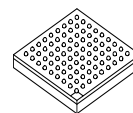




## MCIMX31 and MCIMX31L



**Package Information**  
Plastic Package  
Case 1581 14 x 14 mm, 0.5 mm Pitch

## i.MX31 and i.MX31L

### Multimedia Applications Processors

#### Ordering Information

See [Table 1 on page 3](#) for ordering information.

## 1 Introduction

The i.MX31 (MCIMX31) and i.MX31L (MCIMX31L) are multimedia applications processors that represent the next step in low-power, high-performance application processors. Unless otherwise specified, the material in this data sheet is applicable to both the i.MX31 and i.MX31L processors. The i.MX31L does not include a graphics processing unit (GPU).

Based on an ARM11<sup>™</sup> microprocessor core, the i.MX31 and i.MX31L provide the performance with low power consumption required by modern digital devices such as:

- Feature-rich cellular phones
- Portable media players and mobile gaming machines
- Personal digital assistants (PDAs) and Wireless PDAs
- Portable DVD players
- Digital cameras

The i.MX31 and i.MX31L take advantage of the ARM1136JF-S<sup>™</sup> core running at overdrive speeds of 532 MHz, and are optimized for minimal power

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This document contains information on a new product. Specifications and information herein are subject to change without notice.

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consumption using the most advanced techniques for power saving (DPTC, DVFS, power gating, clock gating). With 90 nm technology and dual-Vt transistors (two threshold voltages), the i.MX31 and i.MX31L provide the optimal performance versus leakage current balance.

The performance of the i.MX31 and i.MX31L is boosted by a multi-level cache system, and features peripheral devices such as an MPEG-4 Hardware Encoder (VGA, 30 fps), an Autonomous Image Processing Unit, a Vector Floating Point (VFP11) co-processor, and a RISC-based SDMA controller.

The i.MX31 and i.MX31L support connections to various types of external memories, such as DDR, NAND Flash, NOR Flash, SDRAM, and SRAM. The i.MX31 and i.MX31L can be connected to a variety of external devices using technology, such as high-speed USB2.0 OTG, ATA, MMC/SDIO, and compact flash.

## 1.1 Features

The i.MX31 and i.MX31L are designed for the high-tier and mid-tier smartphone markets. They provide low-power solutions for high-performance demanding multimedia and graphics applications.

The i.MX31 and i.MX31L are built around the ARM11 MCU core and implemented in the 90 nm technology.

The systems include the following features:

- Multimedia and floating-point hardware acceleration supporting:
  - MPEG-4 real-time encode of up to VGA at 30 fps
  - MPEG-4 real-time video post-processing of up to VGA at 30 fps
  - Video conference call of up to QCIF-30 fps (decoder in software), 128 kbps
  - Video streaming (playback) of up to VGA-30 fps, 384 kbps
  - 3D graphics and other applications acceleration with the ARM<sup>®</sup> tightly-coupled Vector Floating Point co-processor
  - On-the-fly video processing that reduces system memory load (for example, the power-efficient viewfinder application with no involvement of either the memory system or the ARM CPU)
- Advanced power management
  - Dynamic voltage and frequency scaling
  - Multiple clock and power domains
  - Independent gating of power domains
- Multiple communication and expansion ports including a fast parallel interface to an external graphic accelerator (supporting major graphic accelerator vendors)

## 1.2 Ordering Information

Table 1 provides the ordering information for the i.MX31 and i.MX31L.

**Table 1. Ordering Information**

| Part Number   | Silicon Revision <sup>1, 2, 3</sup> | Device Marking  | Operating Temperature Range (°C) | Package <sup>4</sup>                                     |
|---------------|-------------------------------------|-----------------|----------------------------------|----------------------------------------------------------|
| MCIMX31VKN5   | 1.15                                | 2L38W and 3L38W | 0 to 70                          | 14 x 14 mm,<br>0.5 mm pitch,<br>MAPBGA-457,<br>Case 1581 |
| MCIMX31LVKN5  | 1.15                                | 2L38W and 3L38W | 0 to 70                          |                                                          |
| MCIMX31VKN5B  | 1.2                                 | M45G            | 0 to 70                          |                                                          |
| MCIMX31LVKN5B | 1.2                                 | M45G            | 0 to 70                          |                                                          |

<sup>1</sup> Information on reading the silicon revision register can be found in the IC Identification (IIM) chapter of the Reference Manual, document order number MCIMX31RM.

<sup>2</sup> Errata and fix information of the various mask sets can be found in the Errata, document order number MCIMX31CE.

<sup>3</sup> Changes in output buffer characteristics can be found in the I/O Setting Exceptions and Special Pad Descriptions table in Chapter 4 of the Reference Manual, document order number MCIMX31RM.

<sup>4</sup> Case 1581 is RoHS compliant, lead-free, MSL = 3, and solders at 260°C.

## 1.3 Block Diagram

Figure 1 shows the i.MX31 and i.MX31L simplified interface block diagram.

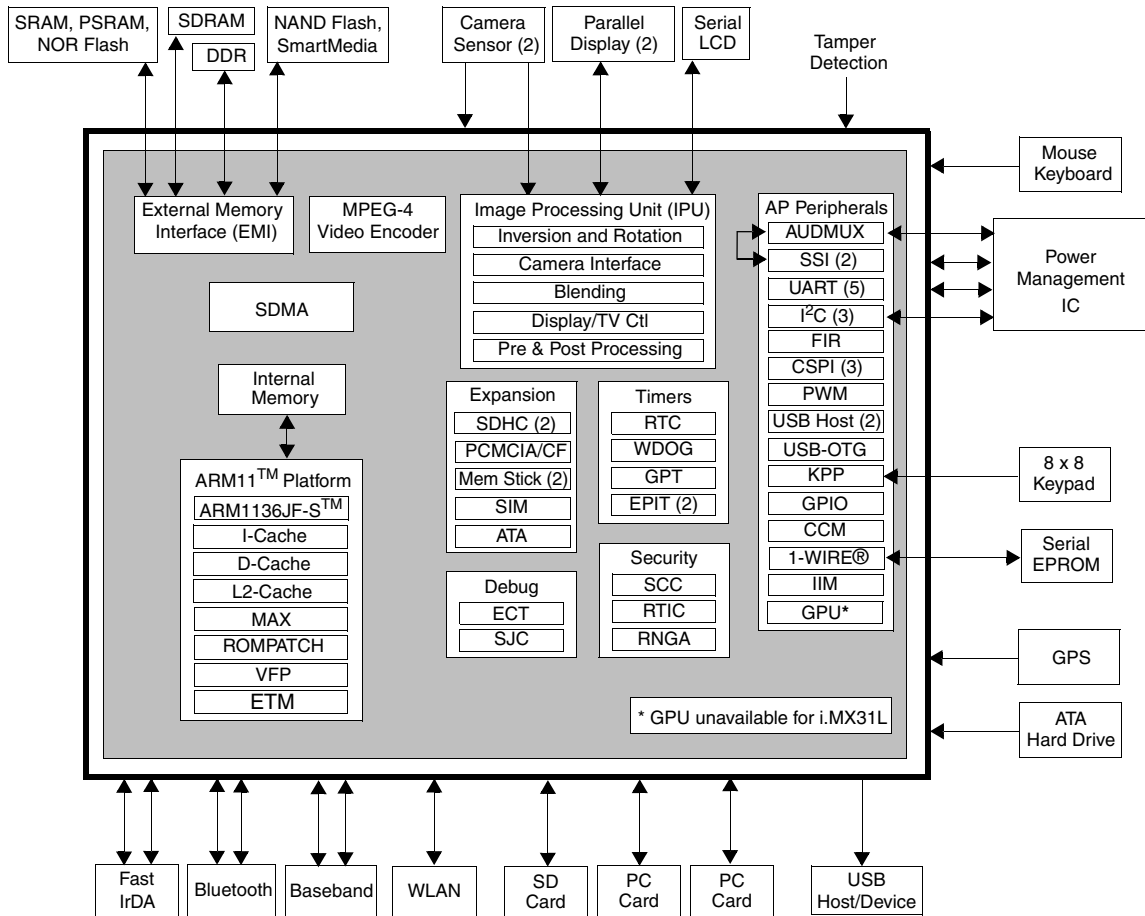


Figure 1. i.MX31/i.MX31L Simplified Interface Block Diagram

## 2 Functional Description and Application Information

### 2.1 ARM11 Microprocessor Core

The CPU of the i.MX31 and i.MX31L is the ARM1136JF-S core based on the ARM v6 architecture. It supports the ARM Thumb<sup>®</sup> instruction sets, features Jazelle<sup>®</sup> technology (which enables direct execution of Java byte codes), and a range of SIMD DSP instructions that operate on 16-bit or 8-bit data values in 32-bit registers.

The ARM1136JF-S processor core features:

- Integer unit with integral EmbeddedICE<sup>™</sup> logic
- Eight-stage pipeline
- Branch prediction with return stack
- Low-interrupt latency

- Instruction and data memory management units (MMUs), managed using micro TLB structures backed by a unified main TLB
- Instruction and data L1 caches, including a non-blocking data cache with Hit-Under-Miss
- Virtually indexed/physically addressed L1 caches
- 64-bit interface to both L1 caches
- Write buffer (bypassable)
- High-speed Advanced Micro Bus Architecture (AMBA)<sup>™</sup> L2 interface
- Vector Floating Point co-processor (VFP) for 3D graphics and other floating-point applications hardware acceleration
- ETM<sup>™</sup> and JTAG-based debug support

### 2.1.1 Memory System

The ARM1136JF-S complex includes 16 KB Instruction and 16 KB Data L1 caches. It connects to the i.MX31 and i.MX31L L2 unified cache through 64-bit instruction (read-only), 64-bit data read/write (bi-directional), and 64-bit data write interfaces.

The embedded 16K SRAM can be used for audio streaming data to avoid external memory accesses for the low-power audio playback, for security, or for other applications. There is also a 32-KB ROM for bootstrap code and other frequently-used code and data.

A ROM patch module provides the ability to patch the internal ROM. It can also initiate an external boot by overriding the boot reset sequence by a jump to a configurable address.

[Table 2](#) shows information about the i.MX31 and i.MX31L core in tabular form.

**Table 2. i.MX31/i.MX31L Core**

| Core Acronym     | Core Name        | Brief Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Integrated Memory Includes                                                                                                                                                                  |
|------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ARM11 or ARM1136 | ARM1136 Platform | The ARM1136 <sup>™</sup> Platform consists of the ARM1136JF-S core, the ETM real-time debug modules, a 6 x 5 multi-layer AHB crossbar switch (MAX), and a Vector Floating Processor (VFP).<br>The i.MX31/i.MX31L provide a high-performance ARM11 microprocessor core and highly integrated system functions. The ARM Application Processor (AP) and other subsystems address the needs of the personal, wireless, and portable product market with integrated peripherals, advanced processor core, and power management capabilities. | <ul style="list-style-type: none"> <li>• 16 Kbyte Instruction Cache</li> <li>• 16 Kbyte Data Cache</li> <li>• 128 Kbyte L2 Cache</li> <li>• 32 Kbyte ROM</li> <li>• 16 Kbyte RAM</li> </ul> |

## 2.2 Module Inventory

Table 3 shows an alphabetical listing of the modules in the multimedia applications processor. For extended descriptions of the modules, see the reference manual. A cross-reference is provided to the electrical specifications and timing information for each module with external signal connections.

**Table 3. Digital and Analog Modules**

| Block Mnemonic | Block Name                                     | Functional Grouping     | Brief Description                                                                                                                                                                                                                                                                                   | Section/ Page                                                                                   |
|----------------|------------------------------------------------|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| 1-Wire®        | 1-Wire Interface                               | Connectivity Peripheral | The 1-Wire module provides bi-directional communication between the ARM11 core and external 1-Wire devices.                                                                                                                                                                                         | <a href="#">4.3.4/19</a>                                                                        |
| ATA            | Advanced Technology (AT) Attachment            | Connectivity Peripheral | The ATA block is an AT attachment host interface. It is designed to interface with IDE hard disc drives and ATAPI optical disc drives.                                                                                                                                                              | <a href="#">4.3.5/21</a>                                                                        |
| AUDMUX         | Digital Audio Multiplexer                      | Multimedia Peripheral   | The AUDMUX interconnections allow multiple, simultaneous audio/voice/data flows between the ports in point-to-point or point-to-multipoint configurations.                                                                                                                                          | <a href="#">4.3.6/29</a>                                                                        |
| CAMP           | Clock Amplifier Module                         | Clock                   | The CAMP converts a square wave/sinusoidal input into a rail-to-rail square wave. The output of CAMP feeds the predivider.                                                                                                                                                                          | <a href="#">4.3.3/19</a>                                                                        |
| CCM            | Clock Control Module                           | Clock                   | The CCM provides clock, reset, and power management control for the i.MX31 and i.MX31L.                                                                                                                                                                                                             | —                                                                                               |
| CSPI           | Configurable Serial Peripheral Interface (x 3) | Connectivity Peripheral | The CSPI is equipped with data FIFOs and is a master/slave configurable serial peripheral interface module, capable of interfacing to both SPI master and slave devices.                                                                                                                            | <a href="#">4.3.7/29</a>                                                                        |
| DPLL           | Digital Phase Lock Loop                        | Clock                   | The DPLLs produce high-frequency on-chip clocks with low frequency and phase jitters.<br><b>Note:</b> External clock sources provide the reference frequencies.                                                                                                                                     | <a href="#">4.3.8/31</a>                                                                        |
| ECT            | Embedded Cross Trigger                         | Debug                   | The ECT is composed of three CTIs (Cross Trigger Interface) and one CTM (Cross Trigger Matrix—key in the multi-core and multi-peripheral debug strategy.                                                                                                                                            | —                                                                                               |
| EMI            | External Memory Interface                      | Memory Interface (EMI)  | The EMI includes <ul style="list-style-type: none"> <li>• Multi-Master Memory Interface (M3IF)</li> <li>• Enhanced SDRAM Controller (ESDCTL)</li> <li>• NAND Flash Controller (NFC)</li> <li>• Wireless External Interface Module (WEIM)</li> </ul>                                                 | —<br><a href="#">4.3.9.3/39</a> ,<br><a href="#">4.3.9.1/32</a> ,<br><a href="#">4.3.9.2/34</a> |
| EPIT           | Enhanced Periodic Interrupt Timer              | Timer Peripheral        | The EPIT is a 32-bit “set and forget” timer which starts counting after the EPIT is enabled by software. It is capable of providing precise interrupts at regular intervals with minimal processor intervention.                                                                                    | —                                                                                               |
| ETM            | Embedded Trace Macrocell                       | Debug/Trace             | The ETM (from ARM, Ltd.) supports real-time instruction and data tracing by way of ETM auxiliary I/O port.                                                                                                                                                                                          | <a href="#">4.3.10/47</a>                                                                       |
| FIR            | Fast InfraRed Interface                        | Connectivity Peripheral | This FIR is capable of establishing a 0.576 Mbit/s, 1.152 Mbit/s or 4 Mbit/s half duplex link via a LED and IR detector. It supports 0.576 Mbit/s, 1.152 Mbit/s medium infrared (MIR) physical layer protocol and 4Mbit/s fast infrared (FIR) physical layer protocol defined by IrDA, version 1.4. | <a href="#">4.3.11/48</a>                                                                       |

