S-4S)

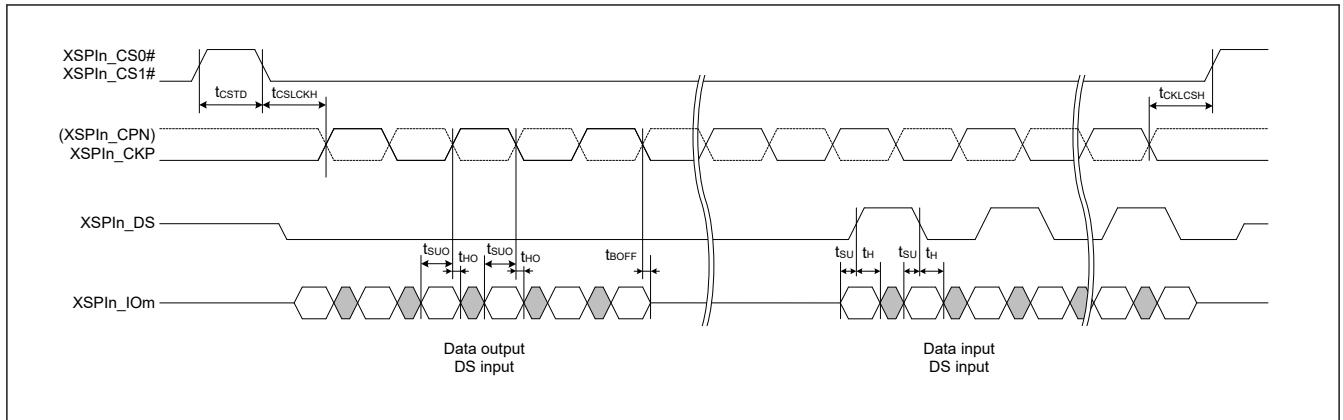


Figure 2.75 DDR transmit/receive timing (4S-4D-4D, 8D-8D-8D)

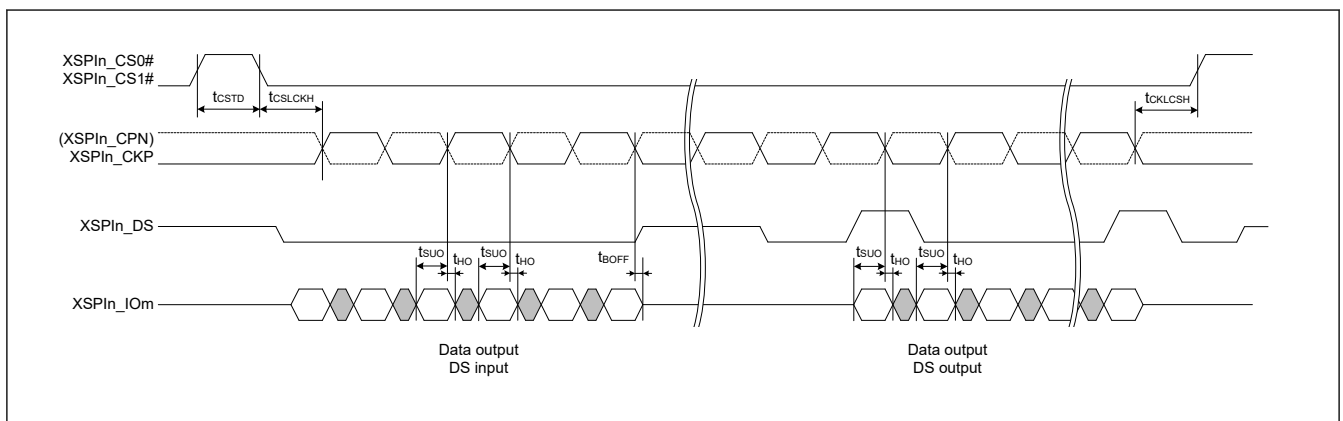


Figure 2.76 DDR transmit/receive timing (HyperRAM write)

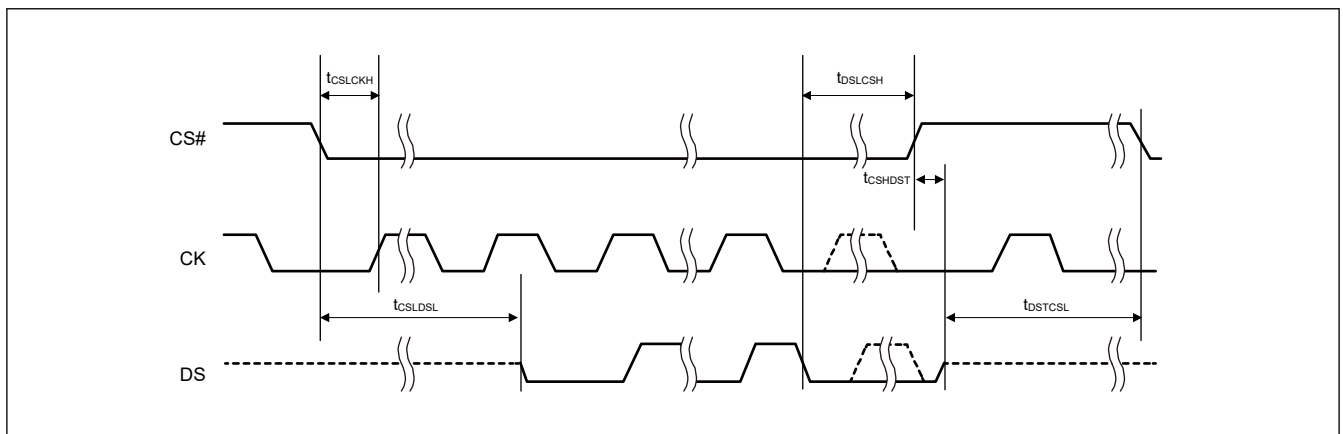


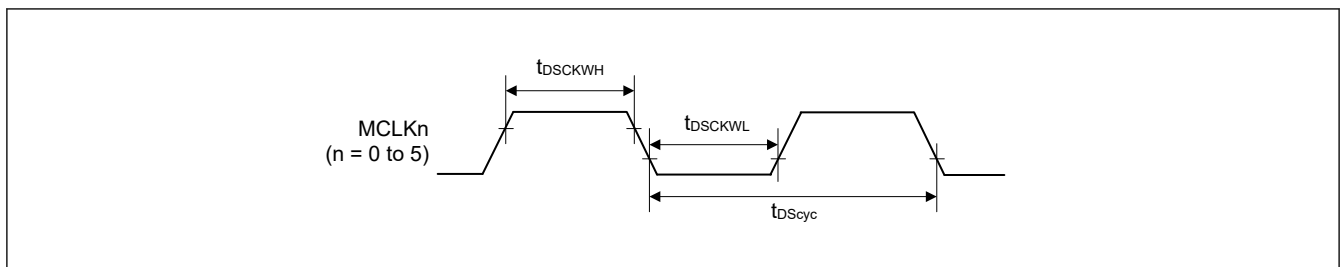
Figure 2.77 DS to CS signal timing

### 2.5.5.13 Delta-Sigma Interface Timing

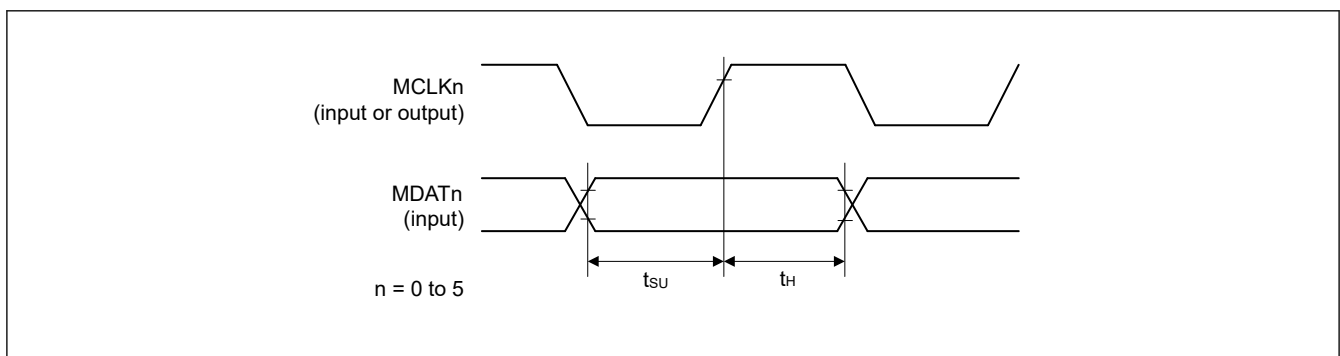
Conditions:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$ ,  $C = 30$  pF

**Table 2.37 ΔΣ interface timing**

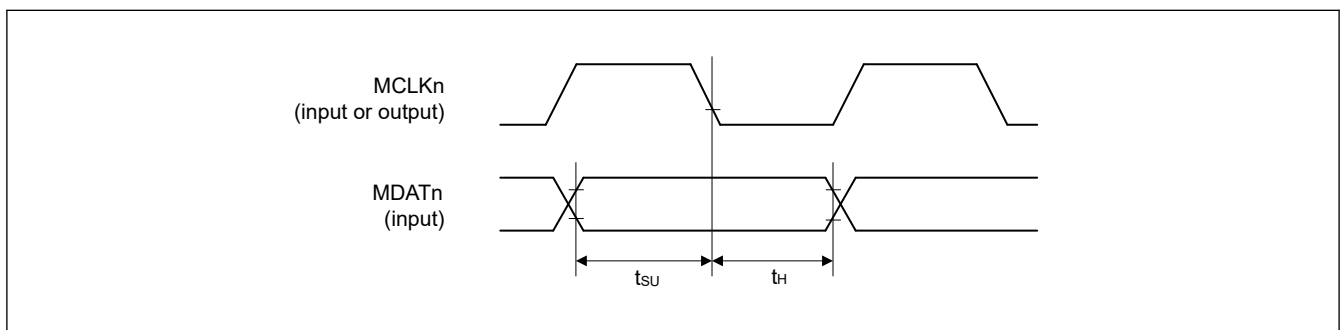
Parameter		Symbol	Min.	Max.	Unit	Reference figure	
DSMIF	Clock cycle	Master	$t_{DScyc}$	40	200	ns	Figure 2.78
		Slave		40	200		
	Clock high level	Master	$t_{DSCKWH}$	16	—	ns	
		Slave		16	—		
	Clock low level	Master	$t_{DSCKWL}$	16	—	ns	
		Slave		16	—		
Setup time	Master	$t_{SU}$	15	—	ns	Figure 2.79, Figure 2.80	
	Slave		10	—			
Hold time	Master	$t_H$	0	—	ns		
	Slave		10	—			



**Figure 2.78 Clock input/output timing**



**Figure 2.79 Reception timing (MCLKn rising synchronous)**



**Figure 2.80 Reception timing (MCLKn falling synchronous)**

**2.5.5.14 Ethernet Interface Timing**

Conditions:

$$V_{OH} = V_{CC18} \times 0.5, V_{OL} = V_{CC18} \times 0.5, C = 15 \text{ pF (RGMII)}$$

$$V_{OH} = V_{CC33} \times 0.5, V_{OL} = V_{CC33} \times 0.5, C = 25 \text{ pF (RMII)}$$

$$V_{OH} = V_{CC33} \times 0.5, V_{OL} = V_{CC33} \times 0.5, C = 30 \text{ pF (MII)}$$

**Table 2.38 Ethernet interface timing**

Parameter		Symbol	Min.	Max.	Unit	Reference figure	
Ethernet (RGMII)	ETHn_TXCLK, ETHn_RXCLK cycle time duration	1 Gbps	$t_{RGMIIck}$	7.2	8.8	ns	Figure 2.81
		100 Mbps		36	44		
		10 Mbps		360	440		
	ETHn_TXCLK, ETHn_RXCLK frequency	1 Gbps	—	125 – 50 ppm	125 + 50 ppm	MHz	
		100 Mbps		25 – 50 ppm	25 + 50 ppm		
		10 Mbps		2.5 – 50 ppm	2.5 + 50 ppm		
	ETHn_TXCLK, ETHn_RXCLK duty cycle	1 Gbps	—	45	55	%	
		100 Mbps 10 Mbps		40	60		
	ETHn_TXCLK, ETHn_TXD0 to ETHn_TXD3, ETHn_TXEN (TX_CTL), ETHn_RXCLK, ETHn_RXD0 to ETHn_RXD3, ETHn_RXDV (RX_CTL) rise/fall time		$t_{RGMIIr}$ , $t_{RGMIIlf}$	—	0.75	ns	
	ETHn_TXD0 to ETHn_TXD3, ETHn_TXEN (TX_CTL) to ETHn_TXCLK output skew		$t_{RGMIIos}$	-0.5	0.5	ns	
ETHn_RXD0 to ETHn_RXD3, ETHn_RXDV (RX_CTL) setup time		$t_{RGMIIls}$	1	—	ns		
ETHn_RXD0 to ETHn_RXD3, ETHn_RXDV (RX_CTL) hold time		$t_{RGMIIh}$	1	—	ns		
Ethernet (RMII)	ETHn_RXCLK cycle time		$t_{RMIIck}$	20	—	ns	Figure 2.82
	ETHn_RXCLK frequency Typ. 50 MHz		—	50 – 50 ppm	50 + 50 ppm	MHz	
	ETHn_RXCLK duty		—	35	65	%	
	ETHn_RXCLK rise/fall time		$t_{RMIIckr}$ , $t_{RMIIckf}$	0.5	3.5	ns	
	ETHn_TXD0, ETHn_TXD1, ETHn_TXEN output delay time		$t_{RMIIld}$	2.5	12	ns	
	ETHn_RXD0, ETHn_RXD1, ETHn_RXER, ETHn_RXDV (CRS_DV) setup time		$t_{RMIIls}$	4	—	ns	
	ETHn_RXD0, ETHn_RXD1, ETHn_RXER, ETHn_RXDV (CRS_DV) hold time		$t_{RMIIh}$	2	—	ns	
	ETHn_TXD0, ETHn_TXD1, ETHn_TXEN, ETHn_RXD0, ETHn_RXD1, ETHn_RXER, ETHn_RXDV (CRS_DV) rise/fall time		$t_{RMIIr}$ , $t_{RMIIlf}$	0.5	4	ns	
Ethernet (MII)	ETHn_TXCLK, ETHn_RXCLK cycle time	100 Mbps	$t_{MIick}$	40	—	ns	Figure 2.83
		10 Mbps		400	—		
	ETHn_TXCLK, ETHn_RXCLK frequency	100 Mbps	—	25 – 50 ppm	25 + 50 ppm	MHz	
		10 Mbps		2.5 – 50 ppm	2.5 + 50 ppm		
	ETHn_TXD0 to ETHn_TXD3, ETHn_TXEN, ETHn_TXER output delay time		$t_{MIld}$	1	20	ns	
	ETHn_RXD0 to ETHn_RXD3, ETHn_RXDV, ETHn_RXER setup time		$t_{MIls}$	10	—	ns	
ETHn_RXD0 to ETHn_RXD3, ETHn_RXDV, ETHn_RXER hold time		$t_{MIlh}$	10	—	ns		

**Table 2.39 Ethernet interface timing (MAC to MAC connection mode)**

Parameter		Symbol	Min.	Max.	Unit	Reference figure
Ethernet (RGMII)	ETH2_TXCLK, ETH2_RXCLK cycle time	$t_{MRGMIIck}$	7.2	8.8	ns	Figure 2.84
	ETH2_TXCLK, ETH2_RXCLK frequency Typ. 125 MHz	—	125 – 50 ppm	125 + 50 ppm	MHz	
	ETH2_TXCLK, ETH2_RXCLK duty cycle	—	45	55	%	
	ETH2_TXCLK, ETH2_TXD0 to ETH2_TXD3, ETH2_TXEN (TX_CTL), ETH2_RXCLK, ETH2_RXD0 to ETH2_RXD3, ETH2_RXDV (RX_CTL) rise/fall time	$t_{MRGMIIr}$ , $t_{MRGMIIl}$	—	0.75	ns	
	ETH2_TXD0 to ETHn_TXD3, ETHn_TXEN (TX_CTL) output skew	$t_{MRGMIIos}$	—	0.6	ns	
	ETH2_TXD0 to ETH2_TXD3, ETH2_TXEN (TX_CTL) output setup time	$t_{MRGMIIso}$	1.1	—	ns	
	ETH2_TXD0 to ETH2_TXD3, ETH2_TXEN (TX_CTL) output hold time	$t_{MRGMIIho}$	1.1	—	ns	
	ETH2_RXD0 to ETH2_RXD3, ETH2_RXDV (RX_CTL) input setup time	$t_{MRGMIIsi}$	-0.7	—	ns	
	ETH2_RXD0 to ETH2_RXD3, ETH2_RXDV (RX_CTL) input hold time	$t_{MRGMIIhi}$	2.9	—	ns	
	Ethernet (MII)	ETH2_REFCLK cycle time	$t_{MMIIck}$	40	—	
ETH2_REFCLK frequency Typ. 25 MHz		—	25 – 50 ppm	25 + 50 ppm	MHz	
ETH2_TXD0 to ETH2_TXD3, ETH2_TXEN, ETH2_TXER output delay time		$t_{MMII d}$	11	25	ns	
ETH2_RXD0 to ETH2_RXD3, ETH2_RXDV, ETH2_RXER setup time		$t_{MMII s}$	10	—	ns	
ETH2_RXD0 to ETH2_RXD3, ETH2_RXDV, ETH2_RXER hold time		$t_{MMII h}$	0	—	ns	