Table 3. Digital and Analog Modules (continued)

| Block Mnemonic   | Block Name                          | Functional Grouping     | Brief Description                                                                                                                                                                              | Section/ Page                                                    |
|------------------|-------------------------------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Fusebox          | Fusebox                             | ROM                     | The Fusebox is a ROM that is factory configured by Freescale.                                                                                                                                  | <a href="#">4.3.12/48</a><br>See also<br><a href="#">Table 9</a> |
| GPIO             | General Purpose I/O Module          | Pins                    | The GPIO provides several groups of 32-bit bidirectional, general purpose I/O. This peripheral provides dedicated general-purpose signals that can be configured as either inputs or outputs.  | –                                                                |
| GPT              | General Purpose Timer               | Timer Peripheral        | The GPT is a multipurpose module used to measure intervals or generate periodic output.                                                                                                        | –                                                                |
| GPU              | Graphics Processing Unit            | Multimedia Peripheral   | The GPU provides hardware acceleration for 2D and 3D graphics algorithms.                                                                                                                      | –                                                                |
| I <sup>2</sup> C | Inter IC Communication              | Connectivity Peripheral | The I <sup>2</sup> C provides serial interface for controlling the Sensor Interface and other external devices. Data rates of up to 100 Kbits/s are supported.                                 | <a href="#">4.3.13/49</a>                                        |
| IIM              | IC Identification Module            | ID                      | The IIM provides an interface for reading device identification.                                                                                                                               | –                                                                |
| IPU              | Image Processing Unit               | Multimedia Peripheral   | The IPU supports video and graphics processing functions in the i.MX31 and i.MX31L and interfaces to video, still image sensors, and displays.                                                 | <a href="#">4.3.14/50</a> ,<br><a href="#">4.3.15/52</a>         |
| KPP              | Keypad Port                         | Connectivity Peripheral | The KPP is used for keypad matrix scanning or as a general purpose I/O. This peripheral simplifies the software task of scanning a keypad matrix.                                              | –                                                                |
| MPEG-4           | MPEG-4 Video Encoder                | Multimedia Peripherals  | The MPEG-4 encoder accelerates video compression, following the MPEG-4 standard                                                                                                                | –                                                                |
| MSHC             | Memory Stick Host Controller        | Connectivity Peripheral | The MSHC is placed in between the AIPS and the customer memory stick to support data transfer from the i.MX31 or i.MX31L to the customer memory stick.                                         | <a href="#">4.3.16/77</a>                                        |
| PADIO            | Pads I/O                            | Buffers and Drivers     | The PADIO serves as the interface between the internal modules and the device's external connections.                                                                                          | <a href="#">4.3.1/16</a>                                         |
| PCMCIA           | PCM                                 | Connectivity Peripheral | The PCMCIA Host Adapter provides the control logic for PCMCIA socket interfaces.                                                                                                               | <a href="#">4.3.17/79</a>                                        |
| PWM              | Pulse-Width Modulator               | Timer Peripheral        | The PWM has a 16-bit counter and is optimized to generate sound from stored sample audio images. It can also generate tones.                                                                   | <a href="#">4.3.18/81</a>                                        |
| RNGA             | Random Number Generator Accelerator | Security                | The RNGA module is a digital integrated circuit capable of generating 32-bit random numbers. It is designed to comply with FIPS-140 standards for randomness and non-determinism.              | –                                                                |
| RTC              | Real Time Clock                     | Timer Peripheral        | The RTC module provides a current stamp of seconds, minutes, hours, and days. Alarm and timer functions are also available for programming. The RTC supports dates from the year 1980 to 2050. | –                                                                |
| RTIC             | Run-Time Integrity Checkers         | Security                | The RTIC ensures the integrity of the peripheral memory contents and assists with boot authentication.                                                                                         | –                                                                |

Table 3. Digital and Analog Modules (continued)

| Block Mnemonic | Block Name                                                    | Functional Grouping       | Brief Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Section/ Page             |
|----------------|---------------------------------------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| SCC            | Security Controller Module                                    | Security                  | The SCC is a hardware component composed of two blocks—the Secure RAM module, and the Security Monitor. The Secure RAM provides a way of securely storing sensitive information.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | —                         |
| SDHC           | Secured Digital Host Controller                               | Connectivity Peripheral   | The SDHC controls the MMC (MultiMediaCard), SD (Secure Digital) memory, and I/O cards by sending commands to cards and performing data accesses to and from the cards.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <a href="#">4.3.19/82</a> |
| SDMA           | Smart Direct Memory Access                                    | System Control Peripheral | The SDMA controller maximizes the system's performance by relieving the ARM core of the task of bulk data transfer from memory to memory or between memory and on-chip peripherals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | —                         |
| SIM            | Subscriber Identification Module                              | Connectivity Peripheral   | The SIM interfaces to an external Subscriber Identification Card. It is an asynchronous serial interface adapted for Smart Card communication for e-commerce applications.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <a href="#">4.3.20/83</a> |
| SJC            | Secure JTAG Controller                                        | Debug                     | The SJC provides debug and test control with maximum security and provides a flexible architecture for future derivatives or future multi-cores architecture.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <a href="#">4.3.21/87</a> |
| SSI            | Synchronous Serial Interface                                  | Multimedia Peripheral     | The SSI is a full-duplex, serial port that allows the device to communicate with a variety of serial devices, such as standard codecs, Digital Signal Processors (DSPs), microprocessors, peripherals, and popular industry audio codecs that implement the inter-IC sound bus standard (I2S) and Intel AC97 standard.                                                                                                                                                                                                                                                                                                                                                                                    | <a href="#">4.3.22/89</a> |
| UART           | Universal Asynchronous Receiver/Transmitter                   | Connectivity Peripheral   | The UART provides serial communication capability with external devices through an RS-232 cable or through use of external circuitry that converts infrared signals to electrical signals (for reception) or transforms electrical signals to signals that drive an infrared LED (for transmission) to provide low speed IrDA compatibility.                                                                                                                                                                                                                                                                                                                                                              | —                         |
| USB            | Universal Serial Bus—2 Host Controllers and 1 OTG (On-The-Go) | Connectivity Peripherals  | <ul style="list-style-type: none"> <li>• USB Host 1 is designed to support transceiverless connection to the on-board peripherals in Low Speed and Full Speed mode, and connection to the ULPI (UTMI+ Low-Pin Count) and Legacy Full Speed transceivers.</li> <li>• USB Host 2 is designed to support transceiverless connection to the Cellular Modem Baseband Processor.</li> <li>• The USB-OTG controller offers HS/FS/LS capabilities in Host mode and HS/FS in device mode. In Host mode, the controller supports direct connection of a FS/LS device (without external hub). In device (bypass) mode, the OTG port functions as gateway between the Host 1 Port and the OTG transceiver.</li> </ul> | <a href="#">4.3.23/97</a> |
| WDOG           | Watchdog Timer Module                                         | Timer Peripheral          | The WDOG module protects against system failures by providing a method for the system to recover from unexpected events or programming errors.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | —                         |

### 3 Signal Descriptions

Signal descriptions are in the reference manual. Special signal considerations are listed following this paragraph. The BGA ball assignment is in [Section 5, “Package Information and Pinout” on page 98](#).

Special Signal Considerations:

- **Tamper detect (GPIO1\_6)**

Tamper detect logic is used to issue a security violation. This logic is activated if the tamper detect input is asserted.

The tamper detect logic is disabled after reset. After enabling the logic, it is impossible to disable it until the next reset. The GPR[16] bit functions as the tamper detect enable bit.

GPIO1\_6 functions similarly to other I/O with GPIO capabilities regardless of the status of the tamper detect enable bit. (For example, the GPIO1\_6 can function as an input with GPIO capabilities, such as sampling through PSR or generating interrupts.)

- **Power ready (GPIO1\_5)**

The power ready input, GPIO1\_5, should be connected to an external power management IC power ready output signal. If not used, GPIO1\_5 must either be (a) externally pulled-up to NVCC1 or (b) a no connect, internally pulled-up by enabling the on-chip pull-up resistor. GPIO1\_5 is a dedicated input and cannot be used as a general-purpose input/output.

- **SJC\_MOD**

SJC\_MOD must be externally connected to GND for normal operation. Termination to GND through an external pull-down resistor (such as 1 k $\Omega$ ) is allowed, but the value should be much smaller than the on-chip 100 k $\Omega$  pull-up.

- **CE\_CONTROL**

CE\_CONTROL is a reserved input and must be externally tied to GND through a 1 k $\Omega$  resistor.

- **TTM\_PAD**

TTM\_PAD is for Freescale factory use only. Control bits indicate pull-up/down disabled. However, TTM\_PAD is actually connected to an on-chip pull-down device. Users must either float this signal or tie it to GND.

- **M\_REQUEST and M\_GRANT**

These two signals are not utilized internally. The user should make no connection to these signals.

- **Clock Source Select (CLKSS)**

The CLKSS is the input that selects the default reference clock source providing input to the DPLL. To select CKIH, tie CLKSS to NVCC1. To select CKIL, tie CLKSS to ground. After initialization, the reference clock source can be changed (initial setting is overwritten) by programming the PRCS bits in the CCMR.

## 4 Electrical Characteristics

This section provides the device-level and module-level electrical characteristics for the i.MX31 and i.MX31L.

### 4.1 i.MX31 and i.MX31L Chip-Level Conditions

This section provides the device-level electrical characteristics for the IC. See [Table 4](#) for a quick reference to the individual tables and sections.

**Table 4. i.MX31/i.MX31L Chip-Level Conditions**

| For these characteristics, ...                                                          | Topic appears ...          |
|-----------------------------------------------------------------------------------------|----------------------------|
| <a href="#">Table 5, "Absolute Maximum Ratings"</a>                                     | <a href="#">on page 10</a> |
| <a href="#">Table 7, "Operating Ranges"</a>                                             | <a href="#">on page 12</a> |
| <a href="#">Table 8, "Interface Frequency"</a>                                          | <a href="#">on page 13</a> |
| <a href="#">Section 4.1.1, "Supply Current Specifications"</a>                          | <a href="#">on page 14</a> |
| <a href="#">Section 4.2, "Supply Power-Up/Power-Down Requirements and Restrictions"</a> | <a href="#">on page 14</a> |

#### CAUTION

Stresses beyond those listed under "[Table 5, "Absolute Maximum Ratings," on page 10](#) may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under "[Table 7, "Operating Ranges," on page 12](#) is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**Table 5. Absolute Maximum Ratings**

| Parameter                                                 | Symbol               | Min  | Max          | Units |
|-----------------------------------------------------------|----------------------|------|--------------|-------|
| Supply Voltage (Core)                                     | $QVCC_{max}$         | -0.5 | 1.65         | V     |
| Supply Voltage (I/O)                                      | $NVCC_{max}$         | -0.5 | 3.3          | V     |
| Input Voltage Range                                       | $V_{I_{max}}$        | -0.5 | $NVCC + 0.3$ | V     |
| Storage Temperature                                       | $T_{storage}$        | -40  | 125          | °C    |
| ESD Damage Immunity:                                      |                      |      |              |       |
| Human Body Model (HBM)                                    | $V_{esd}$            | —    | 2000         | V     |
| Machine Model (MM)                                        |                      | —    | 200          |       |
| Charge Device Model (CDM)                                 |                      | —    | 500          |       |
| Offset voltage allowed in run mode between core supplies. | $V_{core\_offset}^1$ | —    | 15           | mV    |

<sup>1</sup> The offset is the difference between all core voltage pair combinations of QVCC, QVCC1, and QVCC4.

Table 6 provides the thermal resistance data for the  $14 \times 14$  mm, 0.5 mm pitch package.

**Table 6. Thermal Resistance Data— $14 \times 14$  mm Package**

| Rating                                       | Board                   | Symbol           | Value | Unit                 | Notes   |
|----------------------------------------------|-------------------------|------------------|-------|----------------------|---------|
| Junction to Ambient (natural convection)     | Single layer board (1s) | $R_{\theta JA}$  | 56    | $^{\circ}\text{C/W}$ | 1, 2, 3 |
| Junction to Ambient (natural convection)     | Four layer board (2s2p) | $R_{\theta JA}$  | 30    | $^{\circ}\text{C/W}$ | 1, 3    |
| Junction to Ambient (@200 ft/min)            | Single layer board (1s) | $R_{\theta JMA}$ | 46    | $^{\circ}\text{C/W}$ | 1, 2, 3 |
| Junction to Ambient (@200 ft/min)            | Four layer board (2s2p) | $R_{\theta JMA}$ | 26    | $^{\circ}\text{C/W}$ | 1, 3    |
| Junction to Board                            | —                       | $R_{\theta JB}$  | 17    | $^{\circ}\text{C/W}$ | 1, 4    |
| Junction to Case                             | —                       | $R_{\theta JC}$  | 10    | $^{\circ}\text{C/W}$ | 1, 5    |
| Junction to Package Top (natural convection) | —                       | $\Psi_{JT}$      | 2     | $^{\circ}\text{C/W}$ | 1, 6    |

### NOTES

1. Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.
2. Per JEDEC JESD51-2 with the single layer board horizontal. Board meets JESD51-9 specification.
3. Per JEDEC JESD51-6 with the board horizontal.
4. Thermal resistance between the die and the printed circuit board per JEDEC JESD51-8. Board temperature is measured on the top surface of the board near the package.
5. Thermal resistance between the die and the case top surface as measured by the cold plate method (MIL SPEC-883 Method 1012.1).
6. Thermal characterization parameter indicating the temperature difference between package top and the junction temperature per JEDEC JESD51-2. When Greek letters are not available, the thermal characterization parameter is written as Psi-JT.

Table 7 provides the operating ranges.

### NOTE

The term NVCC in this section refers to the associated supply rail of an input or output. The association is shown in the Signal Multiplexing chapter of the reference manual.

### CAUTION

NVCC6 and NVCC9 must be at the same voltage potential. These supplies are connected together on-chip to optimize ESD damage immunity.