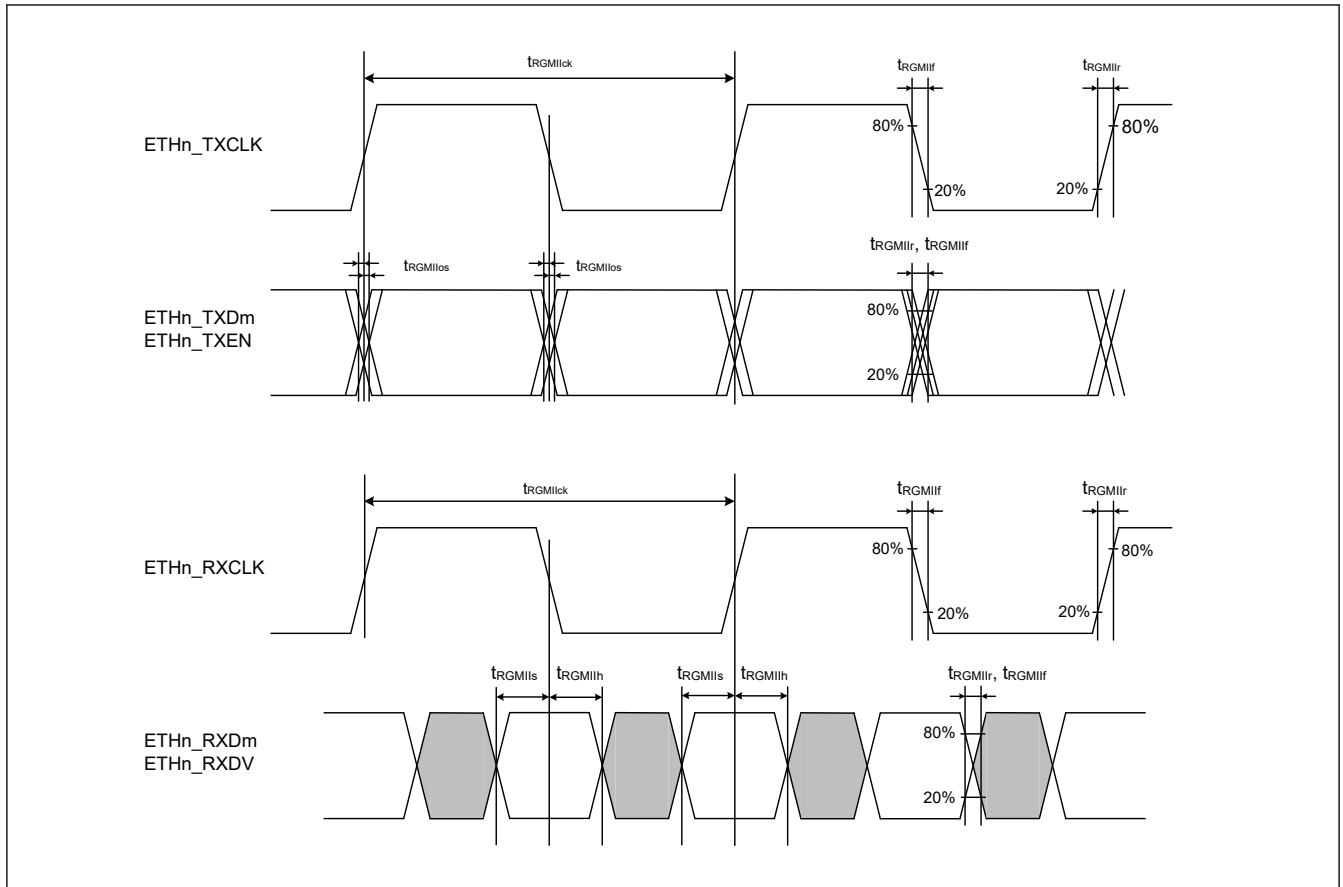


Figure 2.81 RGMII transmission and reception timing (n = 0 to 2, m = 0 to 3)

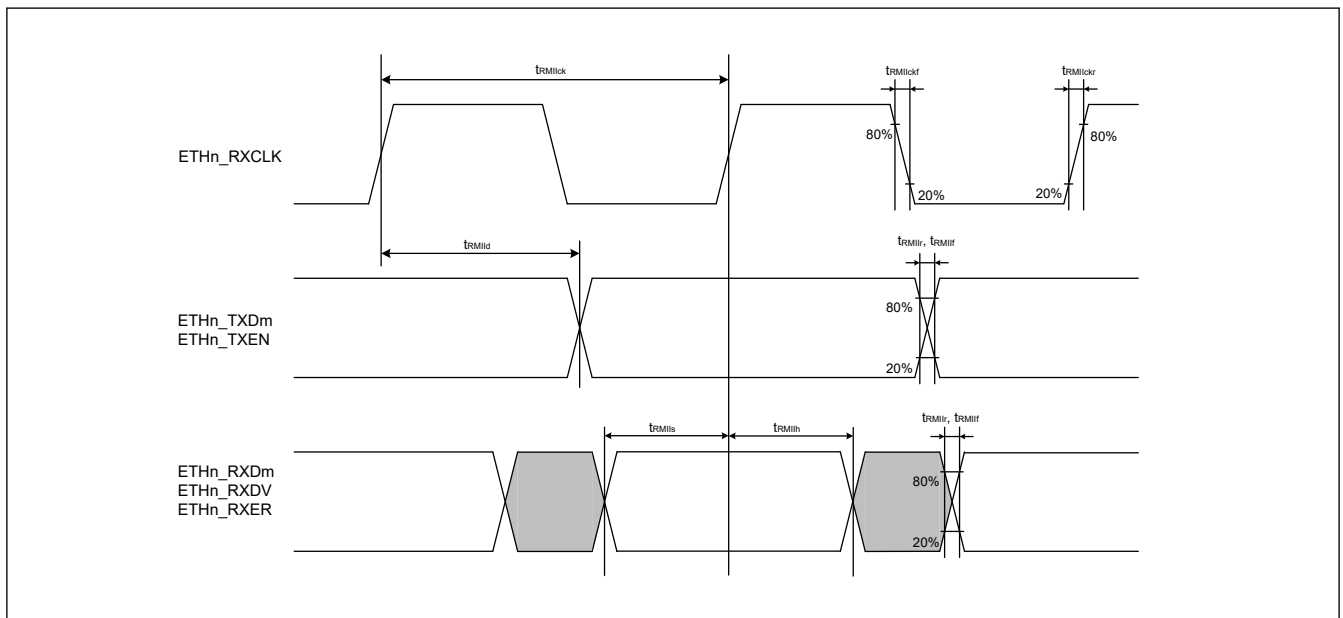


Figure 2.82 RMI transmission and reception timing (n = 0 to 2, m = 0 to 1)



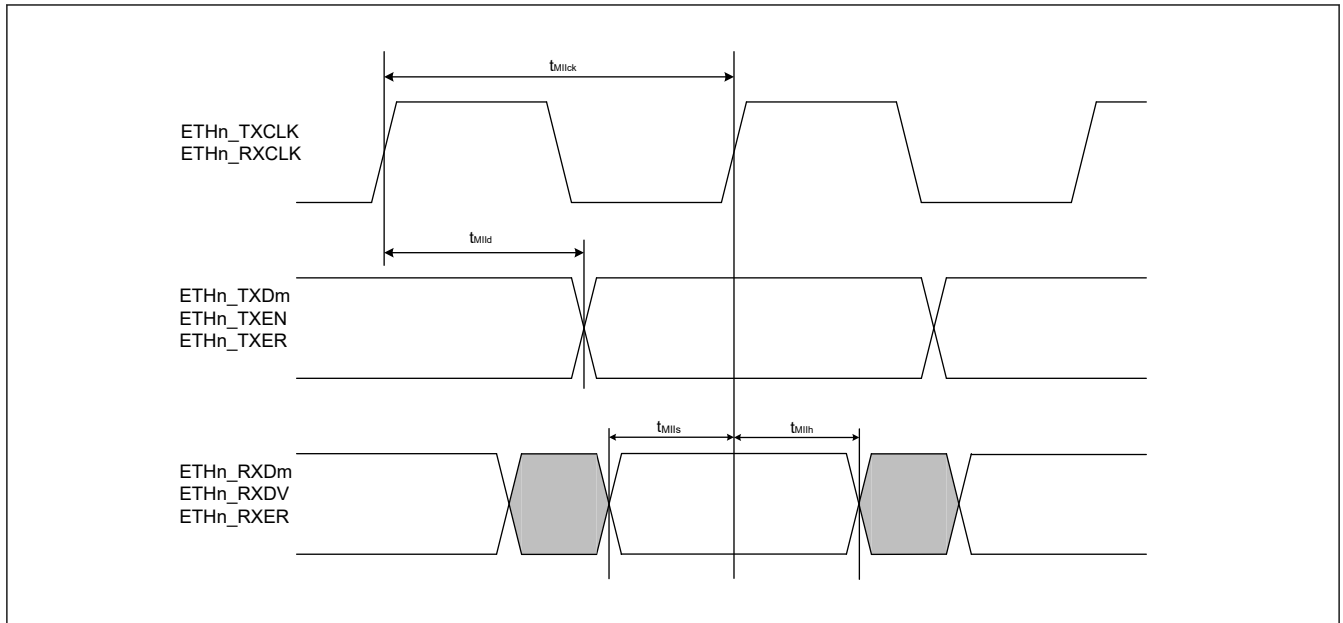


Figure 2.83 MII transmission and reception timing (n = 0 to 2, m = 0 to 3)

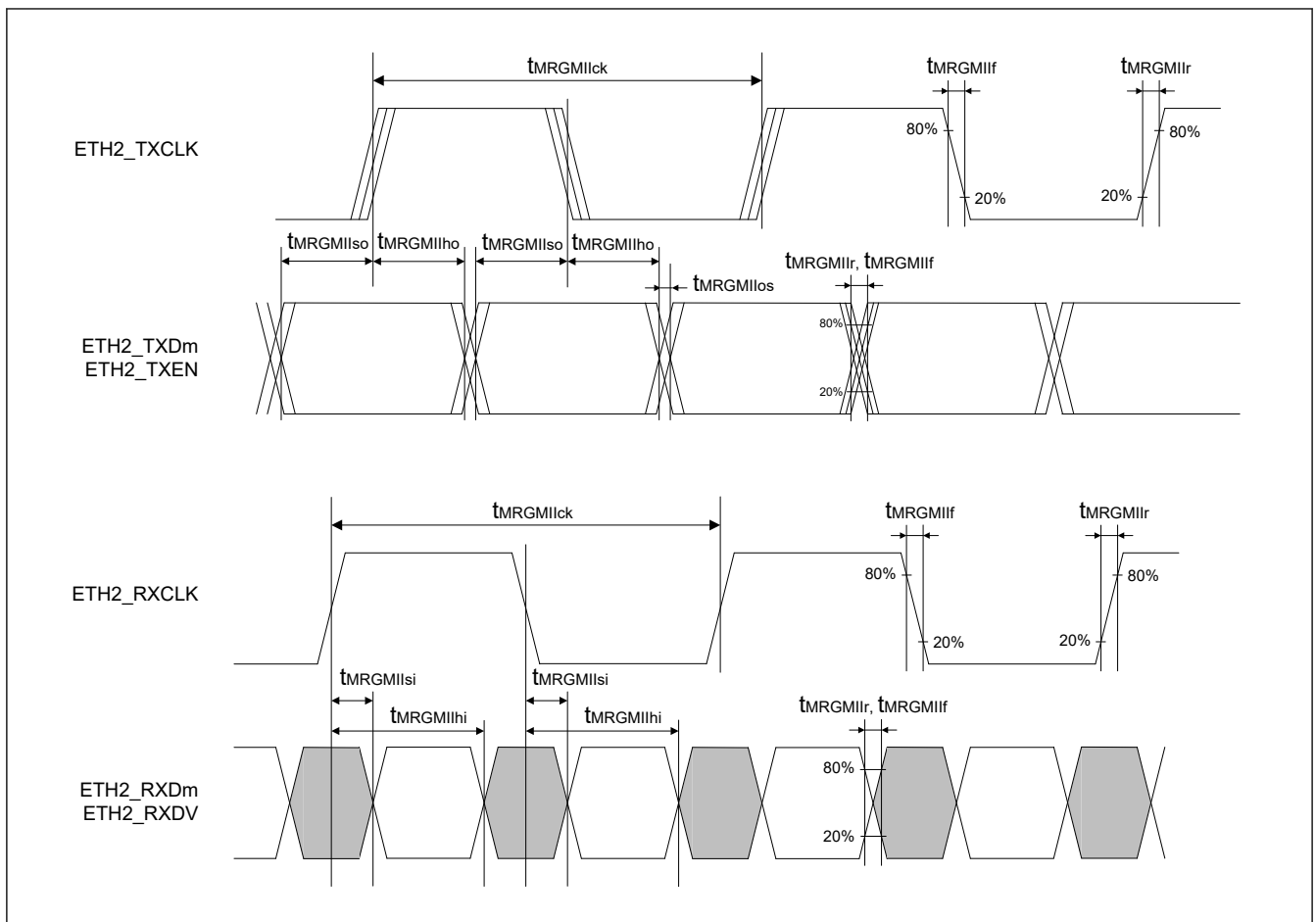


Figure 2.84 RGMII transmission and reception timing (MAC to MAC connection mode) (m = 0 to 3)

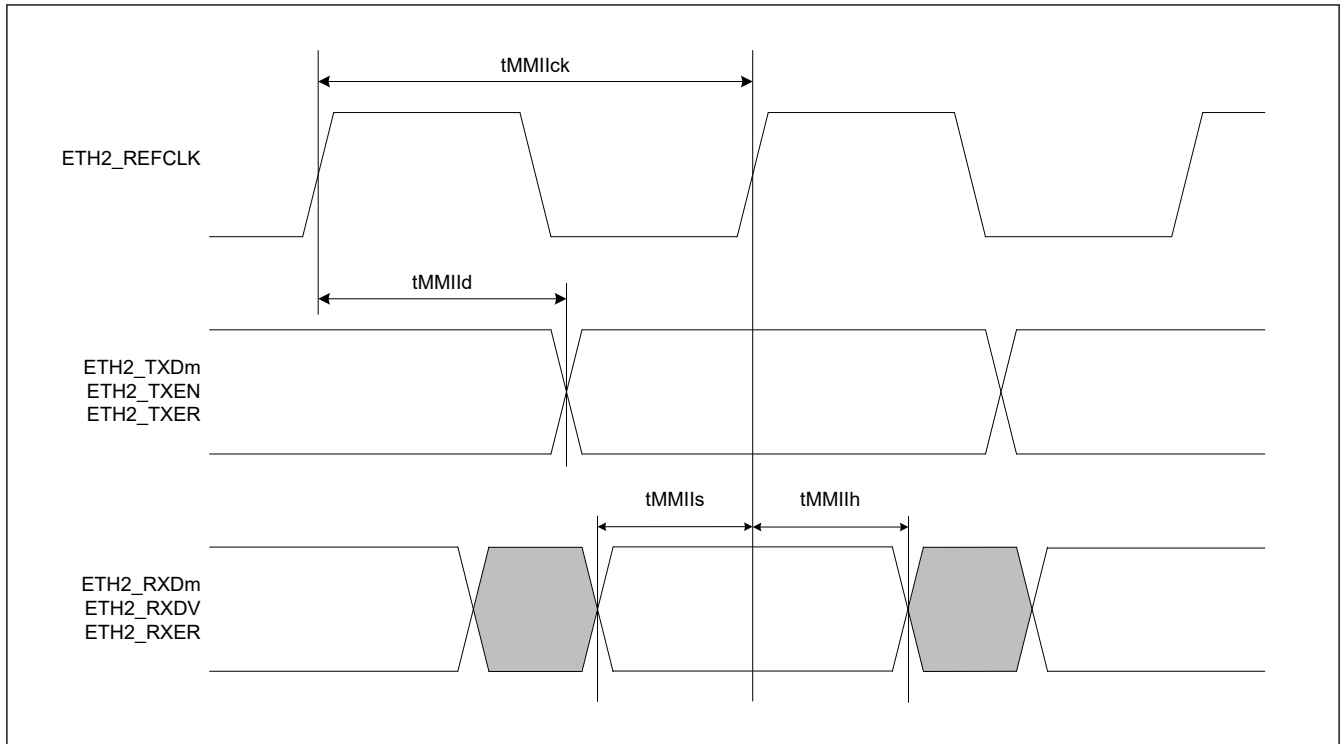


Figure 2.85 MII transmission and reception timing (MAC to MAC connection mode) (m = 0 to 3)

### 2.5.5.15 Serial Management Interface Timing

Conditions:

$$V_{OH} = V_{CC18} \times 0.5, V_{OL} = V_{CC18} \times 0.5, C = 30 \text{ pF (1.8 V)}$$

$$V_{OH} = V_{CC33} \times 0.5, V_{OL} = V_{CC33} \times 0.5, C = 30 \text{ pF (3.3 V)}$$

Table 2.40 Serial management interface timing

Parameter		Symbol	Min.	Max.	Unit	Reference figure
MDIO	MDC output cycle time	GMAC_MDC, ETHSW_MDC	80	—	ns	Figure 2.86
		ESC_MDC	400	—	ns	
	MDIO output delay time (for MDC fall) <sup>*1</sup>	T <sub>MDIOd</sub>	—	20	ns	
	MDIO input setup time (for MDC rise)	T <sub>MDIOs</sub>	18	—	ns	
	MDIO input hold time (for MDC rise)	GMAC_MDC, ETHSW_MDC	T <sub>MDIOh</sub>	0	—	
ESC_MDC			10	—	ns	

Note 1. The output timing from ETHSW is based on the rising edge of MDC, and the output delay can be set in the register.

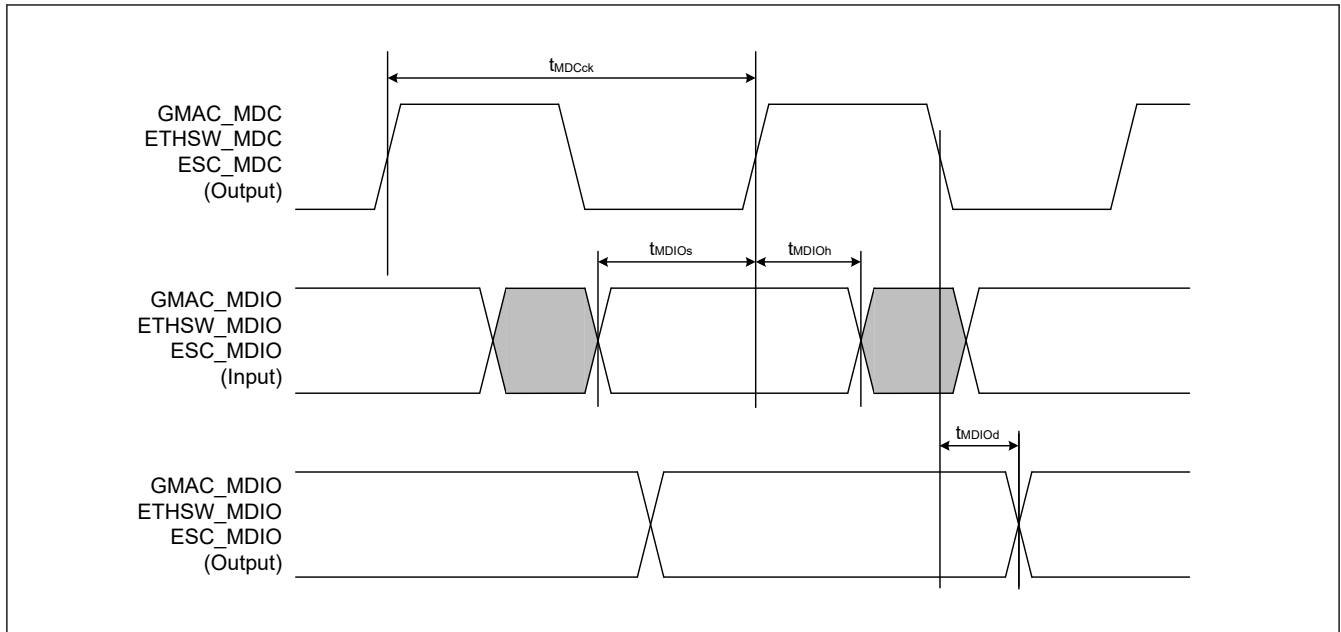


Figure 2.86 Serial management interface timing

### 2.5.5.16 SHOSTIF Timing

Conditions:

$$V_{OH} = V_{CC18} \times 0.5, V_{OL} = V_{CC18} \times 0.5, C = 30 \text{ pF (1.8 V)}$$

$$V_{OH} = V_{CC33} \times 0.5, V_{OL} = V_{CC33} \times 0.5, C = 30 \text{ pF (3.3 V)}$$

Table 2.41 SHOSTIF timing

Parameter	Symbol	Min.	Max.	Unit	Reference figure	
SHOSTIF	Clock cycle time	$t_{SHck}$	25	—	ns	Figure 2.87
	Clock high time	$t_{CH}$	0.45	0.55	$t_{SHck}$	
	Clock low time	$t_{CL}$	0.45	0.55	$t_{SHck}$	
	Clock rise slew rate	$t_{CRT}$	0.1	—	V/ns	
	Clock fall slew rate	$t_{CFT}$	0.1	—	V/ns	
	CS# high time	$t_{CS}$	2	—	$t_{SHck}$	
CS# active setup time	$t_{CSS}$	15	—	ns		
CS# active hold time	$t_{CSH}$	15	—	ns		
Data input setup time	$t_{SU}$	3	—	ns		
Data input hold time	$t_{HD}$	10.5	—	ns		
Clock low to output valid	$t_V$	—	15.5	ns		
Data output hold time	$t_{HO}$	6	—	ns		
Data output disable time	$t_{DIS}$	—	18	ns		

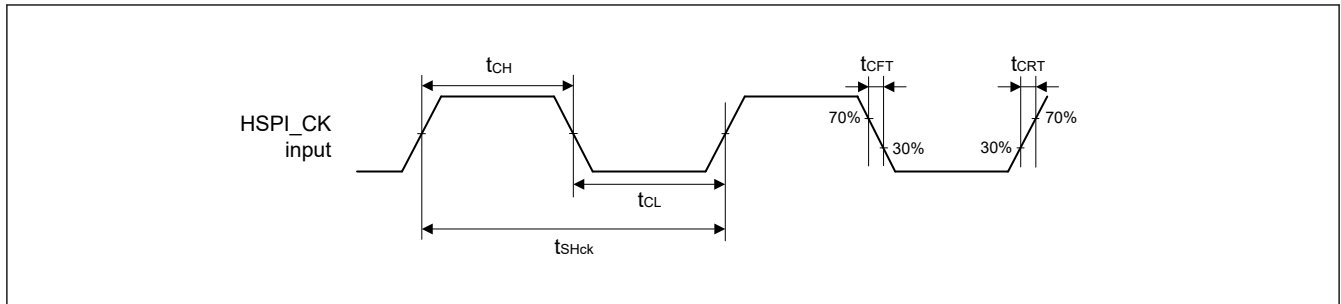


Figure 2.87 SHOSTIF clock timing

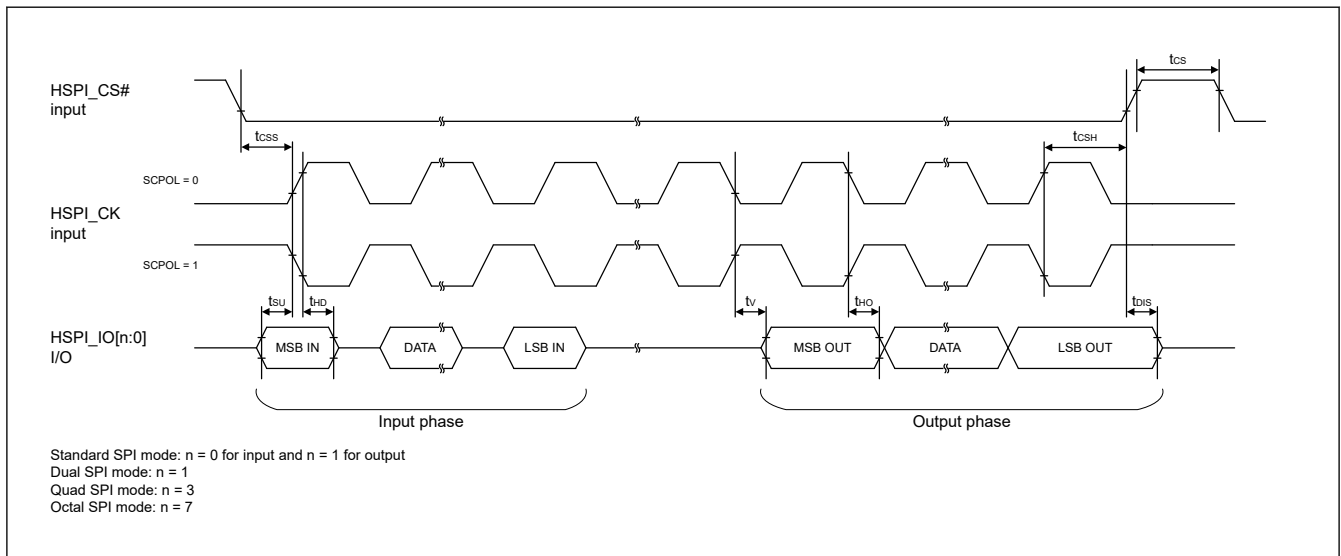


Figure 2.88 SHOSTIF timing (SCPH = 0)

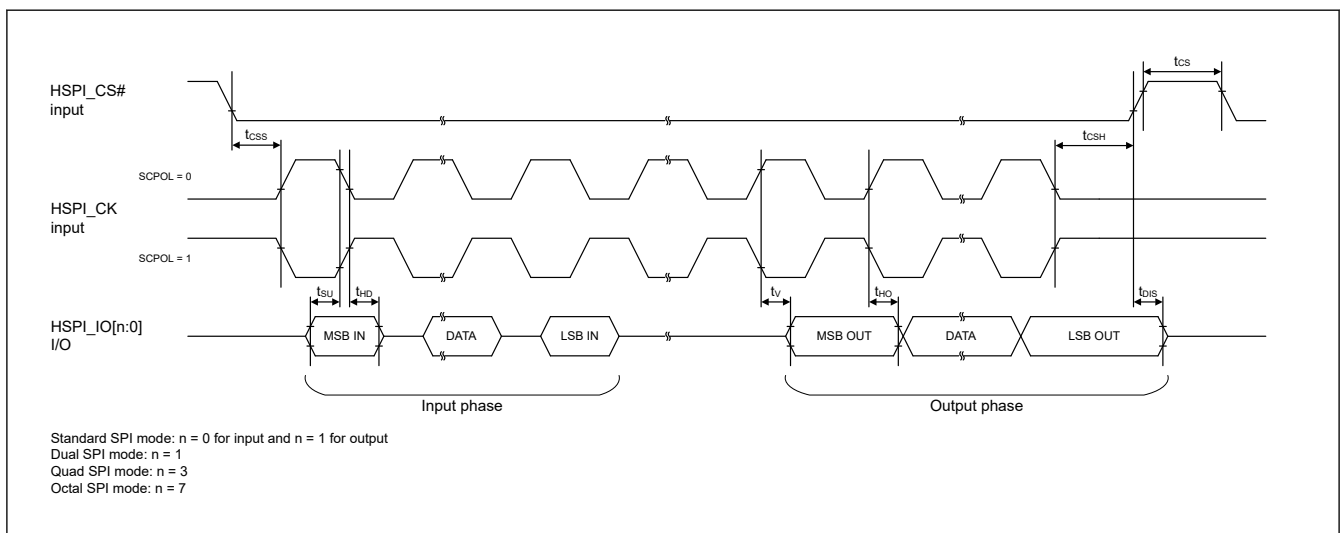


Figure 2.89 SHOSTIF timing (SCPH = 1)

### 2.5.5.17 PHOSTIF Timing

Conditions:

$$V_{OH} = V_{CC33} \times 0.5, V_{OL} = V_{CC33} \times 0.5, C = 30 \text{ pF}$$

## (1) Synchronous SRAM Interface Mode

Table 2.42 PHOSTIF timing (Synchronous SRAM interface mode)

No.	Parameter	Symbol	Min.	Max.	Unit	Reference figure
1	HCKIO input cycle	$t_{\text{HCKIO}}$	20.0	—	ns	Figure 2.90 to Figure 2.94
2	HCKIO High-level width	$t_{\text{HBHIGH}}$	$0.5 \times t_{\text{HCKIO}} - 2.1$	$0.5 \times t_{\text{HCKIO}} + 2.1$	ns	
3	HCKIO Low-level width	$t_{\text{HBLOW}}$	$0.5 \times t_{\text{HCKIO}} - 2.1$	$0.5 \times t_{\text{HCKIO}} + 2.1$	ns	
4	Address and HCS0#/HCS1# input setup time (to HCKIO ↑)	$t_{\text{SKHA}}$	4.0	—	ns	
5	Address and HCS0#/HCS1# input hold time (to HCKIO ↑)	$t_{\text{HKHA}}$	1.0	—	ns	
6	HWR0#/HWR1# input setup time (to HCKIO ↑)	$t_{\text{SKHWR}}$	4.0	—	ns	
7	HWR0#/HWR1# input hold time (to HCKIO ↑)	$t_{\text{HKHWR}}$	1.0	—	ns	
8	HWRSTB# input setup time (to HCKIO ↑)	$t_{\text{SKHWRSTB}}$	4.0	—	ns	
9	HWRSTB# input hold time (to HCKIO ↑)	$t_{\text{HKHWRSTB}}$	1.0	—	ns	
10	HRD# input setup time (to HCKIO ↑)	$t_{\text{SKHRD}}$	4.0	—	ns	
11	HRD# input hold time (to HCKIO ↑)	$t_{\text{HKHRD}}$	1.0	—	ns	
12	Data input setup time (to HCKIO ↑)	$t_{\text{SKIHD}}$	4.0	—	ns	
13	Data input hold time (to HCKIO ↑)	$t_{\text{HKIHD}}$	1.0	—	ns	
14	Data and HWAIT# output delay time (to HRD# ↓)	$t_{\text{DKHDHR}}$	1.0	—	ns	
15	Data and HWAIT# output hold time (to HRD# ↑)	$t_{\text{HKOHD}}$	—	11.0	ns	
16	Data and HWAIT# output delay time (to HCS0#/HCS1# ↓)	$t_{\text{DKHD}}$	1.0	—	ns	
17	Data and HWAIT# output hold time (to HCS0#/HCS1# ↑)	$t_{\text{HKWTCS}}$	—	11.0	ns	
18	HWAIT# output delay time (to HWRSTB#, HWR0#/HWR1# ↓)	$t_{\text{DKHWT}}$	1.0	—	ns	
19	HWAIT# output hold time (to HWRSTB#, HWR0#/HWR1# ↑)	$t_{\text{HKWTWR}}$	—	11.0	ns	
20	HWAIT# output delay time (to HCKIO ↑)	$t_{\text{DKHWTV}}$	2.0	11.0	ns	
21	Data output delay time (to HCKIO ↑)	$t_{\text{DKHDV}}$	2.0	11.0	ns	
22	Data and HWAIT# valid data output hold time (to HRD# ↑)	$t_{\text{HKHWTHR}}$	1.0	—	ns	
23	HWR0#/HWR1#, HWRSTB# recovery time (High-level width)	$t_{\text{WHWR}}$	40.0	—	ns	
24	HRD# recovery time (High-level width)	$t_{\text{WHRD}}$	40.0	—	ns	

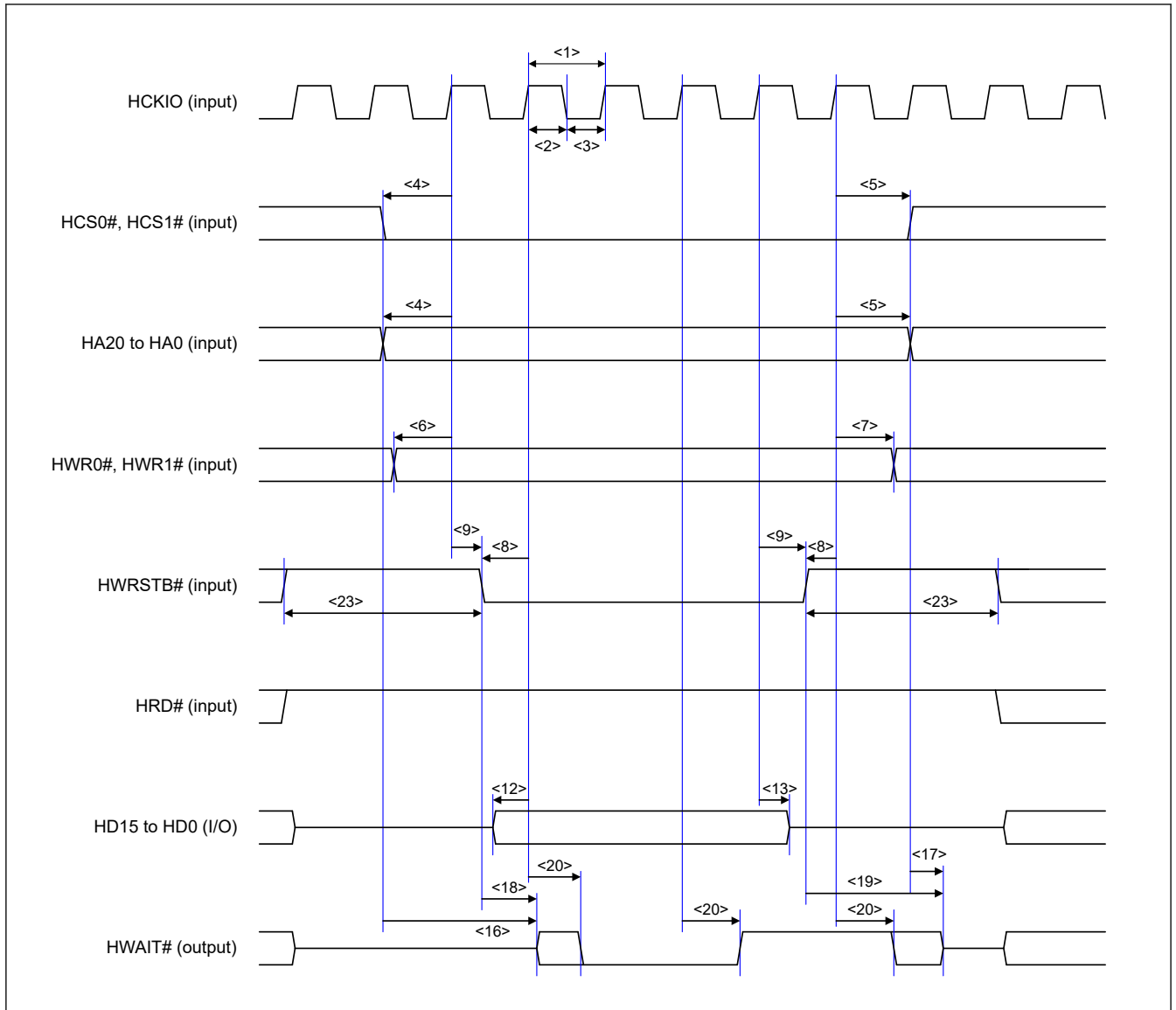


Figure 2.90 PHOSTIF write timing (Synchronous SRAM interface mode)