**Table 7. Operating Ranges**

| Symbol                      | Parameter                                                                              | Min                                     | Max          | Units       |    |
|-----------------------------|----------------------------------------------------------------------------------------|-----------------------------------------|--------------|-------------|----|
| QVCC,<br>QVCC1,<br>QVCC4    | Core Operating Voltage <sup>1</sup>                                                    |                                         |              | V           |    |
|                             | $0 \leq f_{\text{ARM}} \leq 400 \text{ MHz, non-overdrive}$                            | 1.22                                    | 1.47         |             |    |
|                             | $0 \leq f_{\text{ARM}} \leq 400 \text{ MHz, overdrive}^2$                              | >1.47                                   | 1.65         |             |    |
|                             | $0 \leq f_{\text{ARM}} \leq 532 \text{ MHz, overdrive}^2$                              | 1.55                                    | 1.65         |             |    |
|                             | State Retention Voltage <sup>3</sup>                                                   | 0.95                                    | —            |             |    |
| NVCC1,<br>NVCC3–10          | I/O Supply Voltage, except DDR <sup>4</sup>                                            | non-overdrive<br>overdrive <sup>5</sup> | 1.75<br>>3.1 | 3.1<br>3.3  | V  |
| NVCC2,<br>NVCC21,<br>NVCC22 | I/O Supply Voltage, DDR only                                                           | 1.75                                    | 1.95         |             | V  |
| FVCC, MVCC,<br>SVCC, UVCC   | PLL (Phase-Locked Loop) and FPM (Frequency Pre-multiplier) Supply Voltage <sup>6</sup> | non-overdrive<br>overdrive <sup>2</sup> | 1.3<br>>1.47 | 1.47<br>1.6 | V  |
| IOQVDD                      | On-device Level Shifter Supply Voltage                                                 | 1.6                                     | 1.9          |             | V  |
| FUSE_VDD                    | Fusebox read Supply Voltage                                                            | 1.65                                    | 1.95         |             | V  |
|                             | Fusebox write (program) Supply Voltage <sup>7</sup>                                    | 3.0                                     | 3.3          |             | V  |
| T <sub>A</sub>              | Operating Ambient Temperature Range                                                    | 0                                       | 70           |             | °C |

<sup>1</sup> Measured at package balls, including peripherals, ARM, and L2 cache supplies (QVCC, QVCC1, QVCC4, respectively).

<sup>2</sup> Supply voltage is considered “overdrive” for voltages above 1.47 V. Operation time in overdrive—whether switching or not—must be limited to a cumulative duration of 1.25 years (10,950 hours) or less to sustain the maximum operating voltage without significant device degradation—for example, 25% (average 6 hours out of 24 hours per day) duty cycle for 5-year rated equipment. To tolerate the maximum operating overdrive voltage for 10 years, the device must have a duty cycle of 12.5% or less in overdrive (for example 3 out of 24 hours per day). Below 1.47V, duty cycle restrictions may apply for equipment rated above 5 years.

<sup>3</sup> The SR voltage is applied to QVCC, QVCC1, and QVCC4 after the device is placed in SR mode. **The Real-Time Clock (RTC) is operational in State Retention (SR) mode.**

<sup>4</sup> Overshoot and undershoot conditions (transitions above NVCC and below GND) on I/O must be held below 0.6 V, and the duration of the overshoot/undershoot must not exceed 10% of the system clock cycle. Overshoot/undershoot must be controlled through printed circuit board layout, transmission line impedance matching, signal line termination, or other methods. Non-compliance to this specification may affect device reliability or cause permanent damage to the device.

<sup>5</sup> Supply voltage is considered “overdrive” for voltages above 3.1 V. Operation time in overdrive—whether switching or not—must be limited to a cumulative duration of 1 year (8,760 hours) or less to sustain the maximum operating voltage without significant device degradation—for example, 20% (average 4.8 hours out of 24 hours per day) duty cycle for 5-year rated equipment. Operation at 3.3 V that exceeds a cumulative 3,504 hours may cause non-operation whenever supply voltage is reduced to 1.8 V; degradation may render the device too slow or inoperable. Below 3.1 V, duty cycle restrictions may apply for equipment rated above 5 years.

- <sup>6</sup> For normal operating conditions, PLLs' and core supplies must maintain the following relation:  $PLL \geq Core - 100 \text{ mV}$ . In other words, for a 1.6 V core supply, PLL supplies must be set to 1.5 V or higher. PLL voltage must not be altered after power up, otherwise the PLL will be unstable and lose lock. To minimize inducing noise on the PLL supply line, source the voltage from a low-noise, dedicated supply.
- <sup>7</sup> Fuses might be inadvertently blown if written to while the voltage is below this minimum.

Table 8 provides information for interface frequency limits. For more details about clocks characteristics, see Section 4.3.8, “DPLL Electrical Specifications” on page 31 and Section 4.3.3, “Clock Amplifier Module (CAMP) Electrical Characteristics on page 19.

**Table 8. Interface Frequency**

| ID | Parameter                   | Symbol     | Min | Typ    | Max  | Units |
|----|-----------------------------|------------|-----|--------|------|-------|
| 1  | JTAG TCK Frequency          | $f_{JTAG}$ | DC  | 5      | 10   | MHz   |
| 2  | CKIL Frequency <sup>1</sup> | $f_{CKIL}$ | 32  | 32.768 | 38.4 | kHz   |
| 3  | CKIH Frequency <sup>2</sup> | $f_{CKIH}$ | 15  | 26     | 75   | MHz   |

<sup>1</sup> CKIL must be driven by an external clock source to ensure proper start-up and operation of the device. CKIL is needed to clock the internal reset synchronizer, the watchdog, and the real-time clock.

<sup>2</sup> DPTC functionality, specifically the voltage/frequency relation table, is dependent on CKIH frequency. At the time of publication, standard tables used by Freescale OSs provided for a CKIH frequency of 26 MHz only. Any deviation from this frequency requires an update to the OS. For more details, refer to the particular OS user's guide documentation.

Table 9 shows the fusebox supply current parameters.

**Table 9. Fusebox Supply Current Parameters**

| Ref. Num | Description                                                                                    | Symbol               | Minimum | Typical | Maximum | Units |
|----------|------------------------------------------------------------------------------------------------|----------------------|---------|---------|---------|-------|
| 1        | eFuse Program Current. <sup>1</sup><br>Current to program one eFuse bit: efuse_pgm = 3.0V      | $I_{\text{program}}$ | —       | 35      | 60      | mA    |
| 2        | eFuse Read Current <sup>2</sup><br>Current to read an 8-bit eFuse word<br>vdd_fusebox = 1.875V | $I_{\text{read}}$    | —       | 5       | 8       | mA    |

<sup>1</sup> The current  $I_{\text{program}}$  is during program time ( $t_{\text{program}}$ ).

<sup>2</sup> The current  $I_{\text{read}}$  is present for approximately 50 ns of the read access to the 8-bit word.

### 4.1.1 Supply Current Specifications

Table 10 shows the core current consumption for the i.MX31 and i.MX31L.

**Table 10. Current Consumption<sup>1, 2</sup>**

| Mode            | Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | QVCC<br>(Peripheral) |     | QVCC1<br>(ARM) |     | QVCC4<br>(L2) |     | FVCC + MVCC<br>+ SVCC + UVCC<br>(PLL) |     | Unit |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----|----------------|-----|---------------|-----|---------------------------------------|-----|------|
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Typ                  | Max | Typ            | Max | Typ           | Max | Typ                                   | Max |      |
| State Retention | <ul style="list-style-type: none"> <li>QVCC and QVCC1 = 0.95 V</li> <li>L2 caches are power gated (QVCC4 = 0 V)</li> <li>All PLLs are off, VCC = 1.4 V</li> <li>ARM is in well bias</li> <li>FPM is off</li> <li>32 kHz input is on</li> <li>CKIH input is off</li> <li>CAMP is off</li> <li>TCK input is off</li> <li>All modules are off</li> <li>No external resistive loads</li> <li>RNGA oscillator is off</li> </ul>                                                                                                                                         | 0.8                  | –   | 0.5            | –   | –             | –   | 0.04                                  | –   | mA   |
| Wait            | <ul style="list-style-type: none"> <li>QVCC, QVCC1, and QVCC4 = 1.22 V</li> <li>ARM is in wait for interrupt mode</li> <li>MAX is active</li> <li>L2 cache is stopped but powered</li> <li>MCU PLL is on (532 MHz), VCC = 1.4 V</li> <li>USB PLL and SPLN are off, VCC = 1.4 V</li> <li>FPM is on</li> <li>CKIH input is on</li> <li>CAMP is on</li> <li>32 kHz input is on</li> <li>All clocks are gated off</li> <li>All modules are off<br/>(by programming CGR[2:0] registers)</li> <li>RNGA oscillator is off</li> <li>No external resistive loads</li> </ul> | 6.0                  | –   | 3.0            | –   | 0.04          | –   | 3.5                                   | –   | mA   |

<sup>1</sup> Typical column: TA = 25°C

<sup>2</sup> Maximum column: TA = 70°C

## 4.2 Supply Power-Up/Power-Down Requirements and Restrictions

Any i.MX31/i.MX31L board design must comply with the power-up and power-down sequence guidelines as described in this section to guarantee reliable operation of the device. Any deviation from these sequences may result in any or all of the following situations:

- Cause excessive current during power up phase.
- Prevent the device from booting.
- Cause irreversible damage to the i.MX31/i.MX31L (worst-case scenario).

## 4.2.1 Powering Up

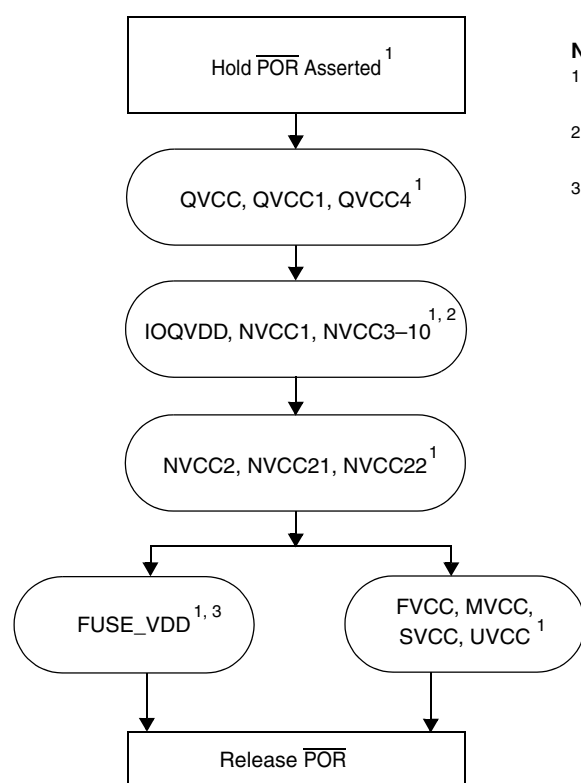
The Power On Reset ( $\overline{\text{POR}}$ ) pin must be kept asserted (low) throughout the power up sequence. Power up logic must guarantee that all power sources reach their target values prior to the release (de-assertion) of  $\overline{\text{POR}}$ . Figure 2 shows the power-up sequence.

### NOTE

Stages need to be performed in the order shown; however, *within* each stage, supplies can be powered up in any order. For example, supplies IOQVDD, NVCC1, and NVCC3 through NVCC10 do not need to be powered up in the order shown.

### CAUTION

NVCC6 and NVCC9 must be at the same voltage potential. These supplies are connected together on-chip to optimize ESD damage immunity.



### Notes:

- <sup>1</sup> The board design must guarantee that supplies reach 90% level before transition to the next state, using Power Management IC or other means.
- <sup>2</sup> The NVCC1 supply must not precede IOQVDD by more than 0.2 V until IOQVDD has reached 1.5 V. If IOQVDD is powered up first, there are no restrictions.
- <sup>3</sup> It is allowable for FVCC, MVCC, SVCC, and UVCC to be up after FUSE\_VDD.

Figure 2. Power-Up Sequence

## 4.2.2 Powering Down

The power-down sequence should be completed as follows:

1. Lower the FUSE\_VDD supply.
2. Lower the remaining supplies.

## 4.3 Module-Level Electrical Specifications

This section contains the i.MX31 and i.MX31L electrical information including timing specifications, arranged in alphabetical order by module name.

### 4.3.1 I/O Pad (PADIO) Electrical Specifications

This section specifies the AC/DC characterization of functional I/O of the i.MX31. There are two main types of I/O: regular and DDR. In this document, the “Regular” type is referred to as GPIO.

#### 4.3.1.1 DC Electrical Characteristics

The i.MX31/i.MX31L I/O parameters appear in [Table 11](#) for GPIO. See [Table 7, "Operating Ranges," on page 12](#) for temperature and supply voltage ranges.

#### NOTE

The term NVCC in this section refers to the associated supply rail of an input or output. The association is shown in the Signal Multiplexing chapter of the reference manual. NVCC for [Table 11](#) refers to NVCC1 and NVCC3–10; QVCC refers to QVCC, QVCC1, and QVCC4.

**Table 11. GPIO DC Electrical Parameters**

| Parameter                                 | Symbol      | Test Conditions                                                          | Min                     | Typ | Max                     | Units |
|-------------------------------------------|-------------|--------------------------------------------------------------------------|-------------------------|-----|-------------------------|-------|
| High-level output voltage                 | $V_{OH}$    | $I_{OH} = -1 \text{ mA}$                                                 | NVCC -0.15              | –   | –                       | V     |
|                                           |             | $I_{OH} = \text{specified Drive}$                                        | $0.8 \cdot \text{NVCC}$ | –   | –                       | V     |
| Low-level output voltage                  | $V_{OL}$    | $I_{OL} = 1 \text{ mA}$                                                  | –                       | –   | 0.15                    | V     |
|                                           |             | $I_{OL} = \text{specified Drive}$                                        | –                       | –   | $0.2 \cdot \text{NVCC}$ | V     |
| High-level output current, slow slew rate | $I_{OH\_S}$ | $V_{OH} = 0.8 \cdot \text{NVCC}$<br>Std Drive<br>High Drive<br>Max Drive | -2<br>-4<br>-8          | –   | –                       | mA    |
| High-level output current, fast slew rate | $I_{OH\_F}$ | $V_{OH} = 0.8 \cdot \text{NVCC}$<br>Std Drive<br>High Drive<br>Max Drive | -4<br>-6<br>-8          | –   | –                       | mA    |
| Low-level output current, slow slew rate  | $I_{OL\_S}$ | $V_{OL} = 0.2 \cdot \text{NVCC}$<br>Std Drive<br>High Drive<br>Max Drive | 2<br>4<br>8             | –   | –                       | mA    |
| Low-level output current, fast slew rate  | $I_{OL\_F}$ | $V_{OL} = 0.2 \cdot \text{NVCC}$<br>Std Drive<br>High Drive<br>Max Drive | 4<br>6<br>8             | –   | –                       | mA    |
| High-Level DC input voltage               | $V_{IH}$    | –                                                                        | $0.7 \cdot \text{NVCC}$ | –   | NVCC                    | V     |
| Low-Level DC input voltage                | $V_{IL}$    | –                                                                        | 0                       | –   | $0.3 \cdot \text{QVCC}$ | V     |

Table 11. GPIO DC Electrical Parameters (continued)

| Parameter                              | Symbol    | Test Conditions                     | Min              | Typ | Max              | Units              |
|----------------------------------------|-----------|-------------------------------------|------------------|-----|------------------|--------------------|
| Input Hysteresis                       | $V_{HYS}$ | Hysteresis enabled                  | 0.25             | –   | –                | V                  |
| Schmitt trigger VT+                    | $V_T +$   | Hysteresis enabled                  | $0.5 \cdot QVCC$ | –   | –                | V                  |
| Schmitt trigger VT-                    | $V_T -$   | Hysteresis enabled                  | –                | –   | $0.5 \cdot QVCC$ | V                  |
| Pull-up resistor (100 k $\Omega$ PU)   | $R_{PU}$  | –                                   | –                | 100 | –                | k $\Omega$         |
| Pull-down resistor (100 k $\Omega$ PD) | $R_{PD}$  | –                                   | –                | 100 | –                |                    |
| Input current (no PU/PD)               | $I_{IN}$  | $V_I = NVCC$ or GND                 | –                | –   | $\pm 1$          | $\mu A$            |
| Input current (100 k $\Omega$ PU)      | $I_{IN}$  | $V_I = 0$<br>$V_I = NVCC$           | –                | –   | 25<br>0.1        | $\mu A$<br>$\mu A$ |
| Input current (100 k $\Omega$ PD)      | $I_{IN}$  | $V_I = 0$<br>$V_I = NVCC$           | –                | –   | 0.25<br>28       | $\mu A$<br>$\mu A$ |
| Tri-state leakage current              | $I_{OZ}$  | $V_I = NVCC$ or GND<br>I/O = High Z | –                | –   | $\pm 2$          | $\mu A$            |

The i.MX31/i.MX31L I/O parameters appear in [Table 12](#) for DDR (Double Data Rate). See [Table 7](#), "Operating Ranges," on [page 12](#) for temperature and supply voltage ranges.

**NOTE**

NVCC for [Table 12](#) refers to NVCC2, NVCC21, and NVCC22.

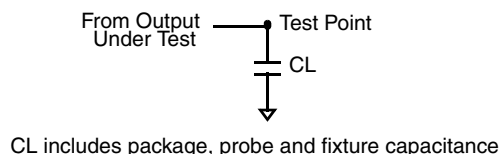
Table 12. DDR (Double Data Rate) I/O DC Electrical Parameters

| Parameter                   | Symbol   | Test Conditions                                                                             | Min                            | Typ  | Max              | Units   |
|-----------------------------|----------|---------------------------------------------------------------------------------------------|--------------------------------|------|------------------|---------|
| High-level output voltage   | $V_{OH}$ | $I_{OH} = -1$ mA                                                                            | $NVCC - 0.12$                  | –    | –                | V       |
|                             |          | $I_{OH} =$ specified Drive                                                                  | $0.8 \cdot NVCC$               | –    | –                | V       |
| Low-level output voltage    | $V_{OL}$ | $I_{OL} = 1$ mA                                                                             | –                              | –    | 0.08             | V       |
|                             |          | $I_{OL} =$ specified Drive                                                                  | –                              | –    | $0.2 \cdot NVCC$ | V       |
| High-level output current   | $I_{OH}$ | $V_{OH} = 0.8 \cdot NVCC$<br>Std Drive<br>High Drive<br>Max Drive<br>DDR Drive <sup>1</sup> | –3.6<br>–7.2<br>–10.8<br>–14.4 | –    | –                | mA      |
| Low-level output current    | $I_{OL}$ | $V_{OL} = 0.2 \cdot NVCC$<br>Std Drive<br>High Drive<br>Max Drive<br>DDR Drive <sup>1</sup> | 3.6<br>7.2<br>10.8<br>14.4     | –    | –                | mA      |
| High-Level DC input voltage | $V_{IH}$ | –                                                                                           | $0.7 \cdot NVCC$               | NVCC | $NVCC + 0.3$     | V       |
| Low-Level DC input voltage  | $V_{IL}$ | –                                                                                           | –0.3                           | 0    | $0.3 \cdot NVCC$ | V       |
| Tri-state leakage current   | $I_{OZ}$ | $V_I = NVCC$ or GND<br>I/O = High Z                                                         | –                              | –    | $\pm 2$          | $\mu A$ |

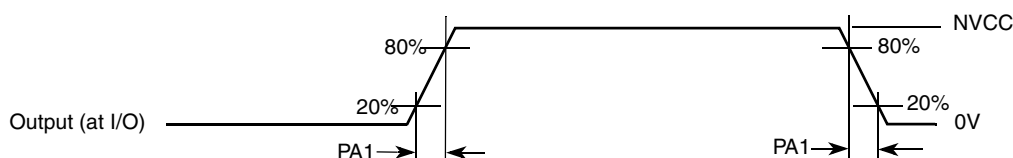
<sup>1</sup> Use of DDR Drive can result in excessive overshoot and ringing.

### 4.3.2 AC Electrical Characteristics

Figure 3 depicts the load circuit for outputs. Figure 4 depicts the output transition time waveform. The range of operating conditions appears in Table 13 for slow general I/O, Table 14 for fast general I/O, and Table 15 for DDR I/O (unless otherwise noted).



**Figure 3. Load Circuit for Output**



**Figure 4. Output Transition Time Waveform**

**Table 13. AC Electrical Characteristics of Slow<sup>1</sup> General I/O**

| ID  | Parameter                            | Symbol | Test Condition | Min          | Typ          | Max           | Units |
|-----|--------------------------------------|--------|----------------|--------------|--------------|---------------|-------|
| PA1 | Output Transition Times (Max Drive)  | tpr    | 25 pF<br>50 pF | 0.92<br>1.5  | 1.95<br>2.98 | 3.17<br>4.75  | ns    |
|     | Output Transition Times (High Drive) | tpr    | 25 pF<br>50 pF | 1.52<br>2.75 | —            | 4.81<br>8.42  | ns    |
|     | Output Transition Times (Std Drive)  | tpr    | 25 pF<br>50 pF | 2.79<br>5.39 | —            | 8.56<br>16.43 | ns    |

<sup>1</sup> Fast/slow characteristic is selected per GPIO (where available) by “slew rate” control. See reference manual.

**Table 14. AC Electrical Characteristics of Fast<sup>1</sup> General I/O <sup>2</sup>**

| ID  | Parameter                            | Symbol | Test Condition | Min          | Typ          | Max          | Units |
|-----|--------------------------------------|--------|----------------|--------------|--------------|--------------|-------|
| PA1 | Output Transition Times (Max Drive)  | tpr    | 25 pF<br>50 pF | 0.68<br>1.34 | 1.33<br>2.6  | 2.07<br>4.06 | ns    |
|     | Output Transition Times (High Drive) | tpr    | 25 pF<br>50 pF | .91<br>1.79  | 1.77<br>3.47 | 2.74<br>5.41 | ns    |
|     | Output Transition Times (Std Drive)  | tpr    | 25 pF<br>50 pF | 1.36<br>2.68 | 2.64<br>5.19 | 4.12<br>8.11 | ns    |

<sup>1</sup> Fast/slow characteristic is selected per GPIO (where available) by “slew rate” control. See reference manual.

<sup>2</sup> Use of GPIO in fast mode with the associated NVCC > 1.95 V can result in excessive overshoot and ringing.

Table 15. AC Electrical Characteristics of DDR I/O

| ID  | Parameter                                        | Symbol | Test Condition | Min          | Typ          | Max          | Units |
|-----|--------------------------------------------------|--------|----------------|--------------|--------------|--------------|-------|
| PA1 | Output Transition Times (DDR Drive) <sup>1</sup> | tpr    | 25 pF<br>50 pF | 0.51<br>0.97 | 0.82<br>1.58 | 1.28<br>2.46 | ns    |
|     | Output Transition Times (Max Drive)              | tpr    | 25 pF<br>50 pF | 0.67<br>1.29 | 1.08<br>2.1  | 1.69<br>3.27 | ns    |
|     | Output Transition Times (High Drive)             | tpr    | 25 pF<br>50 pF | .99<br>1.93  | 1.61<br>3.13 | 2.51<br>4.89 | ns    |
|     | Output Transition Times (Std Drive)              | tpr    | 25 pF<br>50 pF | 1.96<br>3.82 | 3.19<br>6.24 | 4.99<br>9.73 | ns    |

<sup>1</sup> Use of DDR Drive can result in excessive overshoot and ringing.

### 4.3.3 Clock Amplifier Module (CAMP) Electrical Characteristics

This section outlines the Clock Amplifier Module (CAMP) specific electrical characteristics. [Table 16](#) shows clock amplifier electrical characteristics.

Table 16. Clock Amplifier Electrical Characteristics for CKIH Input

| Parameter                   | Min                       | Typ | Max | Units |
|-----------------------------|---------------------------|-----|-----|-------|
| Input Frequency             | 15                        | –   | 75  | MHz   |
| VIL (for square wave input) | 0                         | –   | 0.3 | V     |
| VIH (for square wave input) | (VDD <sup>1</sup> - 0.25) | –   | 3   | V     |
| Sinusoidal Input Amplitude  | 0.4 <sup>2</sup>          | –   | VDD | Vp-p  |
| Duty Cycle                  | 45                        | 50  | 55  | %     |

<sup>1</sup> VDD is the supply voltage of CAMP. See reference manual.

<sup>2</sup> This value of the sinusoidal input will be measured through characterization.

### 4.3.4 1-Wire Electrical Specifications

[Figure 5](#) depicts the RPP timing, and [Table 17](#) lists the RPP timing parameters.

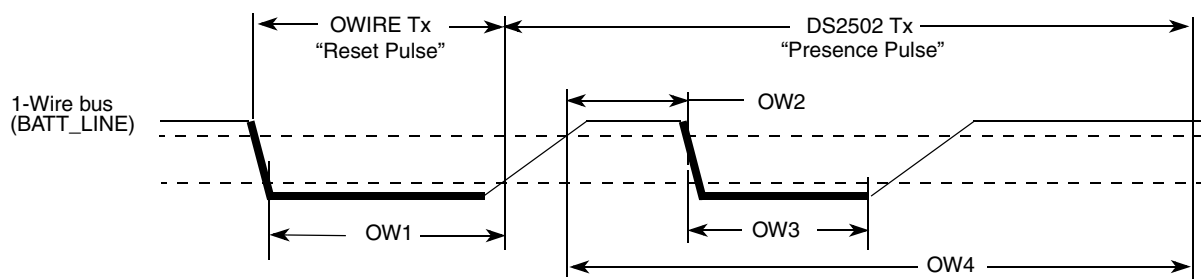
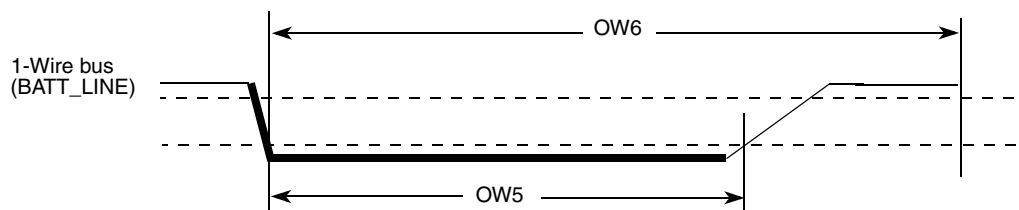


Figure 5. Reset and Presence Pulses (RPP) Timing Diagram

**Table 17. RPP Sequence Delay Comparisons Timing Parameters**

| ID  | Parameters           | Symbol     | Min | Typ | Max | Units   |
|-----|----------------------|------------|-----|-----|-----|---------|
| OW1 | Reset Time Low       | $t_{RSTL}$ | 480 | 511 | –   | $\mu s$ |
| OW2 | Presence Detect High | $t_{PDH}$  | 15  | –   | 60  | $\mu s$ |
| OW3 | Presence Detect Low  | $t_{PDL}$  | 60  | –   | 240 | $\mu s$ |
| OW4 | Reset Time High      | $t_{RSTH}$ | 480 | 512 | –   | $\mu s$ |

Figure 6 depicts Write 0 Sequence timing, and Table 18 lists the timing parameters.

**Figure 6. Write 0 Sequence Timing Diagram****Table 18. WR0 Sequence Timing Parameters**

| ID  | Parameter              | Symbol         | Min | Typ | Max | Units   |
|-----|------------------------|----------------|-----|-----|-----|---------|
| OW5 | Write 0 Low Time       | $t_{WR0\_low}$ | 60  | 100 | 120 | $\mu s$ |
| OW6 | Transmission Time Slot | $t_{SLOT}$     | OW5 | 117 | 120 | $\mu s$ |

Figure 7 depicts Write 1 Sequence timing, Figure 8 depicts the Read Sequence timing, and Table 19 lists the timing parameters.

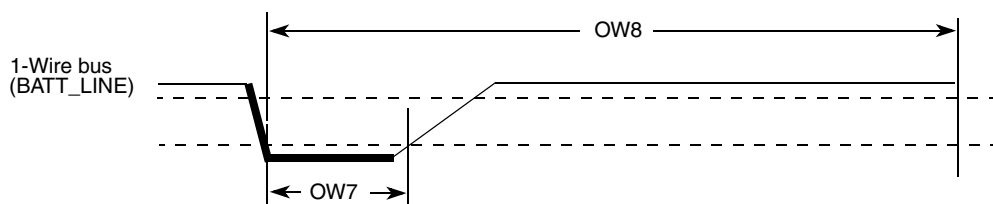
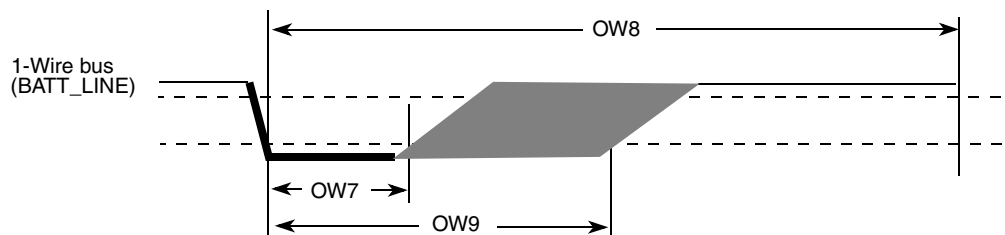
**Figure 7. Write 1 Sequence Timing Diagram****Figure 8. Read Sequence Timing Diagram**

Table 19. WR1/RD Timing Parameters

| ID  | Parameter               | Symbol        | Min | Typ | Max | Units   |
|-----|-------------------------|---------------|-----|-----|-----|---------|
| OW7 | Write 1 / Read Low Time | $t_{LOW1}$    | 1   | 5   | 15  | $\mu s$ |
| OW8 | Transmission Time Slot  | $t_{SLOT}$    | 60  | 117 | 120 | $\mu s$ |
| OW9 | Release Time            | $t_{RELEASE}$ | 15  | –   | 45  | $\mu s$ |

### 4.3.5 ATA Electrical Specifications (ATA Bus, Bus Buffers)

This section discusses ATA parameters. For a detailed description, refer to the ATA specification.