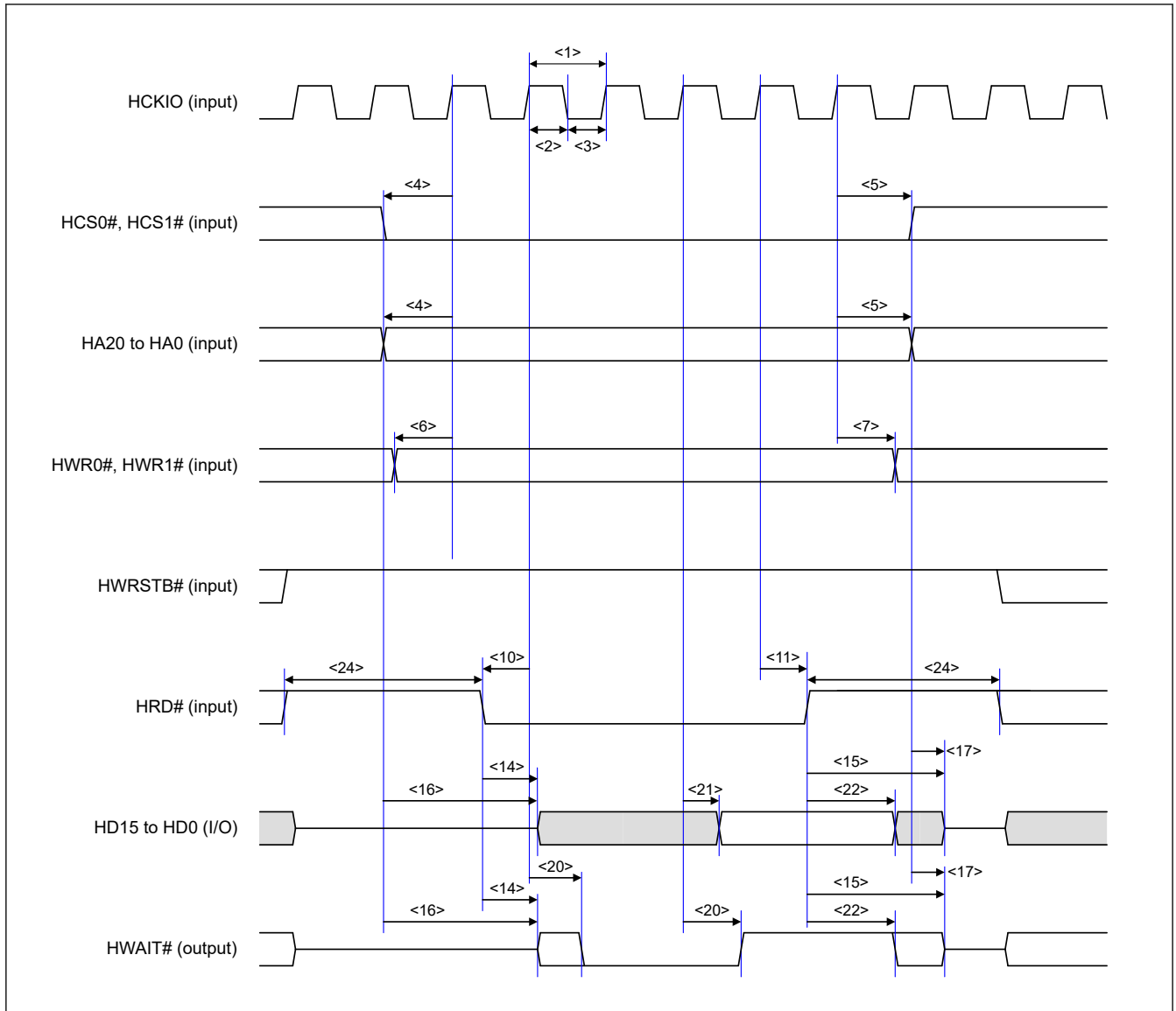


Figure 2.91 PHOSTIF read timing (Synchronous SRAM interface mode)

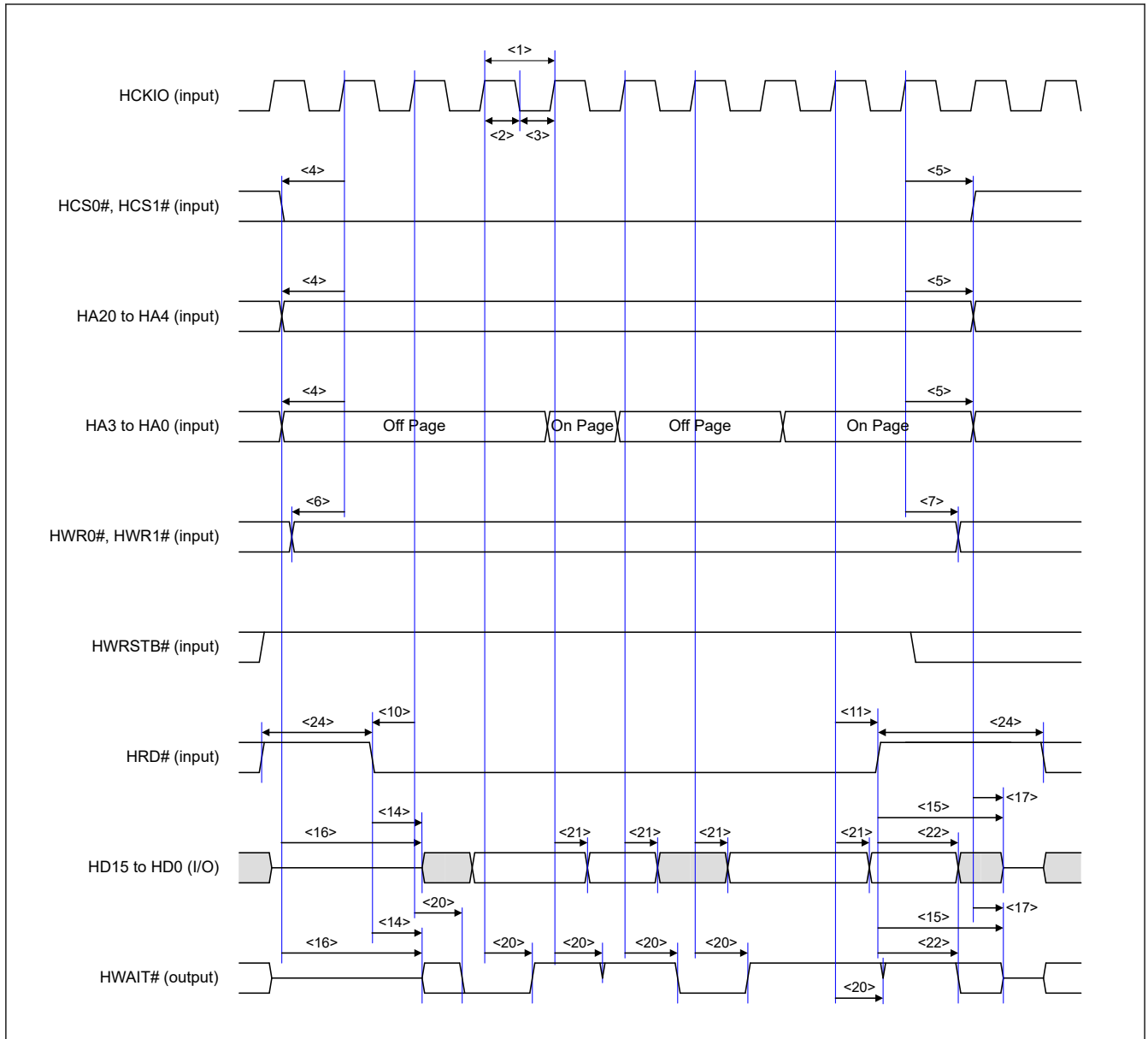


Figure 2.92 PHOSTIF page read timing (Synchronous SRAM interface mode)



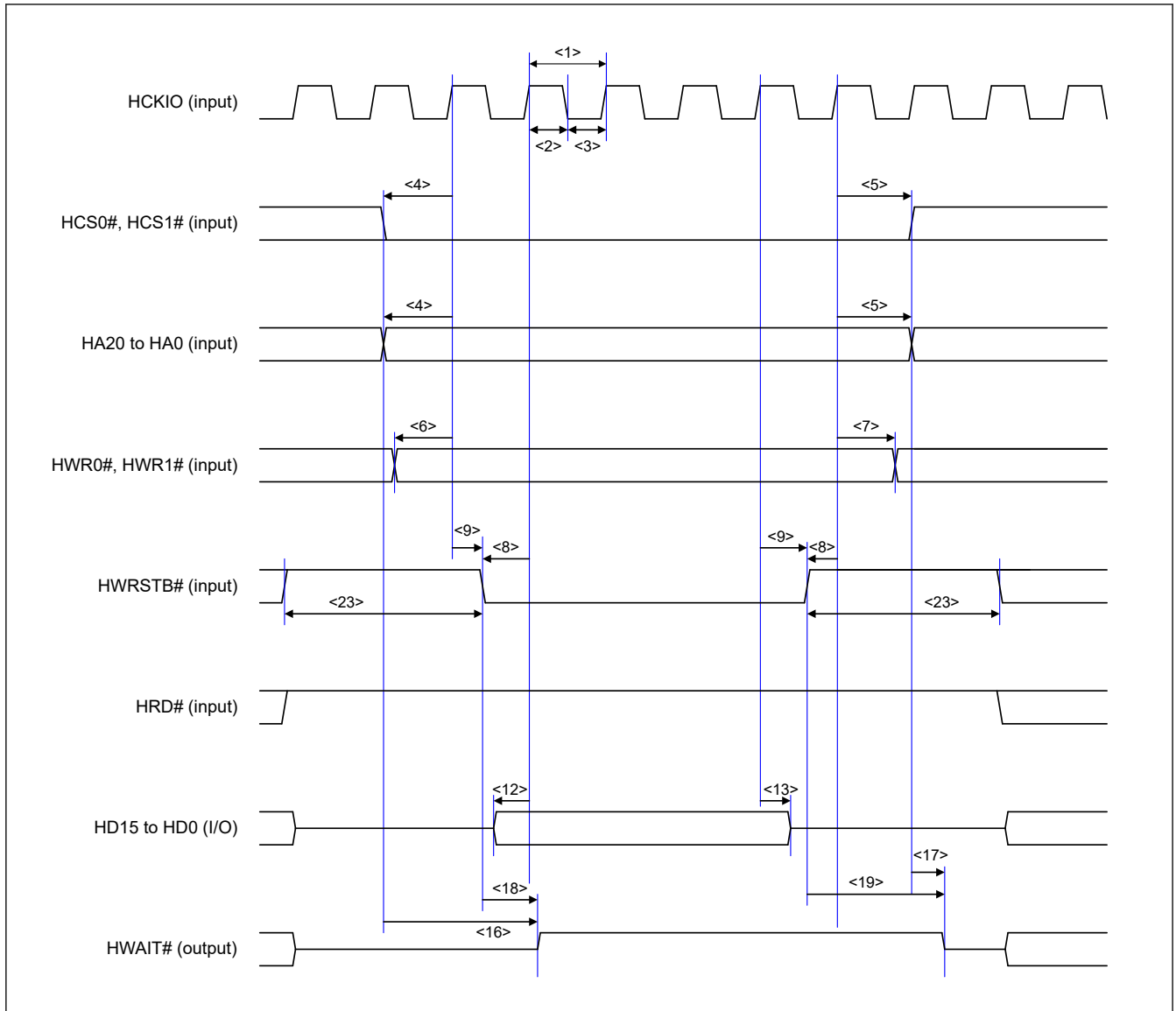


Figure 2.93 PHOSTIF write timing (PHOSTIF register write) (Synchronous SRAM interface mode)

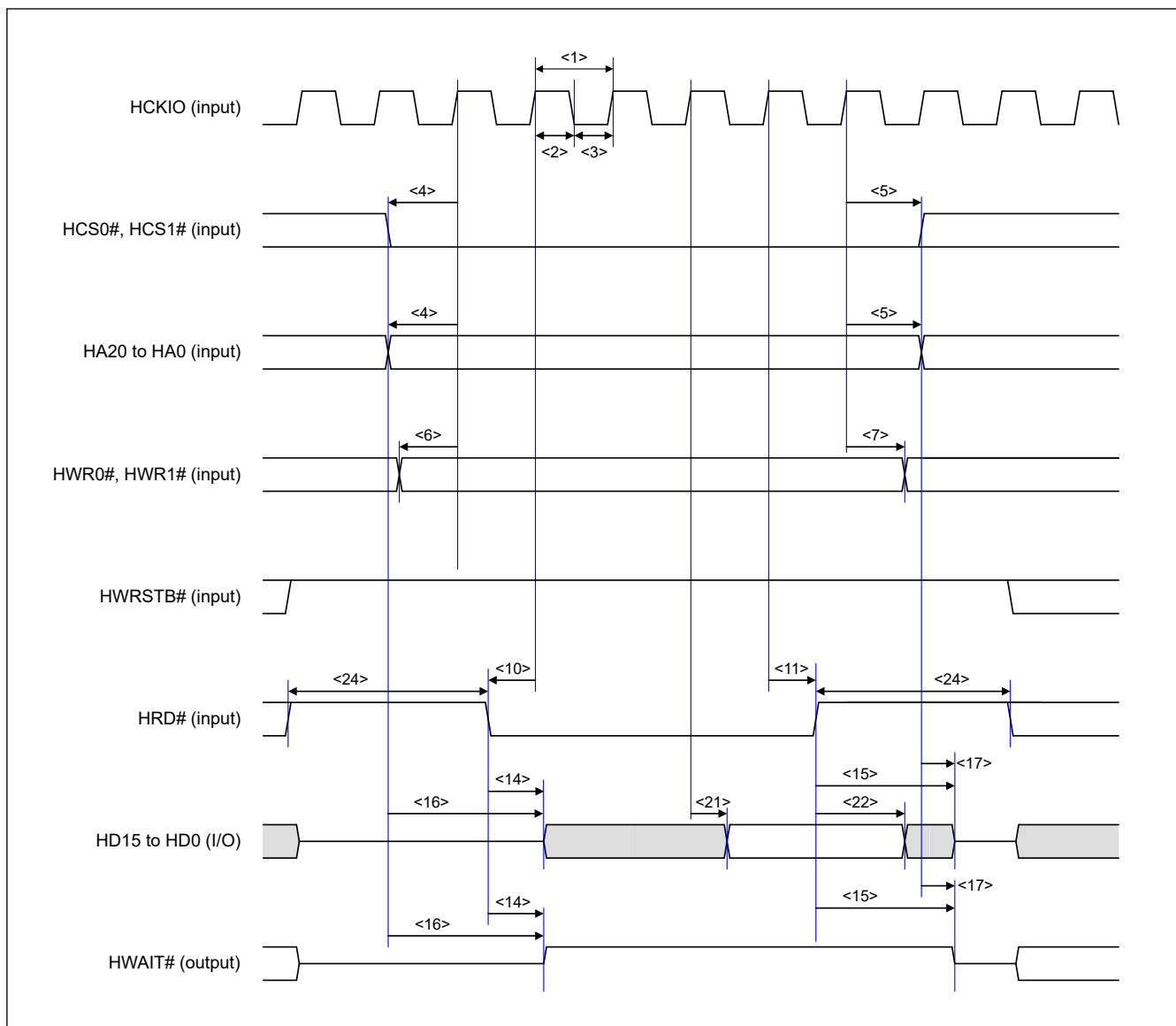


Figure 2.94 PHOSTIF read timing (PHOSTIF register read) (Synchronous SRAM interface mode)

## (2) Asynchronous SRAM Interface Mode

Table 2.43 PHOSTIF timing (Asynchronous SRAM interface mode)

No.	Parameter	Symbol	Min.	Max.	Unit	Reference figure
1	Address, HCS0#/HCS1# input setup time (to HWRSTB#, HWR0#/HWR1# ↓)	$t_{ADDWRS}$	0	—	ns	Figure 2.95 to Figure 2.98
2	HWR0#/HWR1# and HWRSTB# recovery time (High-level width)	$t_{WRW}$	20.0	—	ns	
3	Data input setup time (to HWRSTB#, HWR0#/HWR1# ↓)	$t_{WRS}$	0	—	ns	
4	Data input hold time (to HWRSTB#, HWR0#/HWR1# ↑)	$t_{WRH}$	0	—	ns	
5	HWAIT# output delay time (to HCS0#/HCS1# ↓)	$t_{CLZ}$	1.0	—	ns	
6	HWAIT# output delay time (to HWRSTB#, HWR0#/HWR1# ↓)	$t_{WAITD}$	1.0	—	ns	
7	HWAIT# valid data output delay time (for HWRSTB#, HWR0#/HWR1# ↓)	$t_{WRWAITF}$	—	39.2	ns	
8	HWAIT# valid data output hold time (for HWRSTB#, HWR0#/HWR1# ↑)	$t_{WAITVH}$	0	—	ns	
9	HWAIT# output hold time (to HWR0#/HWR1#, HWRSTB# ↑)	$t_{WAITH}$	—	11.0	ns	
10	HWAIT# output hold time (to HCS0#/HCS1# ↑)	$t_{CHZ}$	—	11.0	ns	
11	Address and HCS0#/HCS1# input setup time (to HRD# ↓)	$t_{ADDRDS}$	0	—	ns	
12	Address input hold time in page access (to HRD# ↑)	$t_{ADDRDH}$	0	—	ns	
13	HRD# recovery time (High-level width)	$t_{RDW}$	20.0	—	ns	
14	Data and HWAIT# output delay time (to HRD# ↓)	$t_{RDLZ}$	1.0	—	ns	
15	HWAIT# valid data output delay time (to HRD# ↓)	$t_{RDWAITF}$	—	39.2	ns	
16	Data fixing time (to HWAIT# ↑)	$t_{WAITR}$	0	—	ns	
17	Data and HWAIT# valid data output hold time (to HRD# ↑)	$t_{DATAOH}$	1.0	—	ns	
18	Data and HWAIT# output hold time (to HRD# ↑)	$t_{RDHZ}$	—	11.0	ns	
19	Data and HWAIT# output delay time in on-page access (to addresses)	$t_{PAGEOND}$	18.0	29.2	ns	
20	Data and HWAIT# output delay time in off-page access (to addresses) (when not crossing a 16-byte boundary)	$t_{PAGEOFD}$	18.0	29.2	ns	
20	Data and HWAIT# output delay time in off-page access (to addresses) (when crossing a 16-byte boundary)	$t_{PAGEOFD}$	18.0	29.2	ns	
21	HWAIT# valid data output delay time (to HCS0#/HCS1# ↓)	$t_{WAITVD}$	—	39.2	ns	
22	Data fixing time (to addresses)	$t_{ADDFIX}$	18.0	—	ns	