The user needs to use level shifters for 3.3 Volt or 5.0 Volt compatibility on the ATA interface.

The use of bus buffers introduces delay on the bus and introduces skew between signal lines. These factors make it difficult to operate the bus at the highest speed (UDMA-5) when bus buffers are used. If fast UDMA mode operation is needed, this may not be compatible with bus buffers.

Another area of attention is the slew rate limit imposed by the ATA specification on the ATA bus. According to this limit, any signal driven on the bus should have a slew rate between 0.4 and 1.2 V/ns with a 40 pF load. Not many vendors of bus buffers specify slew rate of the outgoing signals.

When bus buffers are used, the `ata_data` bus buffer is special. This is a bidirectional bus buffer, so a direction control signal is needed. This direction control signal is `ata_buffer_en`. When its high, the bus should drive from host to device. When its low, the bus should drive from device to host. Steering of the signal is such that contention on the host and device tri-state busses is always avoided.

#### 4.3.5.1 Timing Parameters

In the timing equations, some timing parameters are used. These parameters depend on the implementation of the ATA interface on silicon, the bus buffer used, the cable delay and cable skew. [Table 20](#) shows ATA timing parameters.

Table 20. ATA Timing Parameters

| Name  | Description                                                                                                                         | Value/<br>Contributing Factor <sup>1</sup> |
|-------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| T     | Bus clock period ( <code>ipg_clk_ata</code> )                                                                                       | peripheral clock frequency                 |
| ti_ds | Set-up time <code>ata_data</code> to <code>ata_iordy</code> edge (UDMA-in only)<br>UDMA0<br>UDMA1<br>UDMA2, UDMA3<br>UDMA4<br>UDMA5 | 15 ns<br>10 ns<br>7 ns<br>5 ns<br>4 ns     |
| ti_dh | hold time <code>ata_iordy</code> edge to <code>ata_data</code> (UDMA-in only)<br>UDMA0, UDMA1, UDMA2, UDMA3, UDMA4<br>UDMA5         | 5.0 ns<br>4.6 ns                           |

Table 20. ATA Timing Parameters (continued)

| Name    | Description                                                                                                                                                                                                                                                                | Value/<br>Contributing Factor <sup>1</sup> |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| tco     | propagation delay bus clock L-to-H to <b>ata_cs0</b> , <b>ata_cs1</b> , <b>ata_da2</b> , <b>ata_da1</b> , <b>ata_da0</b> , <b>ata_dior</b> , <b>ata_diow</b> , <b>ata_dmack</b> , <b>ata_data</b> , <b>ata_buffer_en</b>                                                   | 12.0 ns                                    |
| tsu     | set-up time <b>ata_data</b> to bus clock L-to-H                                                                                                                                                                                                                            | 8.5 ns                                     |
| tsui    | set-up time <b>ata_iordy</b> to bus clock H-to-L                                                                                                                                                                                                                           | 8.5 ns                                     |
| thi     | hold time <b>ata_iordy</b> to bus clock H to L                                                                                                                                                                                                                             | 2.5 ns                                     |
| tskew1  | Max difference in propagation delay bus clock L-to-H to any of following signals <b>ata_cs0</b> , <b>ata_cs1</b> , <b>ata_da2</b> , <b>ata_da1</b> , <b>ata_da0</b> , <b>ata_dior</b> , <b>ata_diow</b> , <b>ata_dmack</b> , <b>ata_data</b> (write), <b>ata_buffer_en</b> | 7 ns                                       |
| tskew2  | Max difference in buffer propagation delay for any of following signals <b>ata_cs0</b> , <b>ata_cs1</b> , <b>ata_da2</b> , <b>ata_da1</b> , <b>ata_da0</b> , <b>ata_dior</b> , <b>ata_diow</b> , <b>ata_dmack</b> , <b>ata_data</b> (write), <b>ata_buffer_en</b>          | transceiver                                |
| tskew3  | Max difference in buffer propagation delay for any of following signals <b>ata_iordy</b> , <b>ata_data</b> (read)                                                                                                                                                          | transceiver                                |
| tbuf    | Max buffer propagation delay                                                                                                                                                                                                                                               | transceiver                                |
| tcable1 | cable propagation delay for <b>ata_data</b>                                                                                                                                                                                                                                | cable                                      |
| tcable2 | cable propagation delay for control signals <b>ata_dior</b> , <b>ata_diow</b> , <b>ata_iordy</b> , <b>ata_dmack</b>                                                                                                                                                        | cable                                      |
| tskew4  | Max difference in cable propagation delay between <b>ata_iordy</b> and <b>ata_data</b> (read)                                                                                                                                                                              | cable                                      |
| tskew5  | Max difference in cable propagation delay between ( <b>ata_dior</b> , <b>ata_diow</b> , <b>ata_dmack</b> ) and <b>ata_cs0</b> , <b>ata_cs1</b> , <b>ata_da2</b> , <b>ata_da1</b> , <b>ata_da0</b> , <b>ata_data</b> (write)                                                | cable                                      |
| tskew6  | Max difference in cable propagation delay without accounting for ground bounce                                                                                                                                                                                             | cable                                      |

<sup>1</sup> Values provided where applicable.

#### 4.3.5.2 PIO Mode Timing

Figure 9 shows timing for PIO read, and Table 21 lists the timing parameters for PIO read.

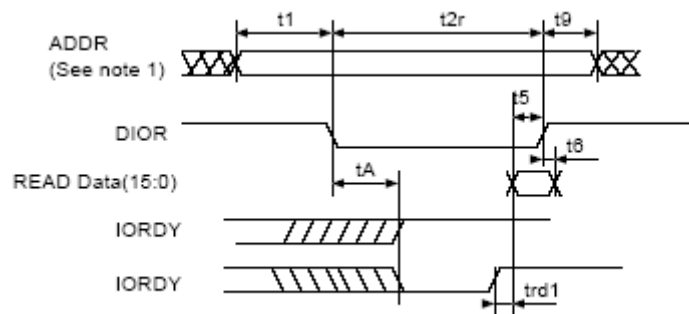


Figure 9. PIO Read Timing Diagram

Table 21. PIO Read Timing Parameters

| ATA Parameter | Parameter from Figure 9 | Value                                                                                                                                                                                                                                                         | Controlling Variable        |
|---------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| t1            | t1                      | $t1 \text{ (min)} = \text{time\_1} * T - (\text{tskew1} + \text{tskew2} + \text{tskew5})$                                                                                                                                                                     | time_1                      |
| t2            | t2r                     | $t2 \text{ (min)} = \text{time\_2r} * T - (\text{tskew1} + \text{tskew2} + \text{tskew5})$                                                                                                                                                                    | time_2r                     |
| t9            | t9                      | $t9 \text{ (min)} = \text{time\_9} * T - (\text{tskew1} + \text{tskew2} + \text{tskew6})$                                                                                                                                                                     | time_3                      |
| t5            | t5                      | $t5 \text{ (min)} = \text{tco} + \text{tsu} + \text{tbuf} + \text{tbuf} + \text{tcable1} + \text{tcable2}$                                                                                                                                                    | If not met, increase time_2 |
| t6            | t6                      | 0                                                                                                                                                                                                                                                             | —                           |
| tA            | tA                      | $tA \text{ (min)} = (1.5 + \text{time\_ax}) * T - (\text{tco} + \text{tsui} + \text{tcable2} + \text{tcable2} + 2 * \text{tbuf})$                                                                                                                             | time_ax                     |
| trd           | trd1                    | $\text{trd1 (max)} = (-\text{trd}) + (\text{tskew3} + \text{tskew4})$<br>$\text{trd1 (min)} = (\text{time\_pio\_rdx} - 0.5) * T - (\text{tsu} + \text{thi})$<br>$(\text{time\_pio\_rdx} - 0.5) * T > \text{tsu} + \text{thi} + \text{tskew3} + \text{tskew4}$ | time_pio_rdx                |
| t0            | —                       | $t0 \text{ (min)} = (\text{time\_1} + \text{time\_2} + \text{time\_9}) * T$                                                                                                                                                                                   | time_1, time_2r, time_9     |

Figure 10 shows timing for PIO write, and Table 22 lists the timing parameters for PIO write.

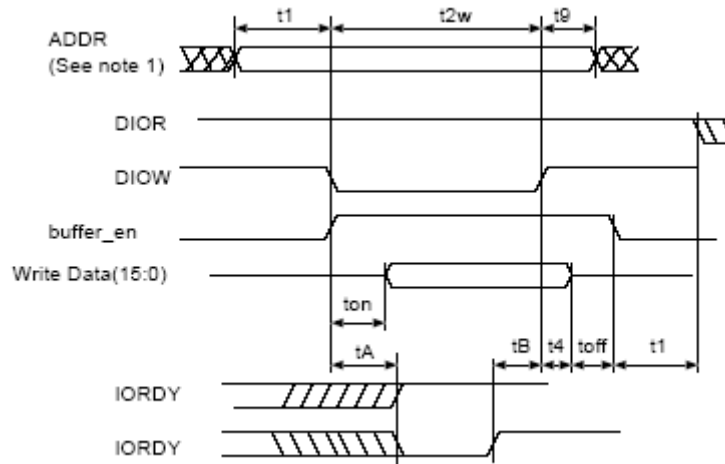


Figure 10. Multiword DMA (MDMA) Timing

Table 22. PIO Write Timing Parameters

| ATA Parameter | Parameter from Figure 10 | Value                                                                                                               | Controlling Variable         |
|---------------|--------------------------|---------------------------------------------------------------------------------------------------------------------|------------------------------|
| t1            | t1                       | $t1 \text{ (min)} = \text{time\_1} * T - (\text{tskew1} + \text{tskew2} + \text{tskew5})$                           | time_1                       |
| t2            | t2w                      | $t2 \text{ (min)} = \text{time\_2w} * T - (\text{tskew1} + \text{tskew2} + \text{tskew5})$                          | time_2w                      |
| t9            | t9                       | $t9 \text{ (min)} = \text{time\_9} * T - (\text{tskew1} + \text{tskew2} + \text{tskew6})$                           | time_9                       |
| t3            | —                        | $t3 \text{ (min)} = (\text{time\_2w} - \text{time\_on}) * T - (\text{tskew1} + \text{tskew2} + \text{tskew5})$      | If not met, increase time_2w |
| t4            | t4                       | $t4 \text{ (min)} = \text{time\_4} * T - \text{tskew1}$                                                             | time_4                       |
| tA            | tA                       | $tA = (1.5 + \text{time\_ax}) * T - (\text{tco} + \text{tsui} + \text{tcable2} + \text{tcable2} + 2 * \text{tbuf})$ | time_ax                      |

Table 22. PIO Write Timing Parameters (continued)

| ATA Parameter | Parameter from Figure 10 | Value                                                                      | Controlling Variable    |
|---------------|--------------------------|----------------------------------------------------------------------------|-------------------------|
| t0            | –                        | $t0(\min) = (\text{time\_1} + \text{time\_2} + \text{time\_9}) * T$        | time_1, time_2r, time_9 |
| –             | –                        | Avoid bus contention when switching buffer on by making ton long enough.   | –                       |
| –             | –                        | Avoid bus contention when switching buffer off by making toff long enough. | –                       |

Figure 11 shows timing for MDMA read, Figure 12 shows timing for MDMA write, and Table 23 lists the timing parameters for MDMA read and write.

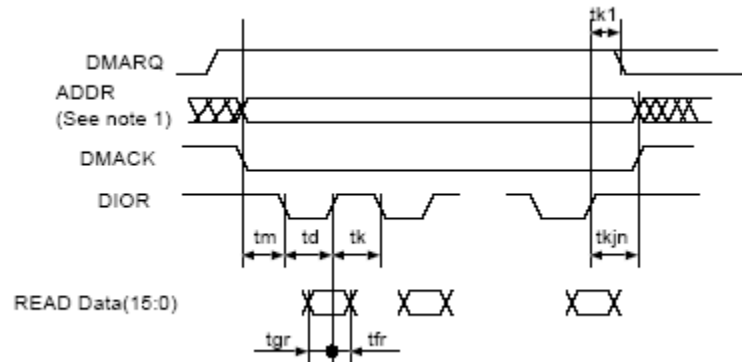


Figure 11. MDMA Read Timing Diagram

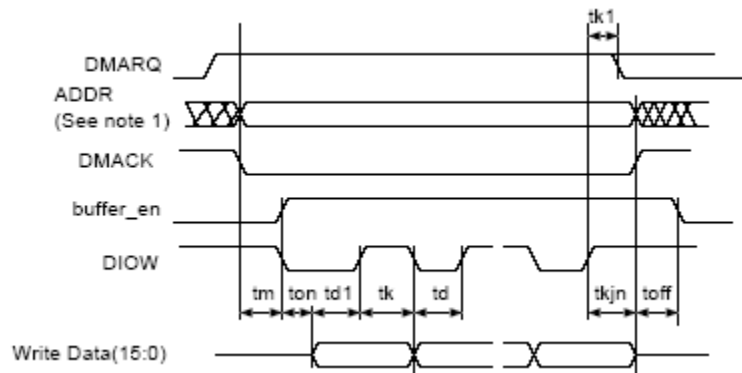


Figure 12. MDMA Write Timing Diagram

Table 23. MDMA Read and Write Timing Parameters

| ATA Parameter | Parameter from Figure 11, Figure 12 | Value                                                                                         | Controlling Variable |
|---------------|-------------------------------------|-----------------------------------------------------------------------------------------------|----------------------|
| tm, ti        | tm                                  | $tm(\min) = ti(\min) = \text{time\_m} * T - (\text{tskew1} + \text{tskew2} + \text{tskew5})$  | time_m               |
| td            | td, td1                             | $td1(\min) = td(\min) = \text{time\_d} * T - (\text{tskew1} + \text{tskew2} + \text{tskew6})$ | time_d               |
| tk            | tk                                  | $tk(\min) = \text{time\_k} * T - (\text{tskew1} + \text{tskew2} + \text{tskew6})$             | time_k               |

Table 23. MDMA Read and Write Timing Parameters (continued)

| ATA Parameter | Parameter from Figure 11, Figure 12 | Value                                                                                                                       | Controlling Variable |
|---------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|----------------------|
| t0            | —                                   | $t0 \text{ (min)} = (\text{time\_d} + \text{time\_k}) * T$                                                                  | time_d, time_k       |
| tg(read)      | tgr                                 | $tgr \text{ (min-read)} = tco + tsu + tbuf + tbuf + tcable1 + tcable2$<br>$tgr \text{ (min-drive)} = td - te(\text{drive})$ | time_d               |
| tf(read)      | tfr                                 | $tfr \text{ (min-drive)} = 0$                                                                                               | —                    |
| tg(write)     | —                                   | $tg \text{ (min-write)} = \text{time\_d} * T - (\text{tskew1} + \text{tskew2} + \text{tskew5})$                             | time_d               |
| tf(write)     | —                                   | $tf \text{ (min-write)} = \text{time\_k} * T - (\text{tskew1} + \text{tskew2} + \text{tskew6})$                             | time_k               |
| tL            | —                                   | $tL \text{ (max)} = (\text{time\_d} + \text{time\_k} - 2) * T - (tsu + tco + 2 * tbuf + 2 * tcable2)$                       | time_d, time_k       |
| tn, tj        | tkjn                                | $tn = tj = tkjn = (\max(\text{time\_k}, \text{time\_jn}) * T - (\text{tskew1} + \text{tskew2} + \text{tskew6}))$            | time_jn              |
| —             | ton<br>toff                         | $ton = \text{time\_on} * T - \text{tskew1}$<br>$toff = \text{time\_off} * T - \text{tskew1}$                                | —                    |

#### 4.3.5.3 UDMA In Timing

Figure 13 shows timing when the UDMA in transfer starts, Figure 14 shows timing when the UDMA in host terminates transfer, Figure 15 shows timing when the UDMA in device terminates transfer, and Table 24 lists the timing parameters for UDMA in burst.