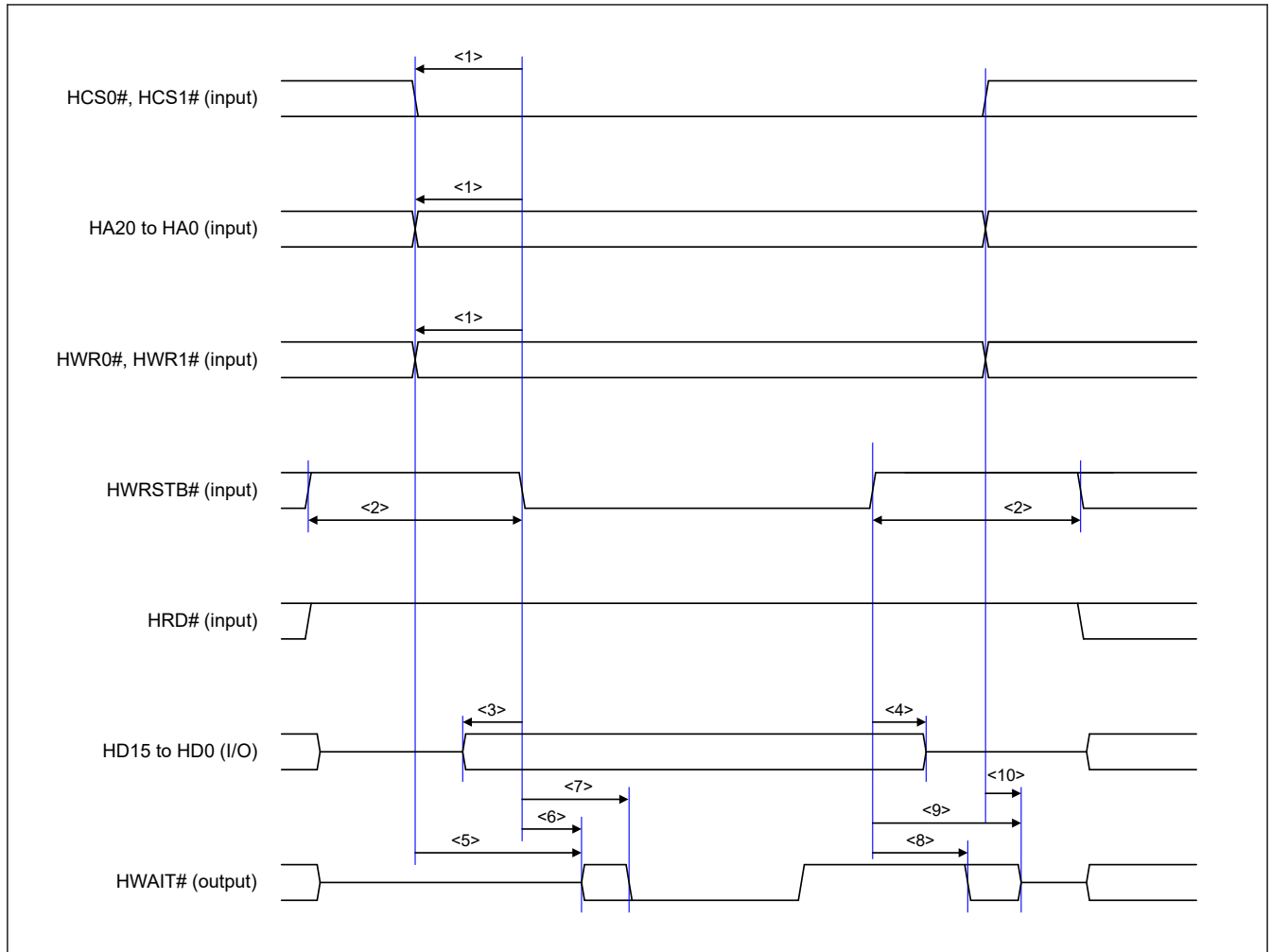


Figure 2.95 PHOSTIF write timing (Asynchronous SRAM interface mode)

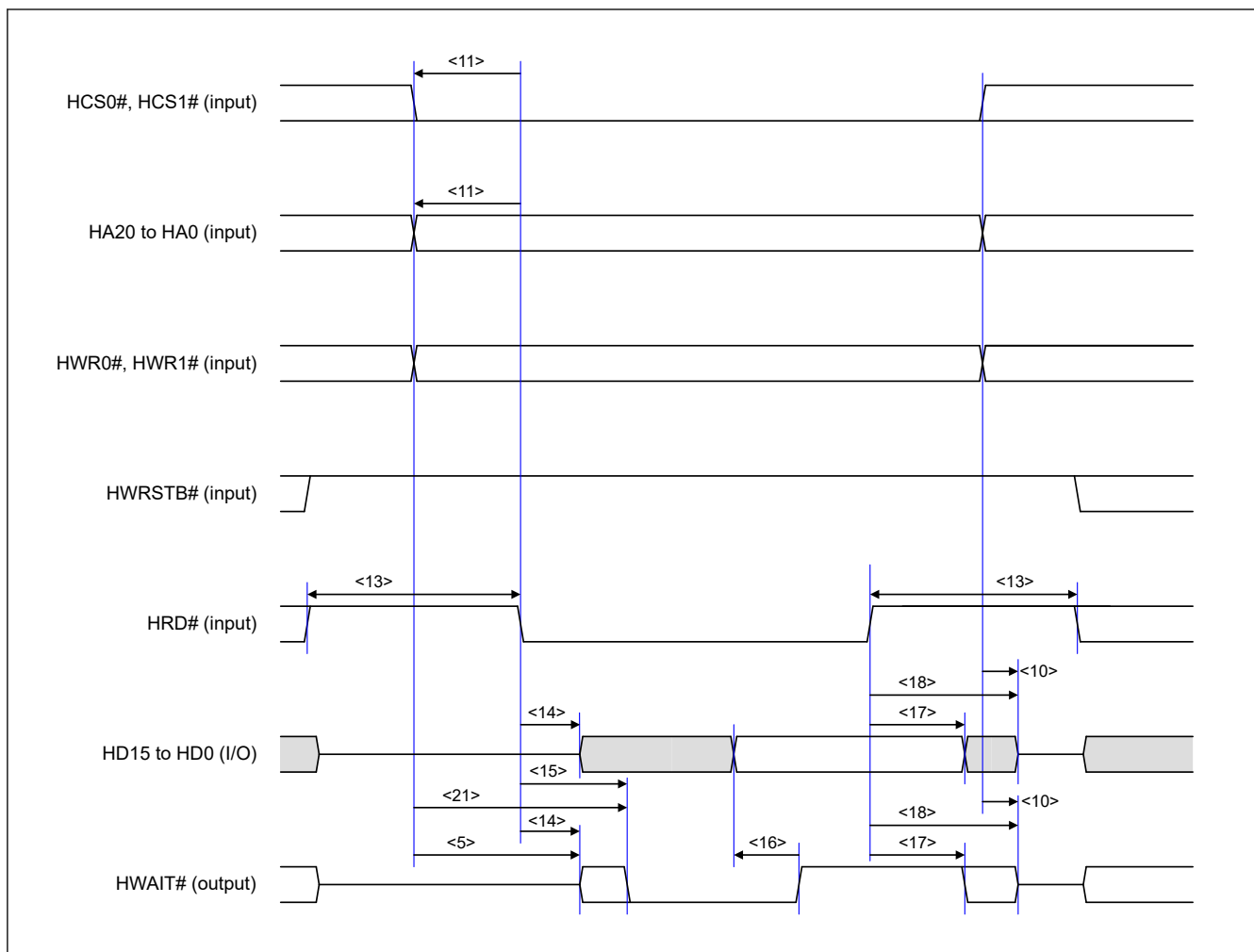


Figure 2.96 PHOSTIF read timing (Asynchronous SRAM interface mode)

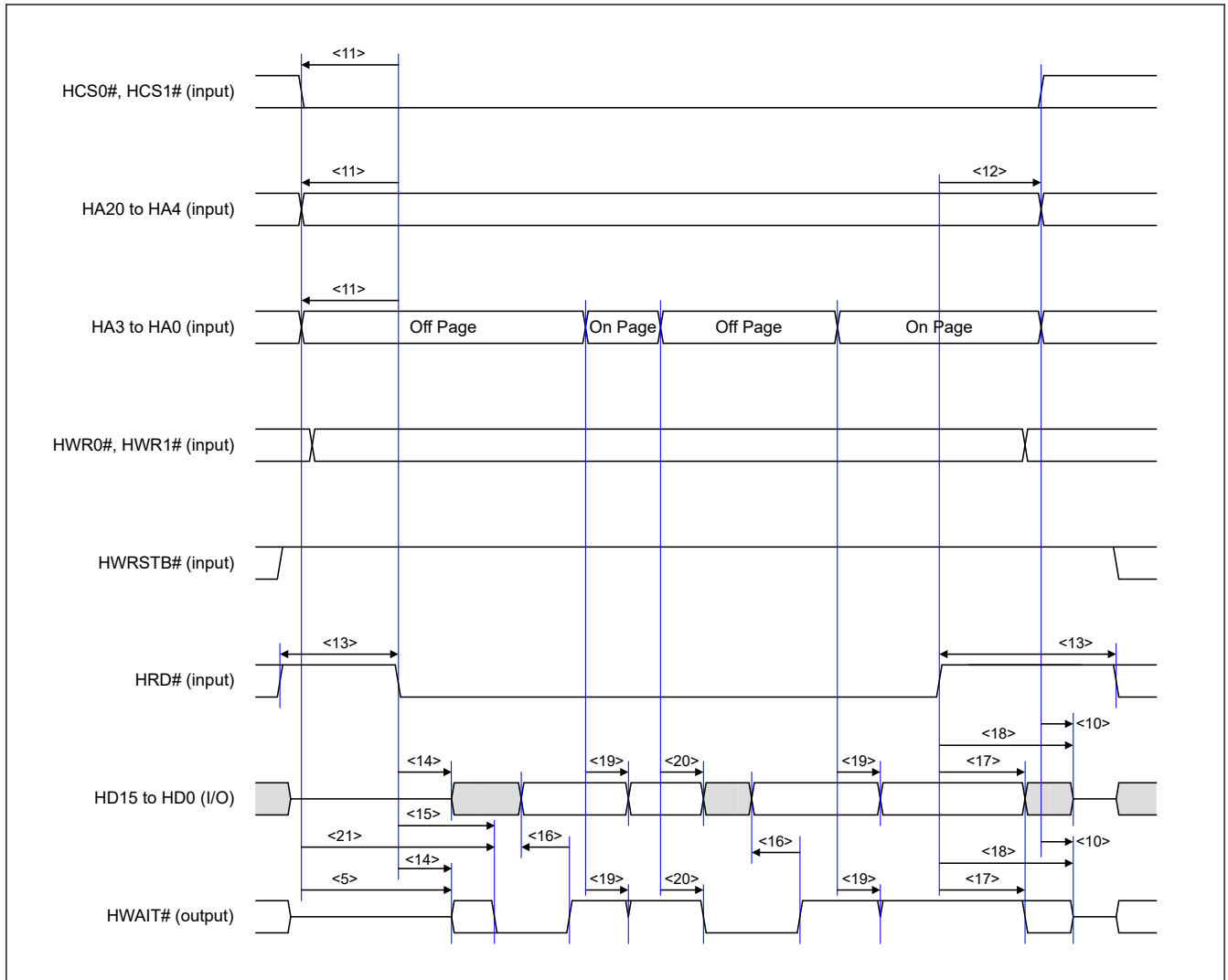


Figure 2.97 PHOSTIF page read timing (Asynchronous SRAM interface mode)

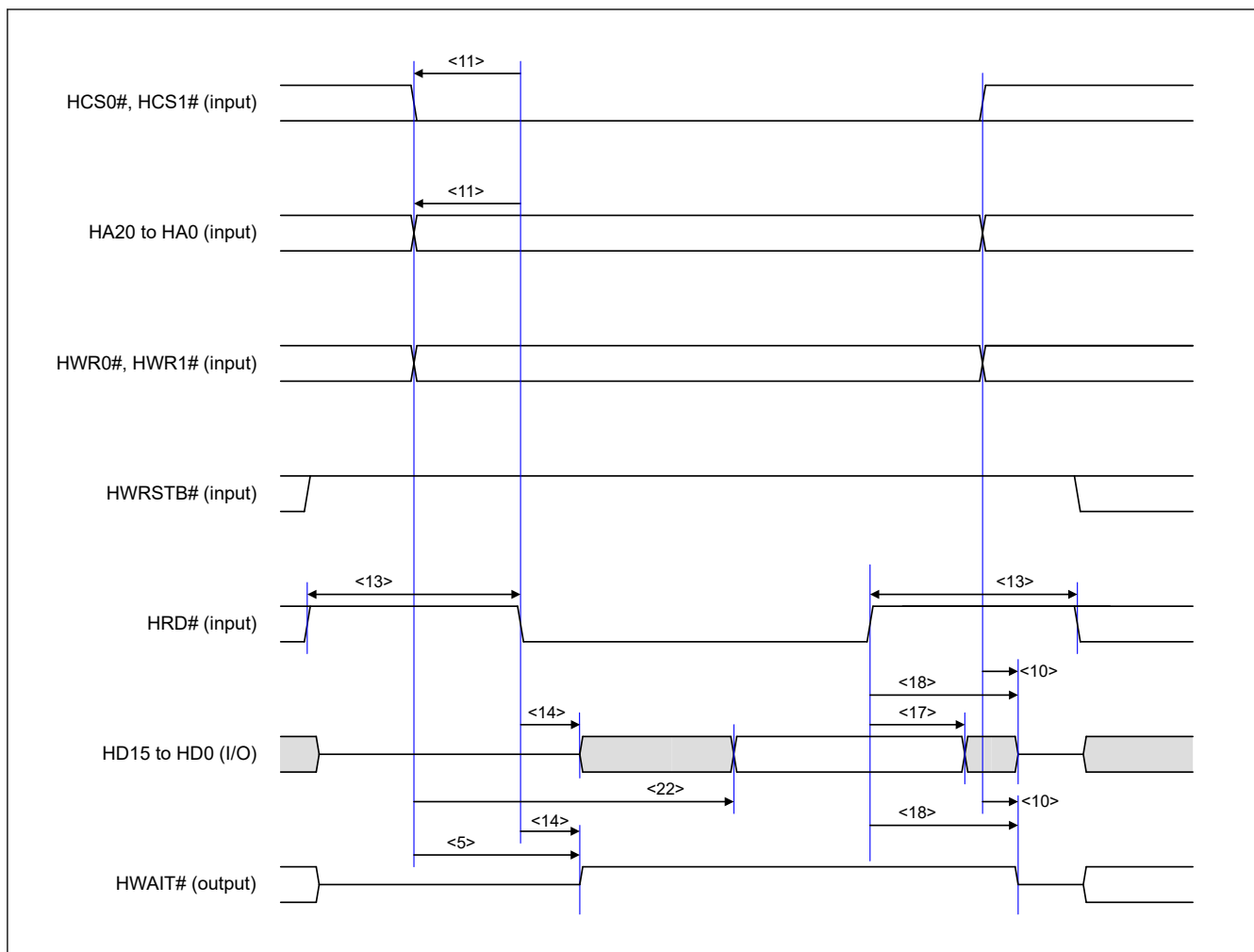


Figure 2.98 PHOSTIF register read timing (Asynchronous SRAM interface mode)

## (3) Synchronous Burst SRAM Type Transfer Mode

Table 2.44 PHOSTIF timing (Synchronous Burst SRAM Type transfer mode)