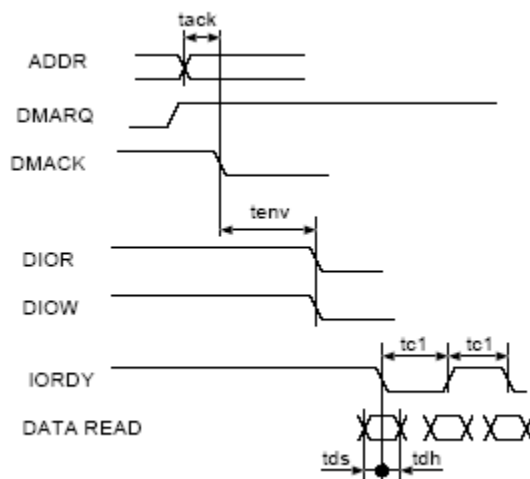


Figure 13. UDMA In Transfer Starts Timing Diagram

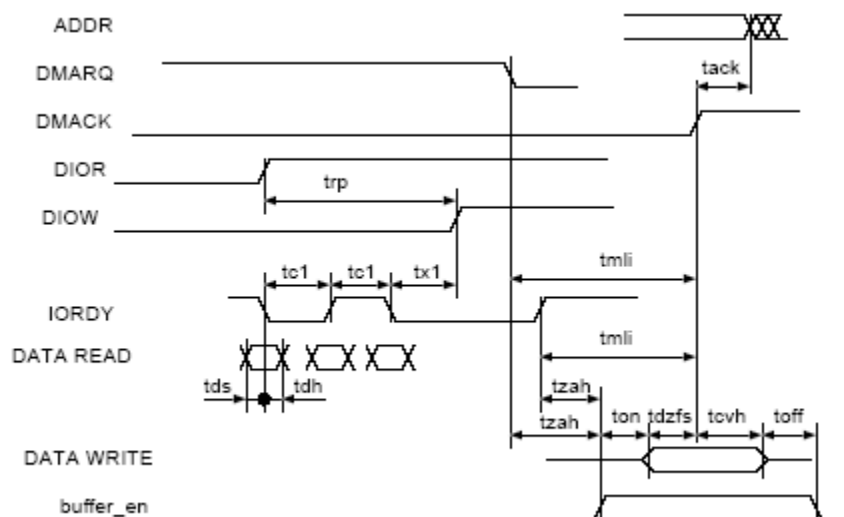


Figure 14. UDMA In Host Terminates Transfer Timing Diagram

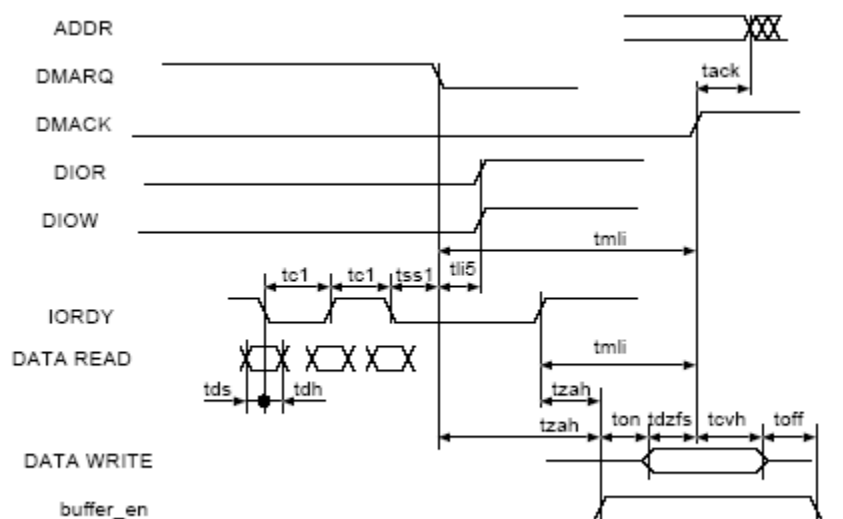


Figure 15. UDMA In Device Terminates Transfer Timing Diagram

Table 24. UDMA In Burst Timing Parameters

| ATA Parameter | Parameter from Figure 13, Figure 14, Figure 15 | Description                                                                                              | Controlling Variable                      |
|---------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------|
| tack          | tack                                           | $tack (min) = (time\_ack * T) - (tskew1 + tskew2)$                                                       | time_ack                                  |
| tenv          | tenv                                           | $tenv (min) = (time\_env * T) - (tskew1 + tskew2)$<br>$tenv (max) = (time\_env * T) + (tskew1 + tskew2)$ | time_env                                  |
| tds           | tds1                                           | $tds - (tskew3) - ti\_ds > 0$                                                                            | tskew3, ti_ds, ti_dh should be low enough |
| tdh           | tdh1                                           | $tdh - (tskew3) - ti\_dh > 0$                                                                            |                                           |

Table 24. UDMA In Burst Timing Parameters (continued)

| ATA Parameter | Parameter from Figure 13, Figure 14, Figure 15 | Description                                                                         | Controlling Variable |
|---------------|------------------------------------------------|-------------------------------------------------------------------------------------|----------------------|
| tcyc          | tc1                                            | $(tcyc - tskew) > T$                                                                | T big enough         |
| trp           | trp                                            | $trp \text{ (min)} = time\_rp * T - (tskew1 + tskew2 + tskew6)$                     | time_rp              |
| —             | tx1 <sup>1</sup>                               | $(time\_rp * T) - (tco + tsu + 3T + 2 * tbuf + 2 * tcable2) > trfs \text{ (drive)}$ | time_rp              |
| tmli          | tmli1                                          | $tmli1 \text{ (min)} = (time\_mlix + 0.4) * T$                                      | time_mlix            |
| tzah          | tzah                                           | $tzah \text{ (min)} = (time\_zah + 0.4) * T$                                        | time_zah             |
| tdzfs         | tdzfs                                          | $tdzfs = (time\_dzfs * T) - (tskew1 + tskew2)$                                      | time_dzfs            |
| tcvh          | tcvh                                           | $tcvh = (time\_cvh * T) - (tskew1 + tskew2)$                                        | time_cvh             |
| —             | ton<br>toff                                    | $ton = time\_on * T - tskew1$<br>$toff = time\_off * T - tskew1$                    | —                    |

<sup>1</sup> There is a special timing requirement in the ATA host that requires the internal DIOW to go only high 3 clocks after the last active edge on the DSTROBE signal. The equation given on this line tries to capture this constraint.

2. Make ton and toff big enough to avoid bus contention

#### 4.3.5.4 UDMA Out Timing

Figure 16 shows timing when the UDMA out transfer starts, Figure 17 shows timing when the UDMA out host terminates transfer, Figure 18 shows timing when the UDMA out device terminates transfer, and Table 25 lists the timing parameters for UDMA out burst.

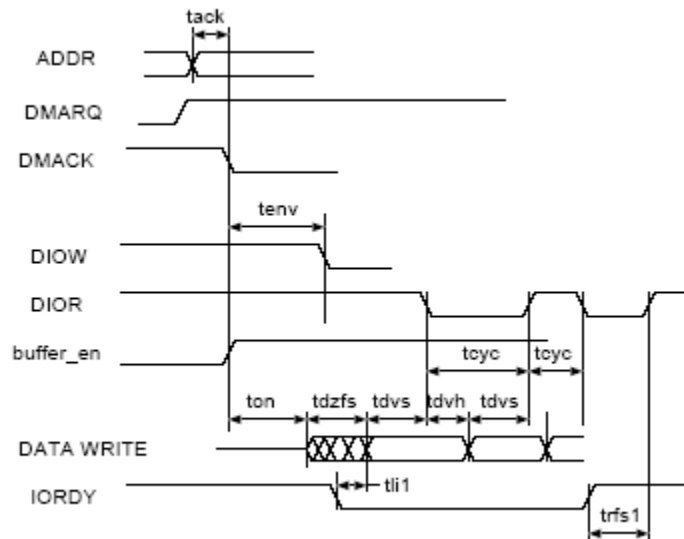


Figure 16. UDMA Out Transfer Starts Timing Diagram

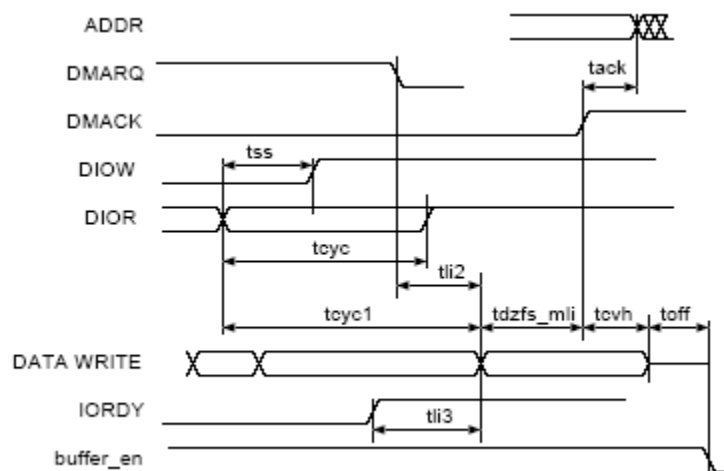


Figure 17. UDMA Out Host Terminates Transfer Timing Diagram

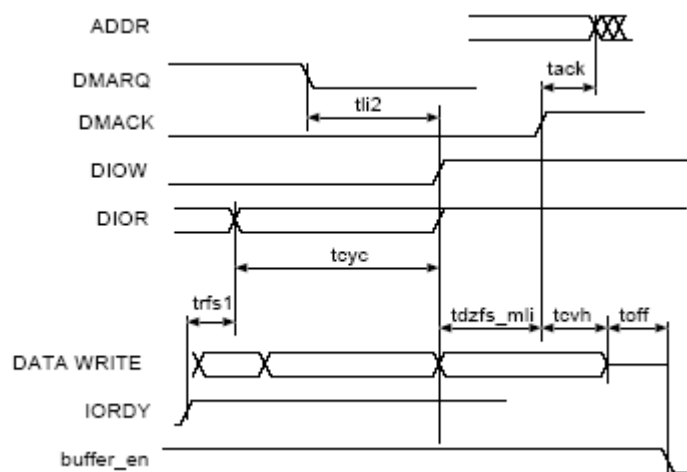


Figure 18. UDMA Out Device Terminates Transfer Timing Diagram

Table 25. UDMA Out Burst Timing Parameters

| ATA Parameter | Parameter from Figure 16, Figure 17, Figure 18 | Value                                                                                                    | Controlling Variable |
|---------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------|
| tack          | tack                                           | $tack (min) = (time\_ack * T) - (tskew1 + tskew2)$                                                       | time_ack             |
| tenv          | tenv                                           | $tenv (min) = (time\_env * T) - (tskew1 + tskew2)$<br>$tenv (max) = (time\_env * T) + (tskew1 + tskew2)$ | time_env             |
| tdvs          | tdvs                                           | $tdvs = (time\_dvs * T) - (tskew1 + tskew2)$                                                             | time_dvs             |
| tdvh          | tdvh                                           | $tdvs = (time\_dvh * T) - (tskew1 + tskew2)$                                                             | time_dvh             |
| tcyc          | tcyc                                           | $tcyc = time\_cyc * T - (tskew1 + tskew2)$                                                               | time_cyc             |
| t2cyc         | —                                              | $t2cyc = time\_cyc * 2 * T$                                                                              | time_cyc             |

Table 25. UDMA Out Burst Timing Parameters (continued)

| ATA Parameter | Parameter from Figure 16, Figure 17, Figure 18 | Value                                                                                                      | Controlling Variable |
|---------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------|
| trfs1         | trfs                                           | $\text{trfs} = 1.6 * T + \text{tsui} + \text{tco} + \text{tbuf} + \text{tbuf}$                             | —                    |
| —             | tdzfs                                          | $\text{tdzfs} = \text{time\_dzfs} * T - (\text{tskew1})$                                                   | time_dzfs            |
| tss           | tss                                            | $\text{tss} = \text{time\_ss} * T - (\text{tskew1} + \text{tskew2})$                                       | time_ss              |
| tmli          | tdzfs_mli                                      | $\text{tdzfs\_mli} = \max(\text{time\_dzfs}, \text{time\_mli}) * T - (\text{tskew1} + \text{tskew2})$      | —                    |
| tli           | tli1                                           | $\text{tli1} > 0$                                                                                          | —                    |
| tli           | tli2                                           | $\text{tli2} > 0$                                                                                          | —                    |
| tli           | tli3                                           | $\text{tli3} > 0$                                                                                          | —                    |
| tcvh          | tcvh                                           | $\text{tcvh} = (\text{time\_cvh} * T) - (\text{tskew1} + \text{tskew2})$                                   | time_cvh             |
| —             | ton<br>toff                                    | $\text{ton} = \text{time\_on} * T - \text{tskew1}$<br>$\text{toff} = \text{time\_off} * T - \text{tskew1}$ | —                    |

### 4.3.6 AUDMUX Electrical Specifications

The AUDMUX provides a programmable interconnect logic for voice, audio and data routing between internal serial interfaces (SSI) and external serial interfaces (audio and voice codecs). The AC timing of AUDMUX external pins is hence governed by the SSI module. Please refer to their respective electrical specifications.

### 4.3.7 CSPI Electrical Specifications

This section describes the electrical information of the CSPI.

#### 4.3.7.1 CSPI Timing

Figure 19 and Figure 20 depict the master mode and slave mode timings of CSPI, and Table 26 lists the timing parameters.

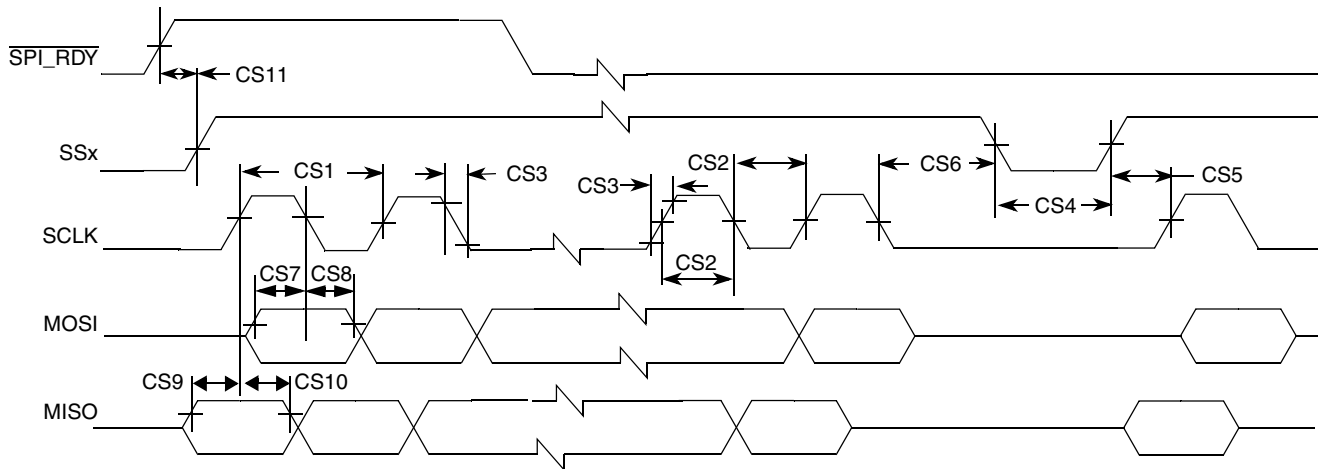


Figure 19. CSPI Master Mode Timing Diagram

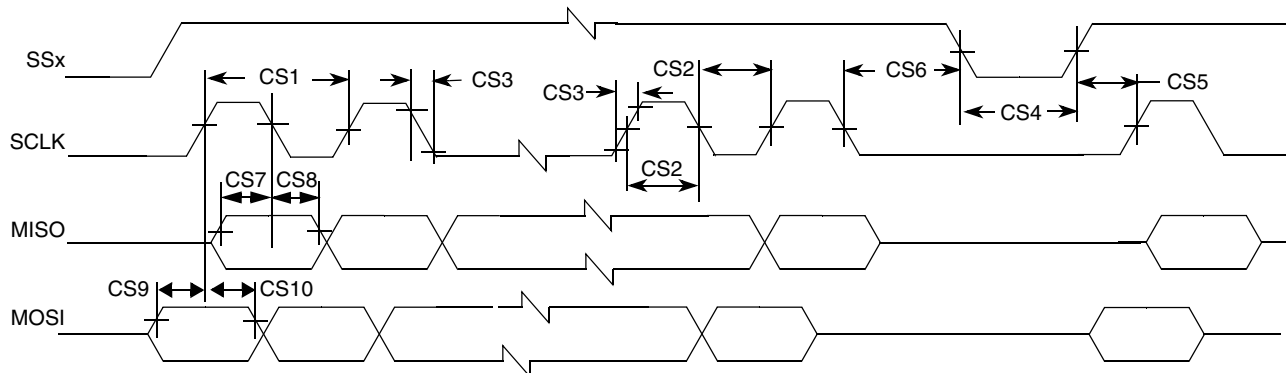


Figure 20. CSPI Slave Mode Timing Diagram

Table 26. CSPI Interface Timing Parameters

| ID   | Parameter                                     | Symbol          | Min | Max | Units |
|------|-----------------------------------------------|-----------------|-----|-----|-------|
| CS1  | SCLK Cycle Time                               | $t_{clk}$       | 60  | —   | ns    |
| CS2  | SCLK High or Low Time                         | $t_{SW}$        | 30  | —   | ns    |
| CS3  | SCLK Rise or Fall                             | $t_{RISE/FALL}$ | —   | 7.6 | ns    |
| CS4  | SSx pulse width                               | $t_{CSLH}$      | 25  | —   | ns    |
| CS5  | SSx Lead Time (CS setup time)                 | $t_{SCS}$       | 25  | —   | ns    |
| CS6  | SSx Lag Time (CS hold time)                   | $t_{HCS}$       | 25  | —   | ns    |
| CS7  | Data Out Setup Time                           | $t_{Smosi}$     | 5   | —   | ns    |
| CS8  | Data Out Hold Time                            | $t_{Hmosi}$     | 5   | —   | ns    |
| CS9  | Data In Setup Time                            | $t_{Smiso}$     | 6   | —   | ns    |
| CS10 | Data In Hold Time                             | $t_{Hmiso}$     | 5   | —   | ns    |
| CS11 | $\overline{SPI\_RDY}$ Setup Time <sup>1</sup> | $t_{SDRY}$      | —   | —   | ns    |

<sup>1</sup> SPI\_RDY is sampled internally by ipg\_clk and is asynchronous to all other CSPI signals.

### 4.3.8 DPLL Electrical Specifications

The three PLL's of the i.MX31/i.MX31L (MCU, USB, and Serial PLL) are all based on same DPLL design. The characteristics provided herein apply to all of them, except where noted explicitly. The PLL characteristics are provided based on measurements done for both sources—external clock source (CKIH), and FPM (Frequency Pre-Multiplier) source.

#### 4.3.8.1 Electrical Specifications

Table 27 lists the DPLL specification.

**Table 27. DPLL Specifications**

| Parameter                                                      | Min       | Typ              | Max             | Unit          | Comments                                                                                                     |
|----------------------------------------------------------------|-----------|------------------|-----------------|---------------|--------------------------------------------------------------------------------------------------------------|
| CKIH frequency                                                 | 15        | 26 <sup>1</sup>  | 75 <sup>2</sup> | MHz           | –                                                                                                            |
| CKIL frequency<br>(Frequency Pre-multiplier (FPM) enable mode) | –         | 32; 32.768, 38.4 | –               | kHz           | FPM lock time $\approx 480 \mu\text{s}$ .                                                                    |
| Predivision factor (PD bits)                                   | 1         | –                | 16              | –             | –                                                                                                            |
| PLL reference frequency range after Predivider                 | 15        | –                | 35              | MHz           | $15 \leq \text{CKIH frequency/PD} \leq 35 \text{ MHz}$<br>$15 \leq \text{FPM output/PD} \leq 35 \text{ MHz}$ |
| PLL output frequency range:<br>MPLL and SPLL<br>UPLL           | 52<br>190 | –                | 532<br>240      | MHz           | –                                                                                                            |
| Maximum allowed reference clock phase noise.                   | –         | –                | $\pm 100$       | ps            | –                                                                                                            |
| Frequency lock time<br>(FOL mode or non-integer MF)            | –         | –                | 398             | –             | Cycles of divided reference clock.                                                                           |
| Phase lock time                                                | –         | –                | 100             | $\mu\text{s}$ | In addition to the frequency                                                                                 |
| Maximum allowed PLL supply voltage ripple                      | –         | –                | 25              | mV            | $F_{\text{modulation}} < 50 \text{ kHz}$                                                                     |
| Maximum allowed PLL supply voltage ripple                      | –         | –                | 20              | mV            | $50 \text{ kHz} < F_{\text{modulation}} < 300 \text{ kHz}$                                                   |
| Maximum allowed PLL supply voltage ripple                      | –         | –                | 25              | mV            | $F_{\text{modulation}} > 300 \text{ kHz}$                                                                    |
| PLL output clock phase jitter                                  | –         | –                | 5.2             | ns            | Measured on CLKO pin                                                                                         |
| PLL output clock period jitter                                 | –         | –                | 420             | ps            | Measured on CLKO pin                                                                                         |

<sup>1</sup> The user or board designer must take into account that the use of a frequency other than 26 MHz would require adjustment to the DPTC-DVFS table, which is incorporated into operating system code.

<sup>2</sup> The PLL reference frequency must be  $\leq 35 \text{ MHz}$ . Therefore, for frequencies between 35 MHz and 70 MHz, program the predivider to divide by 2 or more. If the CKIH frequency is above 70 MHz, program the predivider to 3 or more. For PD bit description, see the reference manual.

### 4.3.9 EMI Electrical Specifications

This section provides electrical parametrics and timings for EMI module.

#### 4.3.9.1 NAND Flash Controller Interface (NFC)

The NFC supports normal timing mode, using two flash clock cycles for one access of  $\overline{RE}$  and  $\overline{WE}$ . AC timings are provided as multiplications of the clock cycle and fixed delay. [Figure 21](#), [Figure 22](#), [Figure 23](#), and [Figure 24](#) depict the relative timing requirements among different signals of the NFC at module level, for normal mode, and [Table 28](#) lists the timing parameters.