No.	Parameter	Symbol	Min.	Max.	Unit	Reference figure
1	HCKIO input cycle	$t_{\text{HCKIO}}$	20.0	—	ns	Figure 2.99 to Figure 2.102
2	HCKIO High-level width	$t_{\text{HBHIGH}}$	$0.5 \times t_{\text{HCKIO}} - 2.1$	$0.5 \times t_{\text{HCKIO}} + 2.1$	ns	
3	HCKIO Low-level width	$t_{\text{HLOW}}$	$0.5 \times t_{\text{HCKIO}} - 2.1$	$0.5 \times t_{\text{HCKIO}} + 2.1$	ns	
4	Address and HCS0#/HCS1# input setup time (to HCKIO ↑)	$t_{\text{SKPHA}}$	4.0	—	ns	
5	Address and HCS0#/HCS1# input hold time (to HCKIO ↑)	$t_{\text{HKPCS}}$	1.0	—	ns	
6	Address and HCS0#/HCS1# input setup time (to HCKIO ↓)	$t_{\text{SKNHA}}$	4.0	—	ns	
7	Address and HCS0#/HCS1# input hold time (to HCKIO ↓)	$t_{\text{HKNHA}}$	1.0	—	ns	
8	HWR0#/HWR1# input setup time (to HCKIO ↑)	$t_{\text{SKPHWR}}$	4.0	—	ns	
9	HWR0#/HWR1# input hold time (to HCKIO ↑)	$t_{\text{HKPHWR}}$	1.0	—	ns	
10	HWR0#/HWR1# input setup time (to HCKIO ↓)	$t_{\text{SKNHWR}}$	4.0	—	ns	
11	HWR0#/HWR1# input hold time (to HCKIO ↓)	$t_{\text{HKNHWR}}$	1.0	—	ns	
12	HBS#, HWRSTB# input setup time (to CKIO ↑)	$t_{\text{SKPHBCY}}$	4.0	—	ns	
13	HBS#, HWRSTB# input hold time (to CKIO ↑)	$t_{\text{HKPHBCY}}$	1.0	—	ns	
14	HBS#, HWRSTB# input setup time (to CKIO ↓)	$t_{\text{SKNHBCY}}$	4.0	—	ns	
15	HBS#, HWRSTB# input hold time (to CKIO ↓)	$t_{\text{HKNHBCY}}$	1.0	—	ns	
16	HRD# input setup time (to CKIO ↑)	$t_{\text{SKPHRD}}$	4.0	—	ns	
17	HRD# input hold time (to CKIO ↑)	$t_{\text{HKPHRD}}$	1.0	—	ns	
18	HRD# input setup time (to CKIO ↓)	$t_{\text{SKNHRD}}$	4.0	—	ns	
19	HRD# input hold time (to CKIO ↓)	$t_{\text{HKNHRD}}$	1.0	—	ns	
20	Data input setup time (to CKIO ↑)	$t_{\text{SKPHD}}$	4.0	—	ns	
21	Data input hold time (to CKIO ↑)	$t_{\text{HKPHD}}$	1.0	—	ns	
22	Data input setup time (to CKIO ↓)	$t_{\text{SKNHd}}$	4.0	—	ns	
23	Data input hold time (to CKIO ↓)	$t_{\text{HKNHD}}$	1.0	—	ns	
24	Data output delay time (to HRD# ↓)	$t_{\text{DKNHRD}}$	1.0	—	ns	
25	Data output hold time (to HRD# ↑)	$t_{\text{HKPHRD}}$	—	11.0	ns	
26	Data output delay time (to HCKIO ↑)	$t_{\text{DKPHD}}$	2.0	11.0	ns	
27	Data output delay time (to HCKIO ↓)	$t_{\text{DKNHd}}$	2.0	11.0	ns	
28	HWAIT# output delay time (to HCKIO ↑)	$t_{\text{DKPHWT}}$	2.0	11.0	ns	
29	HWAIT# output delay time (to HCKIO ↓)	$t_{\text{DKNHWT}}$	2.0	11.0	ns	
30	Data output hold time (to HCS0#/HCS1# ↑)	$t_{\text{HKPHCS}}$	—	11.0	ns	
31	HWRSTB# recovery time (High-level width)	$t_{\text{WHWR}}$	40.0	—	ns	
32	HRD# recovery time (High-level width)	$t_{\text{WHRD}}$	40.0	—	ns	



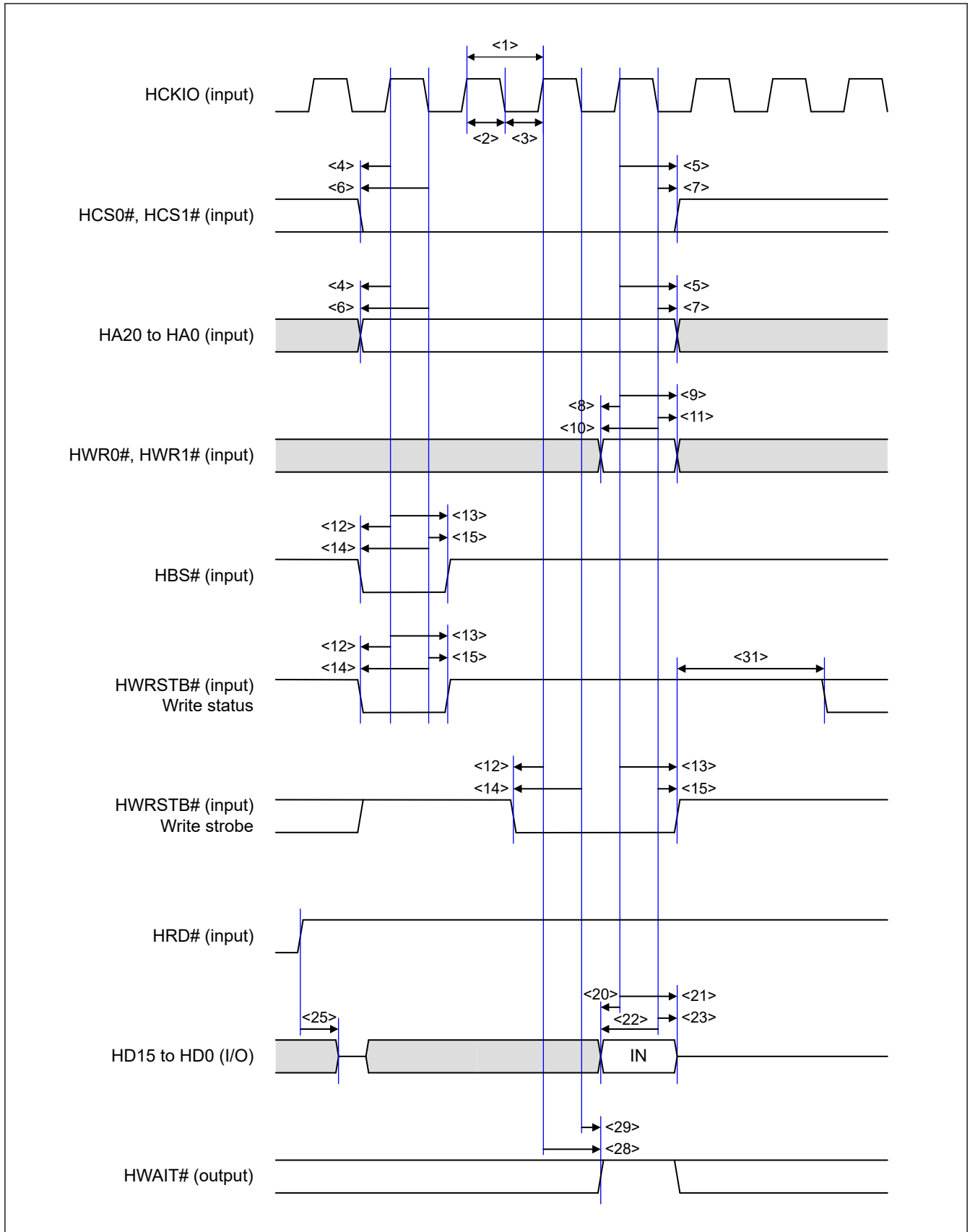


Figure 2.99 PHOSTIF write timing (Synchronous Burst SRAM Type transfer mode, Address/Data separation)

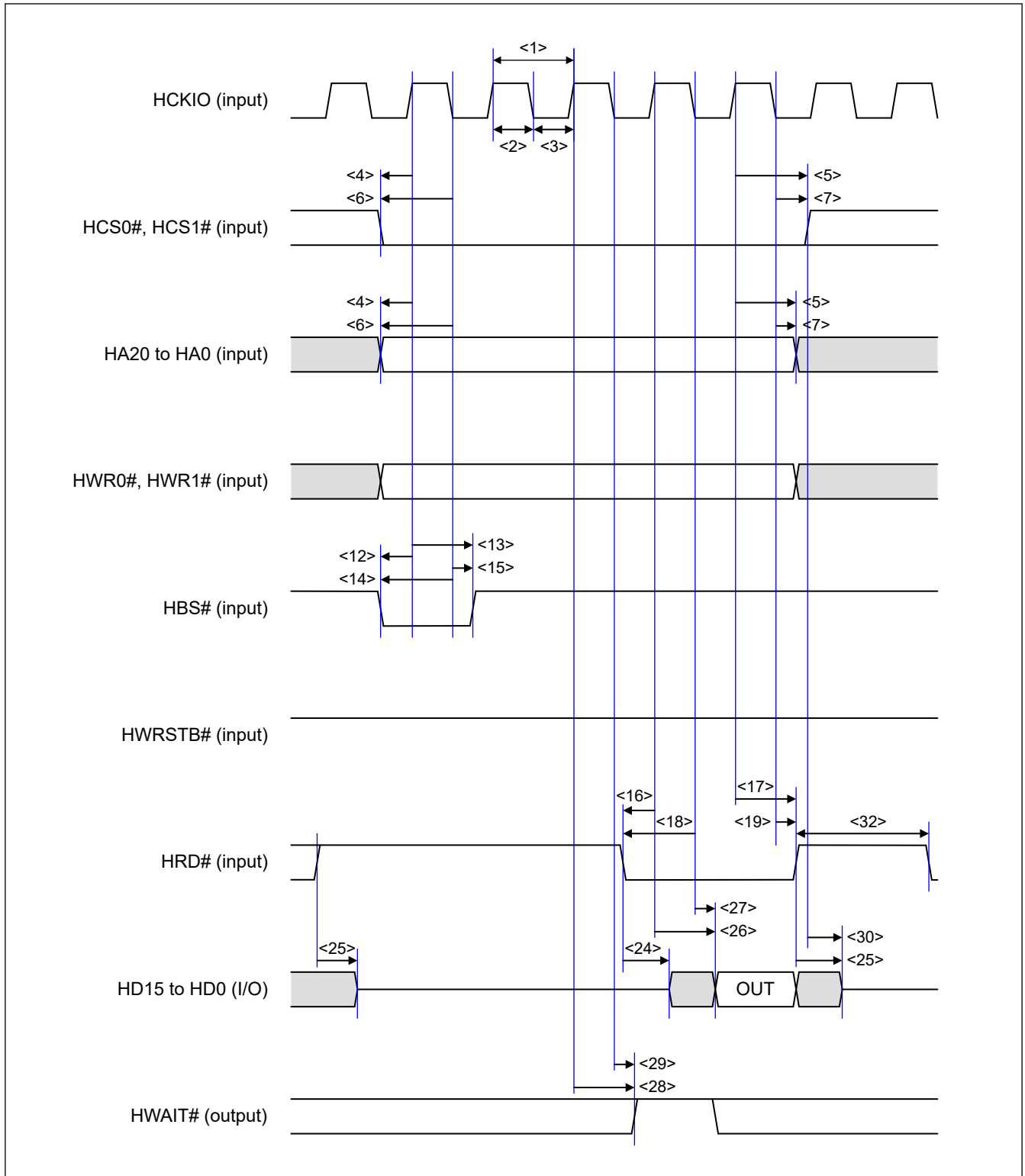


Figure 2.100 PHOSTIF read timing (Synchronous Burst SRAM Type transfer mode, Address/Data separation)

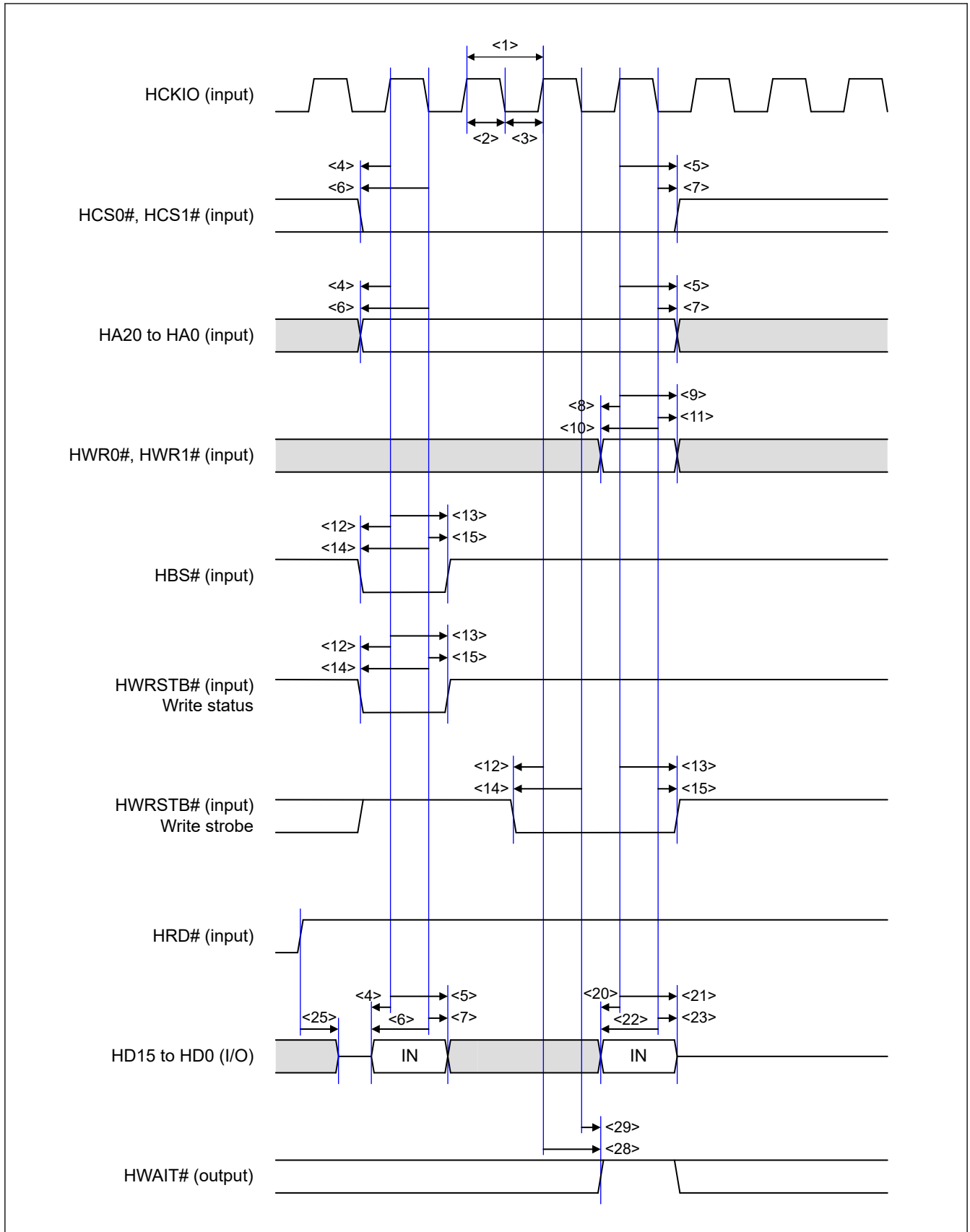


Figure 2.101 PHOSTIF write timing (Synchronous Burst SRAM Type transfer mode, Address/Data multiplexing)

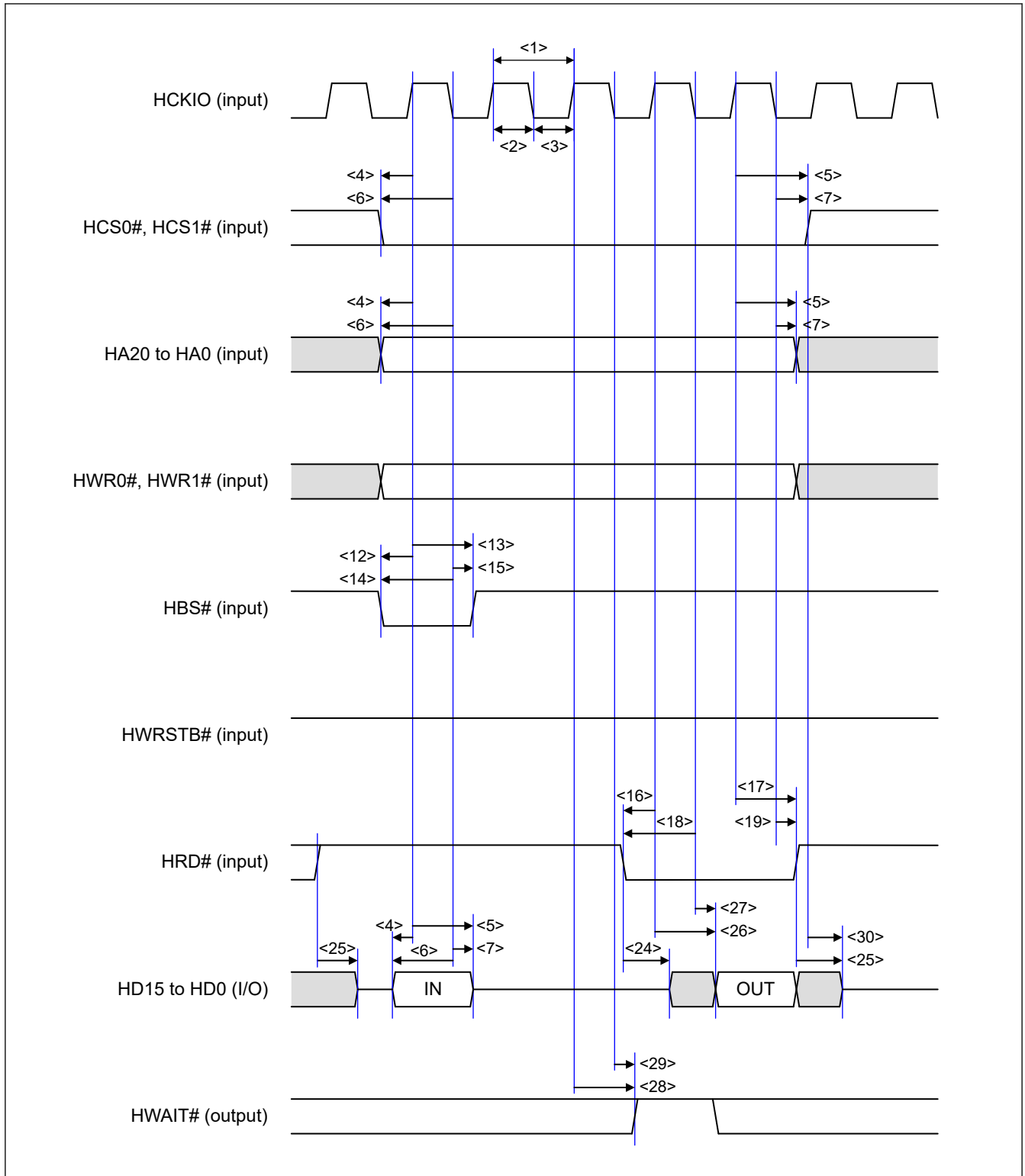


Figure 2.102 PHOSTIF read timing (Synchronous Burst SRAM Type transfer mode, Address/Data multiplexing)

2.6 USB Characteristics

Table 2.45 On-chip USB low-speed (host only) characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference figure
Rising time	$t_{LR}$	75	—	300	ns	Figure 2.103, Figure 2.104
Falling time	$t_{LF}$	75	—	300	ns	
Rising/falling time ratio	$t_{LR}/t_{LF}$	80	—	125	%	

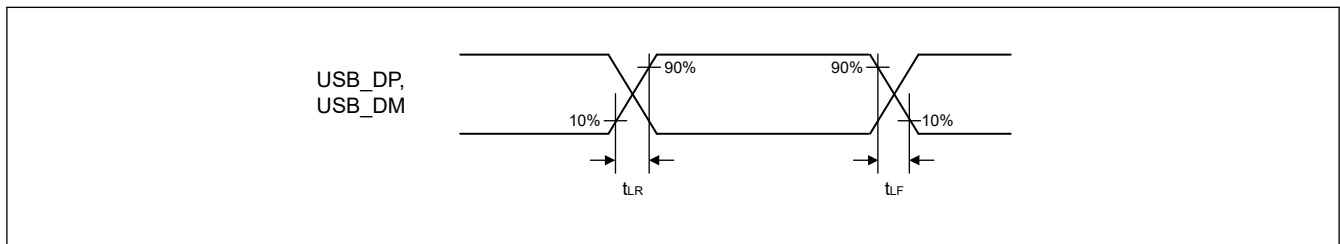


Figure 2.103 USB\_DP, USB\_DM output timing (low-speed/host only)

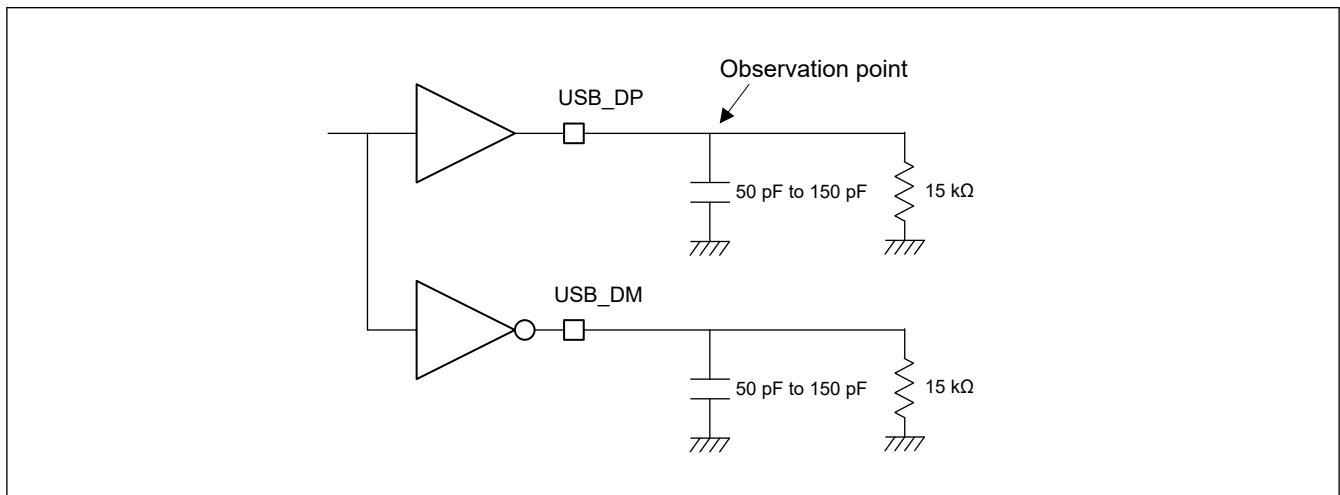


Figure 2.104 Measurement circuit (low-speed/host only)

Table 2.46 On-chip USB full-speed characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference figure
Rising time	$t_{FR}$	4	—	20	ns	Figure 2.105, Figure 2.106
Falling time	$t_{FF}$	4	—	20	ns	
Rising/falling time ratio	$t_{FR}/t_{FF}$	90	—	111.11	%	

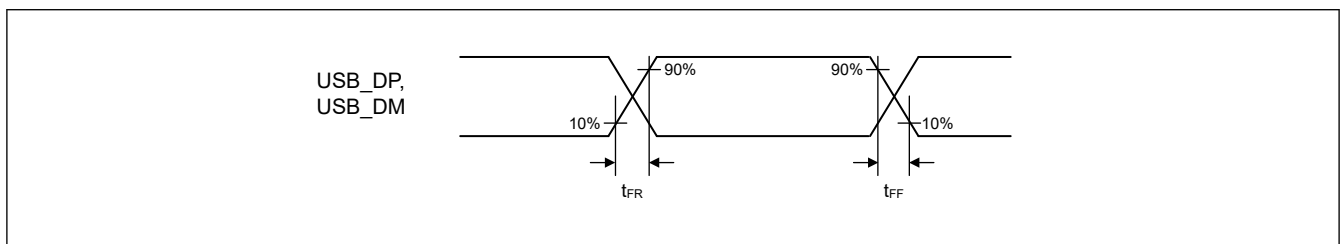


Figure 2.105 USB\_DP, USB\_DM output timing (full speed)

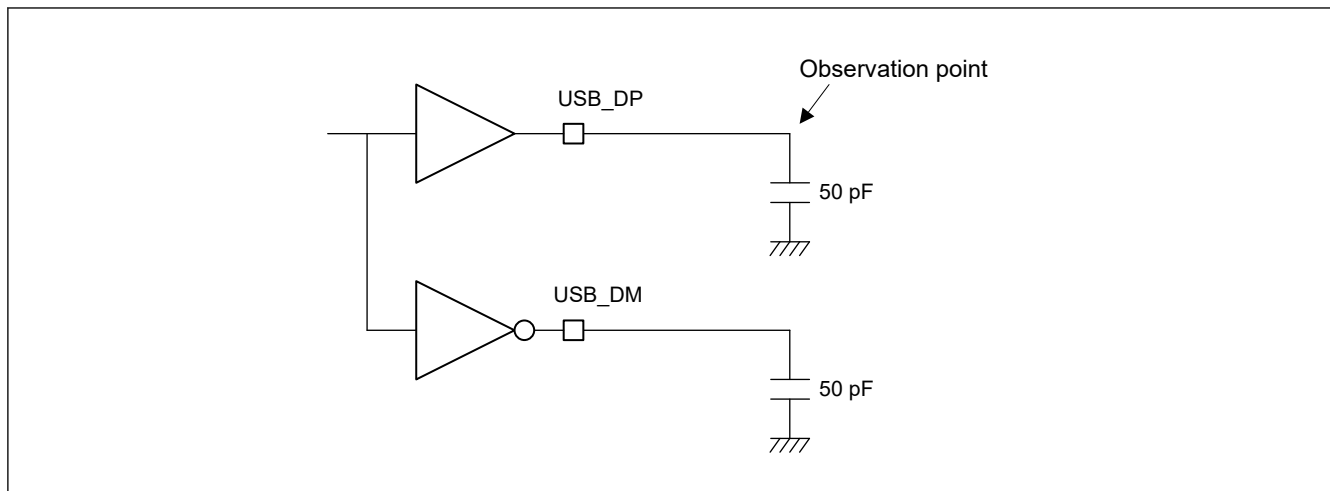


Figure 2.106 Measurement circuit (full speed)

Table 2.47 On-chip USB high-speed characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference figure
Rising time	$t_{HSR}$	—	—	2.133	V/ $\mu$ s	Figure 2.107, Figure 2.108
Falling time	$t_{HSF}$	—	—	2.133	V/ $\mu$ s	
Output resistors (also used as high-speed terminating resistor)	$Z_{HSDRV}$	40.5	—	49.5	$\Omega$	—

Note: The output resistors ( $Z_{HSDRV}$ ) for connection to the USB\_DP and USB\_DM pins are within the LSI.

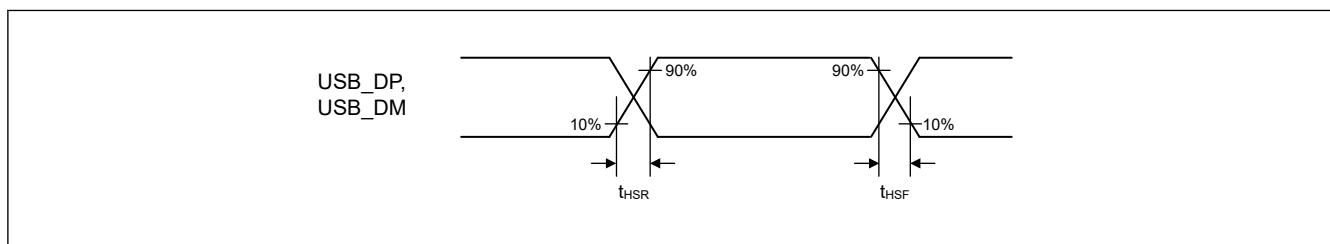


Figure 2.107 USB\_DP, USB\_DM output timing (high speed)

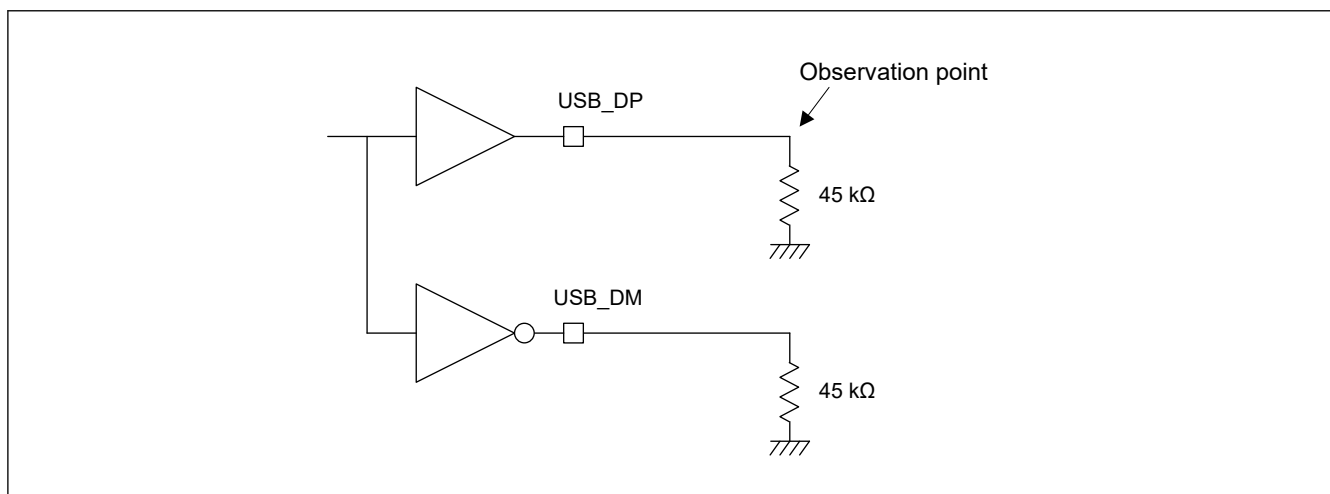


Figure 2.108 Measurement circuit (high speed)

## 2.7 A/D Conversion Characteristics

Table 2.48 12-Bit A/D (unit 0) conversion characteristics

Parameter		Min.	Typ.	Max.	Unit	Reference figure
Resolution		12			bits	—
Analog input capacitance		—	—	13	pF	—
Channel-dedicated sample-and-hold circuits in use (AN000 to AN002)	Conversion time* <sup>1</sup> Permissible signal source impedance Max. = 1.0 kΩ	1.52	—	—	μs	—
	Offset error	—	—	±13	LSB	—
	Full-scale error	—	—	±13	LSB	—
	Quantization error	—	±0.5	—	LSB	—
	Absolute accuracy	—	—	±14	LSB	—
	DNL differential non-linearity error	—	—	±3	LSB	—
	INL integral non-linearity error	—	—	±4	LSB	—
	Holding characteristics of sample-and-hold circuits	—	—	2.67	μs	—
Dynamic range	0.15	—	VREFH0 - 0.15	V	—	
Channel-dedicated sample-and-hold circuits not in use (AN000 to AN007)	Conversion time* <sup>1</sup> Permissible signal source impedance Max. = 1.0 kΩ	0.84	—	—	μs	—
	Offset error	—	—	±11	LSB	—
	Full-scale error	—	—	±11	LSB	—
	Quantization error	—	±0.5	—	LSB	—
	Absolute accuracy	—	—	±12	LSB	—
	DNL differential non-linearity error	—	—	±3	LSB	—
	INL integral non-linearity error	—	—	±4	LSB	—

Note: The specified values in the table apply when there is no access to the external bus during A/D conversion. If access proceeds during A/D conversion, values may not fall within the specified ranges.

Note 1. The conversion time is the total of the sampling time and the comparison time.

Table 2.49 12-Bit A/D (unit 1) conversion characteristics

Parameter		Min.	Typ.	Max.	Unit	Reference figure
Resolution		12			bits	—
Conversion time* <sup>1</sup>	Permissible signal source impedance Max = 1.0 kΩ	0.84	—	—	μs	—
Analog input capacitance		—	—	13	pF	—
Offset error		—	—	±11	LSB	—
Full-scale error		—	—	±11	LSB	—
Quantization error		—	±0.5	—	LSB	—
Absolute accuracy		—	—	±12	LSB	—
DNL differential non-linearity error		—	—	±3	LSB	—
INL integral non-linearity error		—	—	±4	LSB	—

Note: The specified values in the table apply when there is no access to the external bus during A/D conversion. If access proceeds during A/D conversion, values may not fall within the specified ranges.

Note 1. The conversion time is the total of the sampling time and the comparison time.

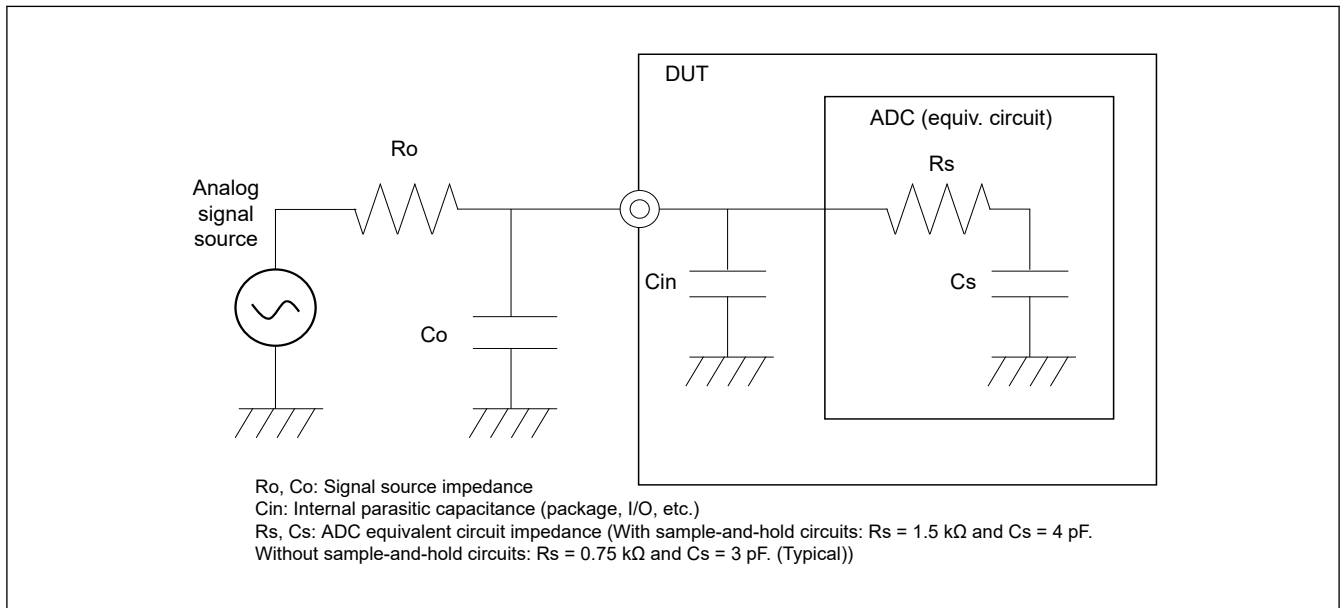


Figure 2.109 A/D converter equivalent circuit and peripheral configuration diagram

## 2.8 Temperature Sensor Characteristics

Table 2.50 Temperature sensor characteristics

Parameter	Min.	Typ.	Max.	Unit	Test Conditions
Relative accuracy	—	±1	—	°C	*1
Temperature slope	—	0.0625	—	°C/LSB	—
Output code (at 25°C)	—	1545 (decimal)	—	—	TSUSAD register

Note 1. 2-point calibration ( $T_j = 25^\circ\text{C}$  and  $T_j = 85^\circ\text{C}$ ) and 8 times averaging.

## 2.9 Debug Interface Timing

Condition:  $V_{OH} = V_{CC33} \times 0.5$ ,  $V_{OL} = V_{CC33} \times 0.5$

Table 2.51 Debug interface timing (1 of 2)

Parameter	Symbol	Min.	Max.	Unit	Reference figure
TCK cycle time	With an ICE connected	$t_{TCKcyc}^{*1}$	—	ns	Figure 2.110
	For use in BSCAN	80	—		
TCK high pulse width	$t_{TCKH}$	0.4	0.6	$t_{TCKcyc}$	
TCK low pulse width	$t_{TCKL}$	0.4	0.6	$t_{TCKcyc}$	
TDI setup time	$t_{TDIS}$	5	—	ns	Figure 2.111 Output load: 30 pF
TDI hold time	$t_{TDIH}$	5	—	ns	
TMS/SWDIO setup time	$t_{TMSS}$	5	—	ns	
TMS/SWDIO hold time	$t_{TMSh}$	5	—	ns	
SWDIO delay time	$t_{SWDO}$	—	15	ns	
TDO delay time	With an ICE connected	$t_{TDOD}$	—	15	ns
	For use in BSCAN		—	22	



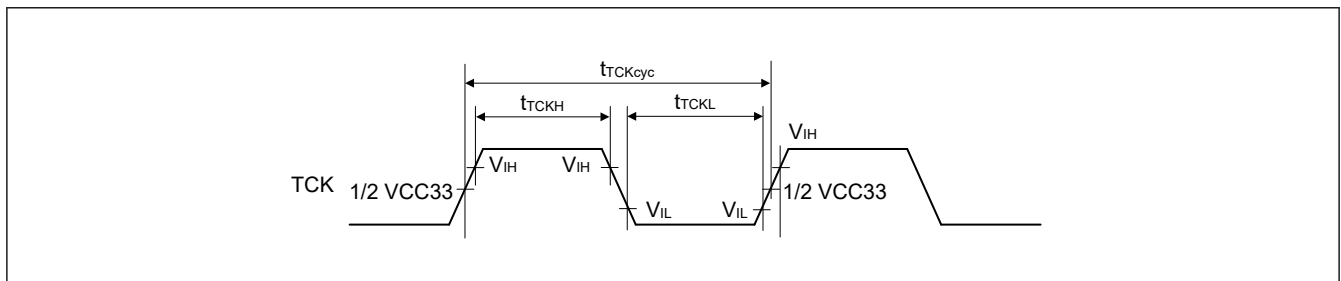
**Table 2.51 Debug interface timing (2 of 2)**

Parameter	Symbol	Min.	Max.	Unit	Reference figure	
Capture register setup time	$t_{CAPTS}$	5	—	ns	Figure 2.112	
Capture register hold time	$t_{CAPTH}$	5	—	ns		
Update register delay time	$t_{UPDATED}$	—	15	ns		
Trace clock cycle	$t_{TCYC}$	20	—	ns	Figure 2.113 Output load: 15 pF	
Trace data delay time	Trace clock: P18_6	$t_{TDT}$	-2.9	3.2		ns
	Trace clock: P17_4		-2.8	3.3		
	Trace clock: P22_2		-2.2*2	4.0		

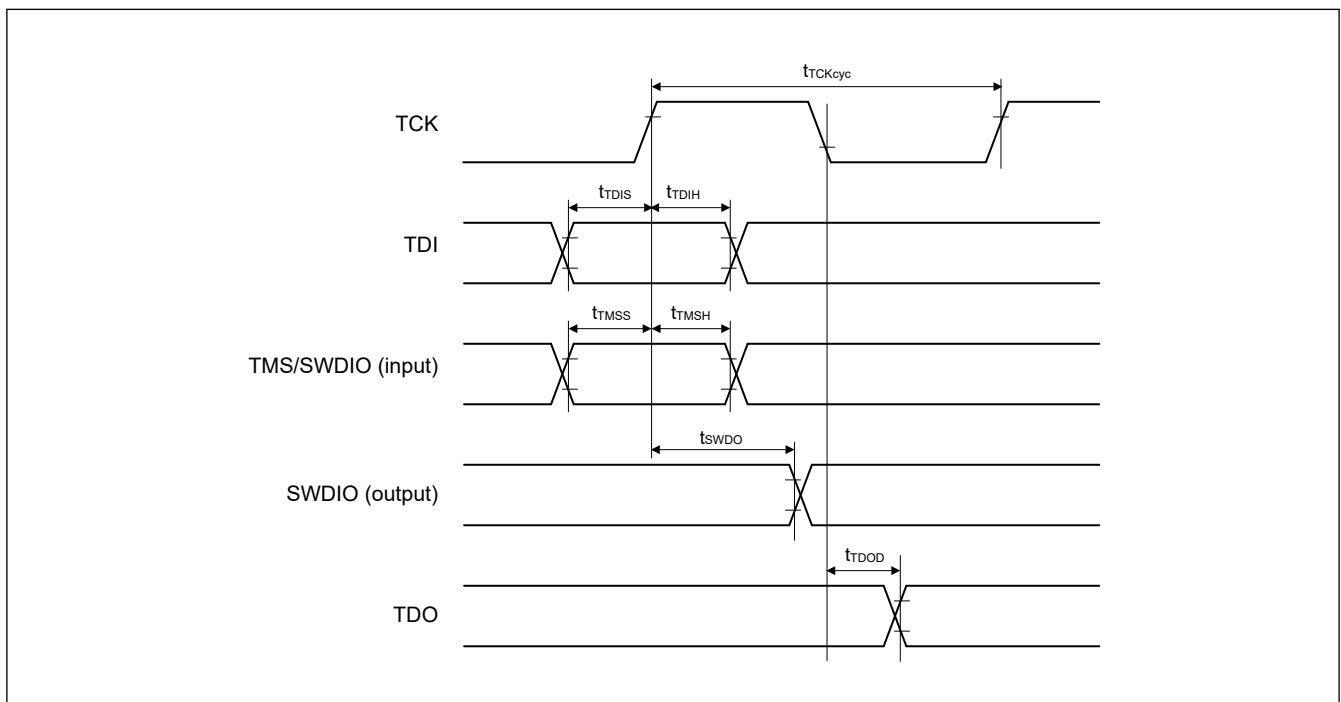
Note 1. This value is the minimum cycle time for the normal operation of internal circuits.

The actual cycle time should be determined in consideration of the TCK capture edge timing and cable length of the connected ICE.

Note 2. If P22\_1 is not used as trace control, this value is -1.8 ns.



**Figure 2.110 TCK input timing**



**Figure 2.111 Data transfer timing**

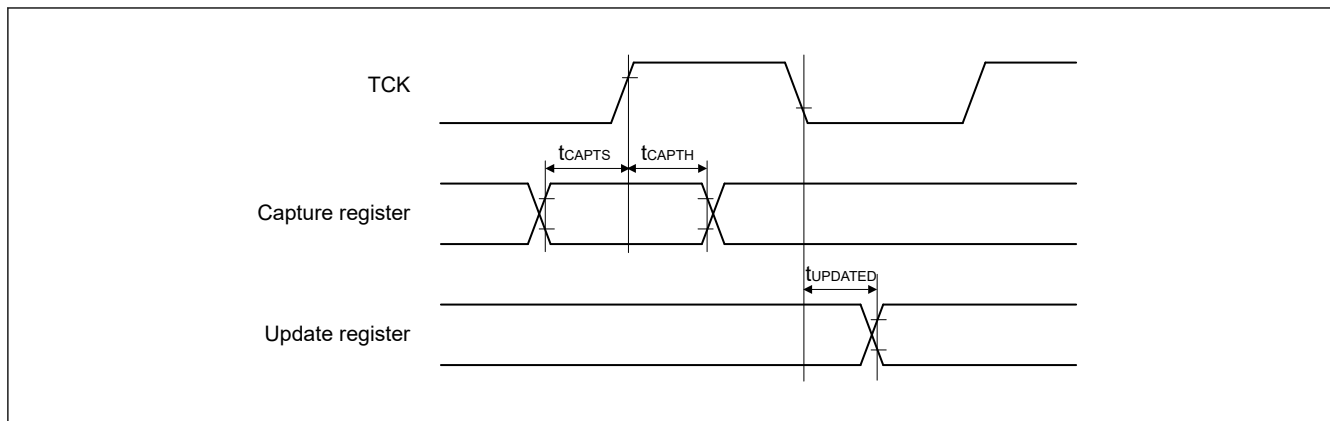


Figure 2.112 Boundary scan input/output timing

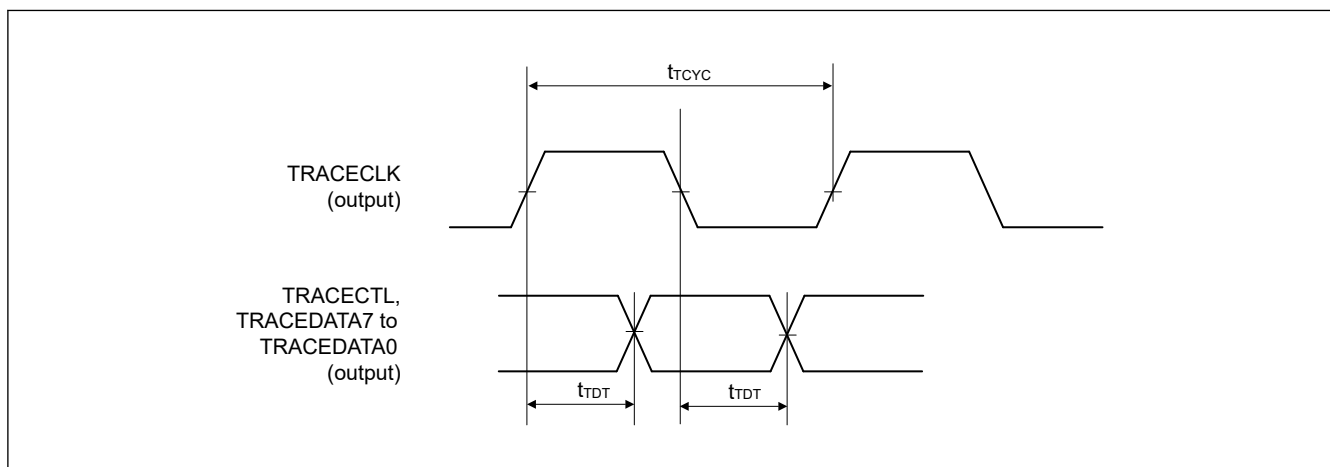
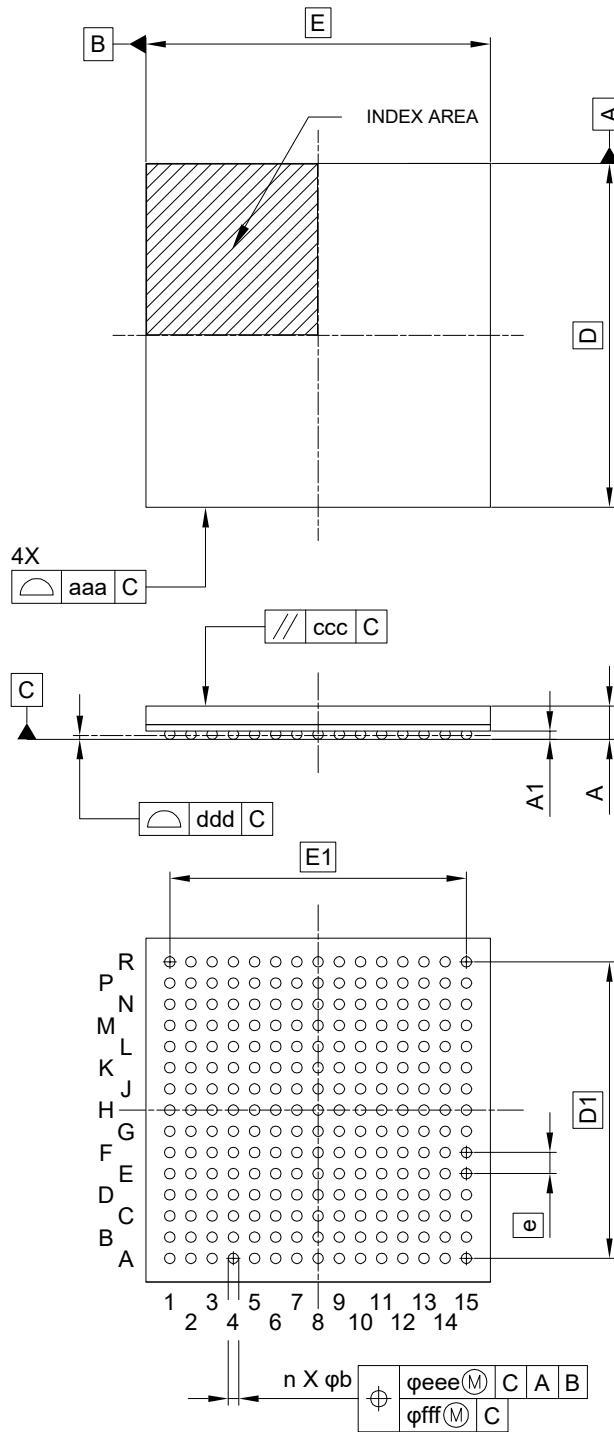


Figure 2.113 Trace interface timing

## Appendix 1. Package Dimensions

Information on the latest version of the package dimensions or mountings is displayed in “Packages” on the Renesas Electronics Corporation website.

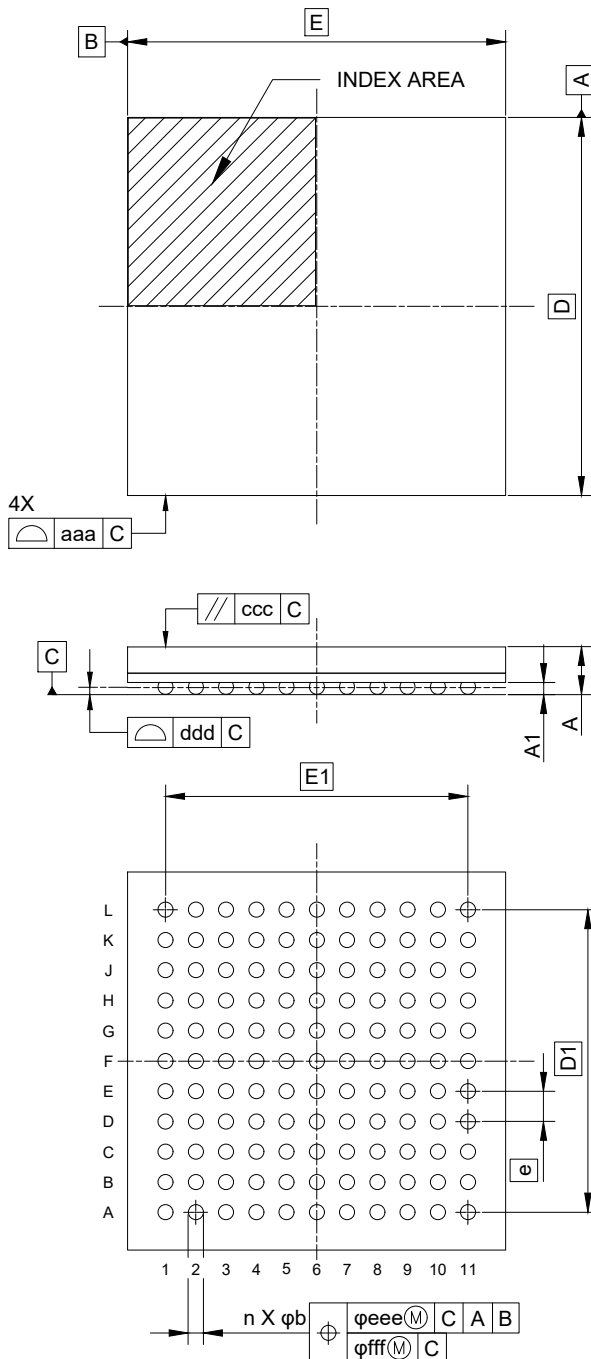
JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LFBGA225-13x13-0.80	PLBG0225GB-A	0.39



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
D	—	13.00	—
E	—	13.00	—
D1	—	11.20	—
E1	—	11.20	—
A	—	—	1.40
A1	0.27	—	—
b	0.38	0.43	0.48
e	—	0.80	—
aaa	—	—	0.15
ccc	—	—	0.20
ddd	—	—	0.12
eee	—	—	0.15
fff	—	—	0.08
n	—	225	—

Figure 1.1 225 pin FBGA

JEITA Package code	RENESAS code	MASS(TYP.)[g]
P-LFBGA121-10x10-0.80	PLBG0121GF-A	0.23



Reference Symbol	Dimension in Millimeters		
	Min.	Nom.	Max.
D	—	10.00	—
E	—	10.00	—
D1	—	8.00	—
E1	—	8.00	—
A	—	—	1.40
A1	0.27	—	—
b	0.38	0.43	0.48
e	—	0.80	—
aaa	—	—	0.15
ccc	—	—	0.20
ddd	—	—	0.12
eee	—	—	0.15
fff	—	—	0.08
n	—	121	—

Figure 1.2 121 pin FBGA

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## Revision History

### Revision 1.00 — June 10, 2022

- Initial release

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