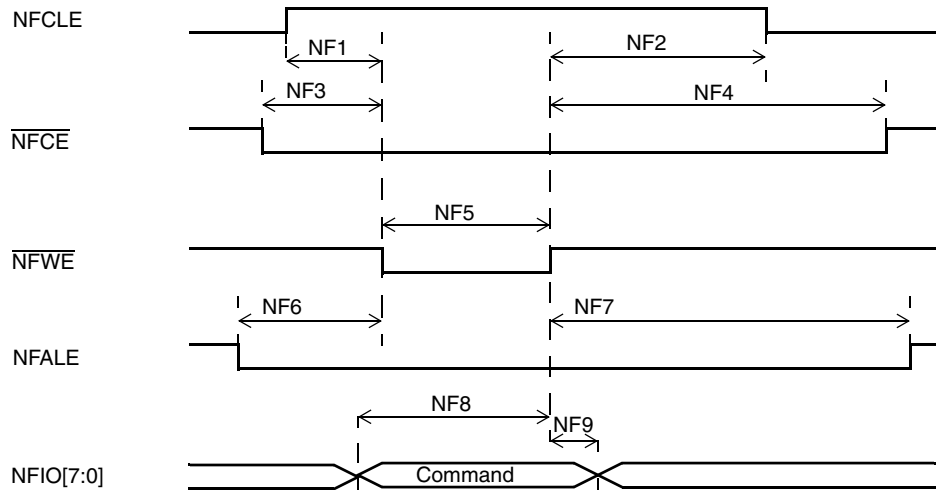


Figure 21. Command Latch Cycle Timing Diagram

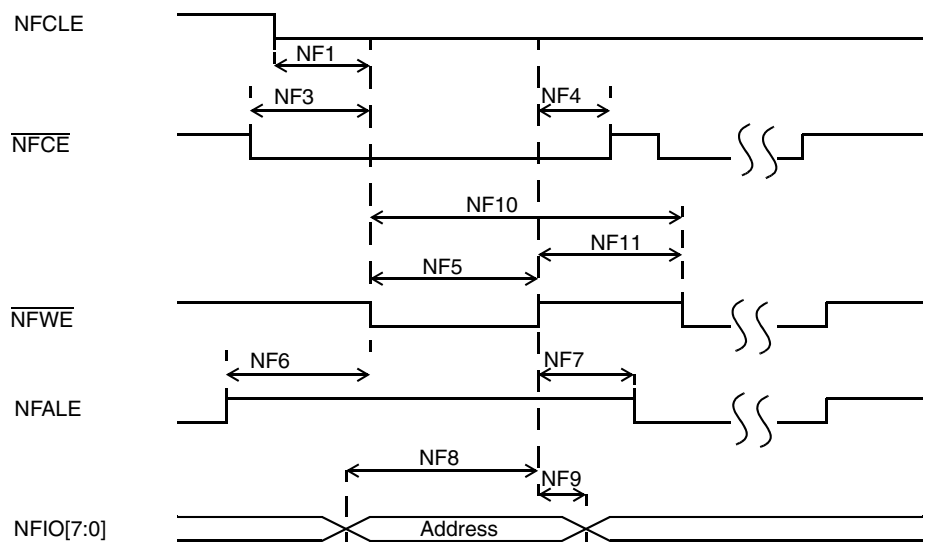


Figure 22. Address Latch Cycle Timing Diagram

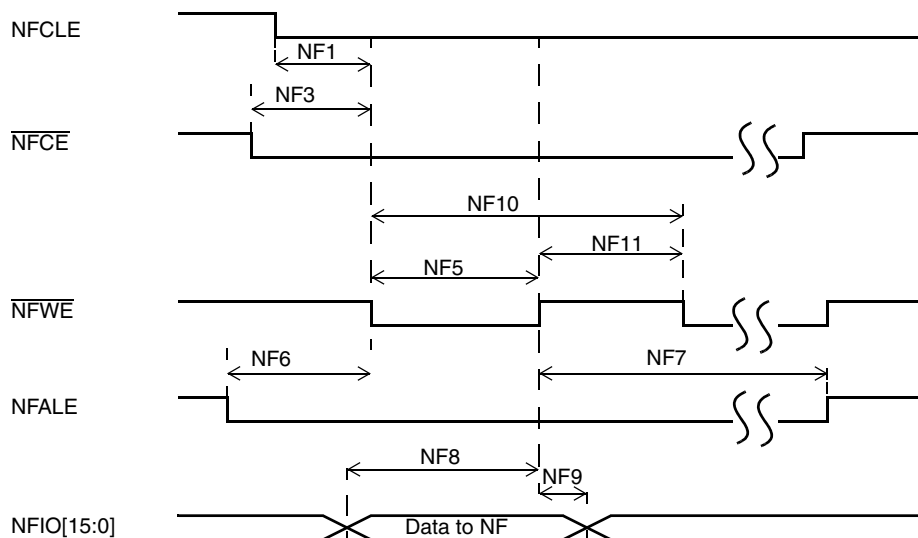


Figure 23. Write Data Latch Cycle Timing Diagram

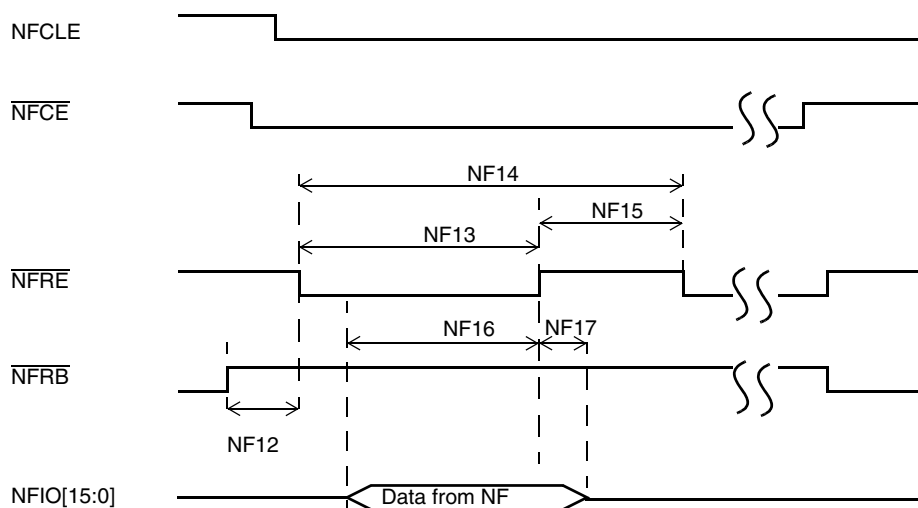


Figure 24. Read Data Latch Cycle Timing Diagram

Table 28. NFC Timing Parameters<sup>1</sup>

| ID  | Parameter                              | Symbol | Timing<br>T = NFC Clock Cycle <sup>2</sup> |     | Example Timing for<br>NFC Clock ≈ 33 MHz<br>T = 30 ns |     | Unit |
|-----|----------------------------------------|--------|--------------------------------------------|-----|-------------------------------------------------------|-----|------|
|     |                                        |        | Min                                        | Max | Min                                                   | Max |      |
| NF1 | NFCLE Setup Time                       | tCLS   | T-1.0 ns                                   | –   | 29                                                    | –   | ns   |
| NF2 | NFCLE Hold Time                        | tCLH   | T-2.0 ns                                   | –   | 28                                                    | –   | ns   |
| NF3 | $\overline{\text{NFCE}}$ Setup Time    | tCS    | T-1.0 ns                                   | –   | 29                                                    | –   | ns   |
| NF4 | $\overline{\text{NFCE}}$ Hold Time     | tCH    | T-2.0 ns                                   | –   | 28                                                    | –   | ns   |
| NF5 | $\overline{\text{NF\_WP}}$ Pulse Width | tWP    | T-1.5 ns                                   |     | 28.5                                                  |     | ns   |
| NF6 | NFALE Setup Time                       | tALS   | T                                          | –   | 30                                                    | –   | ns   |

Table 28. NFC Timing Parameters<sup>1</sup> (continued)

| ID   | Parameter                                                 | Symbol | Timing<br>T = NFC Clock Cycle <sup>2</sup> |     | Example Timing for<br>NFC Clock $\approx$ 33 MHz<br>T = 30 ns |     | Unit |
|------|-----------------------------------------------------------|--------|--------------------------------------------|-----|---------------------------------------------------------------|-----|------|
|      |                                                           |        | Min                                        | Max | Min                                                           | Max |      |
| NF7  | NFALE Hold Time                                           | tALH   | T–3.0 ns                                   | –   | 27                                                            | –   | ns   |
| NF8  | Data Setup Time                                           | tDS    | T                                          | –   | 30                                                            | –   | ns   |
| NF9  | Data Hold Time                                            | tDH    | T–5.0 ns                                   | –   | 25                                                            | –   | ns   |
| NF10 | Write Cycle Time                                          | tWC    | 2T                                         |     | 60                                                            |     | ns   |
| NF11 | $\overline{\text{NFW}}\overline{\text{E}}$ Hold Time      | tWH    | T–2.5 ns                                   |     | 27.5                                                          |     | ns   |
| NF12 | Ready to $\overline{\text{NFR}}\overline{\text{E}}$ Low   | tRR    | 6T                                         | –   | 180                                                           | –   | ns   |
| NF13 | $\overline{\text{NFR}}\overline{\text{E}}$ Pulse Width    | tRP    | 1.5T                                       | –   | 45                                                            | –   | ns   |
| NF14 | READ Cycle Time                                           | tRC    | 2T                                         | –   | 60                                                            | –   | ns   |
| NF15 | $\overline{\text{NFR}}\overline{\text{E}}$ High Hold Time | tREH   | 0.5T–2.5 ns                                |     | 12.5                                                          | –   | ns   |
| NF16 | Data Setup on READ                                        | tDSR   | N/A                                        |     | 10                                                            | –   | ns   |
| NF17 | Data Hold on READ                                         | tDHR   | N/A                                        |     | 0                                                             | –   | ns   |

<sup>1</sup> The flash clock maximum frequency is 50 MHz.

<sup>2</sup> Subject to DPLL jitter specification on [Table 27, "DPLL Specifications," on page 31](#).

#### NOTE

High is defined as 80% of signal value and low is defined as 20% of signal value.

#### NOTE

Timing for HCLK is 133 MHz and internal NFC clock (flash clock) is approximately 33 MHz (30 ns). All timings are listed according to this NFC clock frequency (multiples of NFC clock phases), except NF16 and NF17, which are not NFC clock related.

### 4.3.9.2 Wireless External Interface Module (WEIM)

All WEIM output control signals may be asserted and deasserted by internal clock related to BCLK rising edge or falling edge according to corresponding assertion/negation control fields. Address always begins related to BCLK falling edge but may be ended both on rising and falling edge in muxed mode according to control register configuration. Output data begins related to BCLK rising edge except in muxed mode where both rising and falling edge may be used according to control register configuration. Input data,  $\overline{\text{ECB}}$  and  $\overline{\text{DTACK}}$  all captured according to BCLK rising edge time. [Figure 25](#) depicts the timing of the WEIM module, and [Table 29](#) lists the timing parameters.

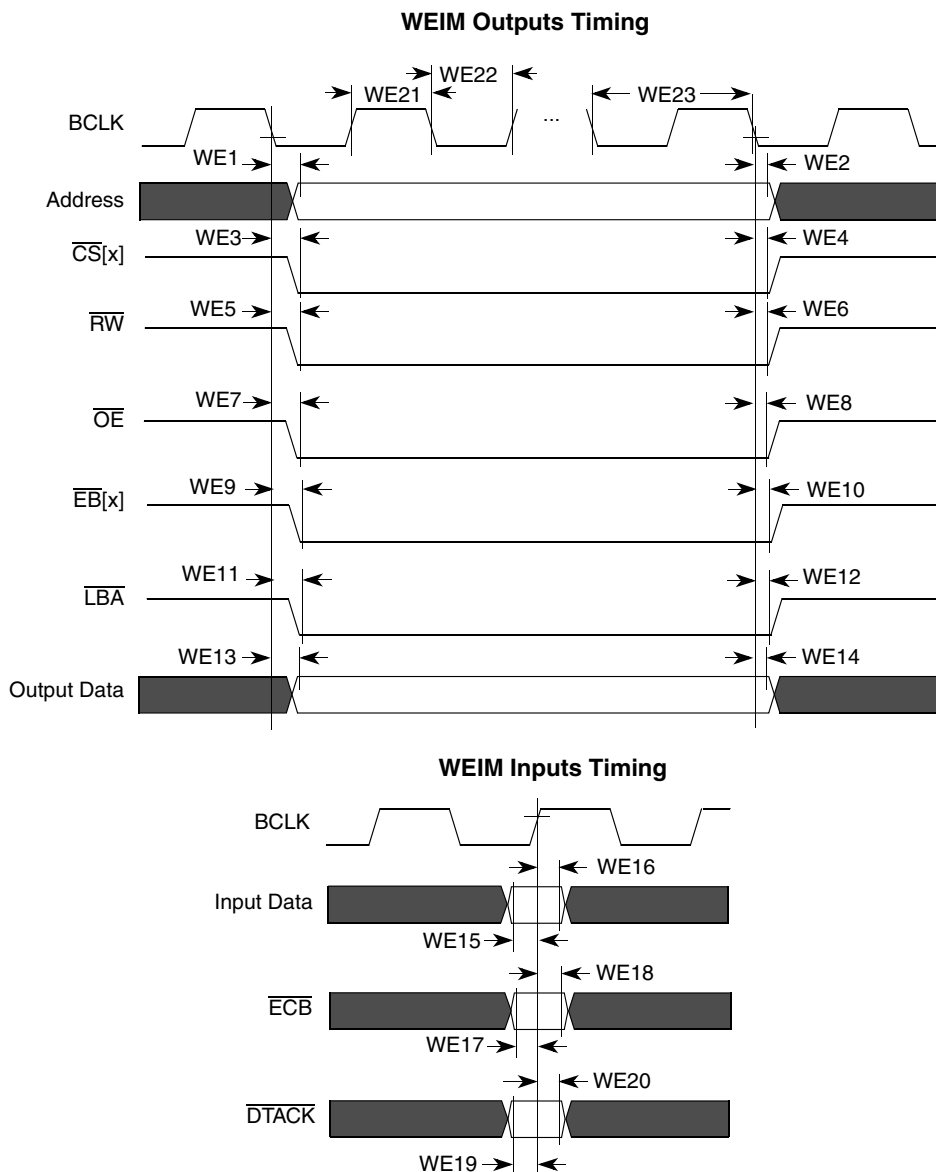


Figure 25. WEIM Bus Timing Diagram

Table 29. WEIM Bus Timing Parameters

| ID  | Parameter                                     | Min  | Max | Unit |
|-----|-----------------------------------------------|------|-----|------|
| WE1 | Clock fall to Address Valid                   | -0.5 | 2.5 | ns   |
| WE2 | Clock rise/fall to Address Invalid            | -0.5 | 5   | ns   |
| WE3 | Clock rise/fall to $\overline{CS}[x]$ Valid   | -3   | 3   | ns   |
| WE4 | Clock rise/fall to $\overline{CS}[x]$ Invalid | -3   | 3   | ns   |
| WE5 | Clock rise/fall to $\overline{RW}$ Valid      | -3   | 3   | ns   |
| WE6 | Clock rise/fall to $\overline{RW}$ Invalid    | -3   | 3   | ns   |
| WE7 | Clock rise/fall to $\overline{OE}$ Valid      | -3   | 3   | ns   |

Table 29. WEIM Bus Timing Parameters (continued)

| ID   | Parameter                                        | Min        | Max            | Unit |
|------|--------------------------------------------------|------------|----------------|------|
| WE8  | Clock rise/fall to $\overline{OE}$ Invalid       | -3         | 3              | ns   |
| WE9  | Clock rise/fall to $\overline{EB}[x]$ Valid      | -3         | 3              | ns   |
| WE10 | Clock rise/fall to $\overline{EB}[x]$ Invalid    | -3         | 3              | ns   |
| WE11 | Clock rise/fall to $\overline{LBA}$ Valid        | -3         | 3              | ns   |
| WE12 | Clock rise/fall to $\overline{LBA}$ Invalid      | -3         | 3              | ns   |
| WE13 | Clock rise/fall to Output Data Valid             | - 2.5      | 4              | ns   |
| WE14 | Clock rise to Output Data Invalid                | - 2.5      | 4              | ns   |
| WE15 | Input Data Valid to Clock rise, FCE=0<br>FCE=1   | 8<br>2.5   | —              | ns   |
| WE16 | Clock rise to Input Data Invalid, FCE=0<br>FCE=1 | -2<br>-2   | —              | ns   |
| WE17 | $\overline{ECB}$ setup time, FCE=0<br>FCE=1      | 6.5<br>3.5 | —              | ns   |
| WE18 | $\overline{ECB}$ hold time, FCE=0<br>FCE=1       | -2<br>2    | —              | ns   |
| WE19 | $\overline{DTACK}$ setup time <sup>1</sup>       | 0          | —              | ns   |
| WE20 | $\overline{DTACK}$ hold time <sup>1</sup>        | 4.5        | —              | ns   |
| WE21 | BCLK High Level Width <sup>2, 3</sup>            | —          | Tcycle/<br>2-3 | ns   |
| WE22 | BCLK Low Level Width <sup>2, 3</sup>             | —          | Tcycle/<br>2-3 | ns   |
| WE23 | BCLK Cycle time <sup>2</sup>                     | 15         | —              | ns   |

<sup>1</sup> Applies to rising edge timing

<sup>2</sup> BCLK parameters are being measured from the 50% VDD.

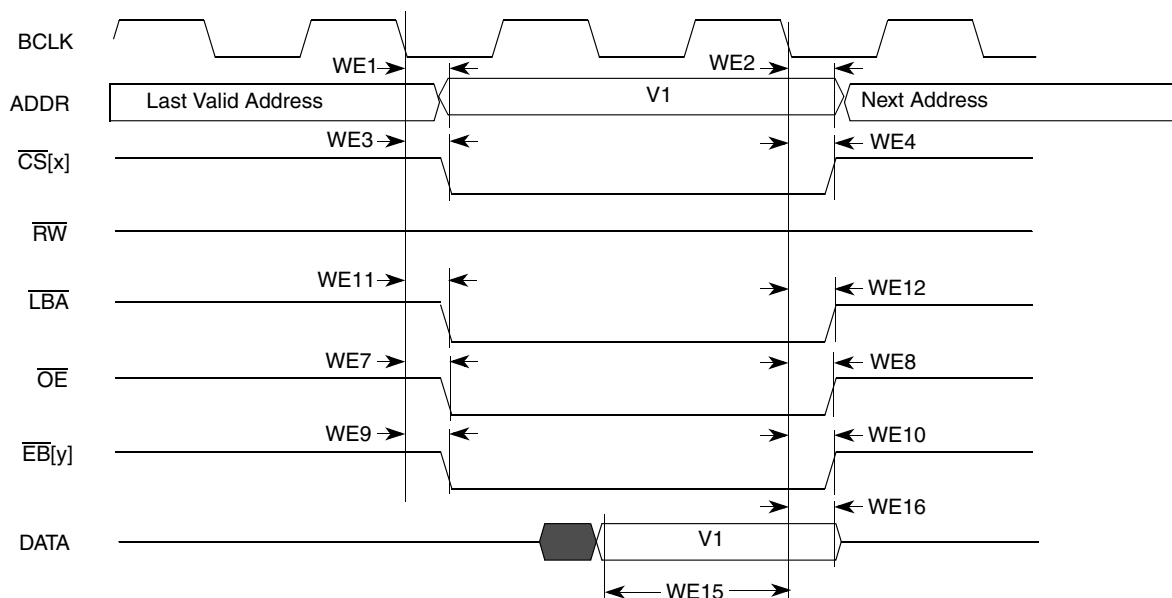
<sup>3</sup> The actual cycle time is derived from the AHB bus clock frequency.

### NOTE

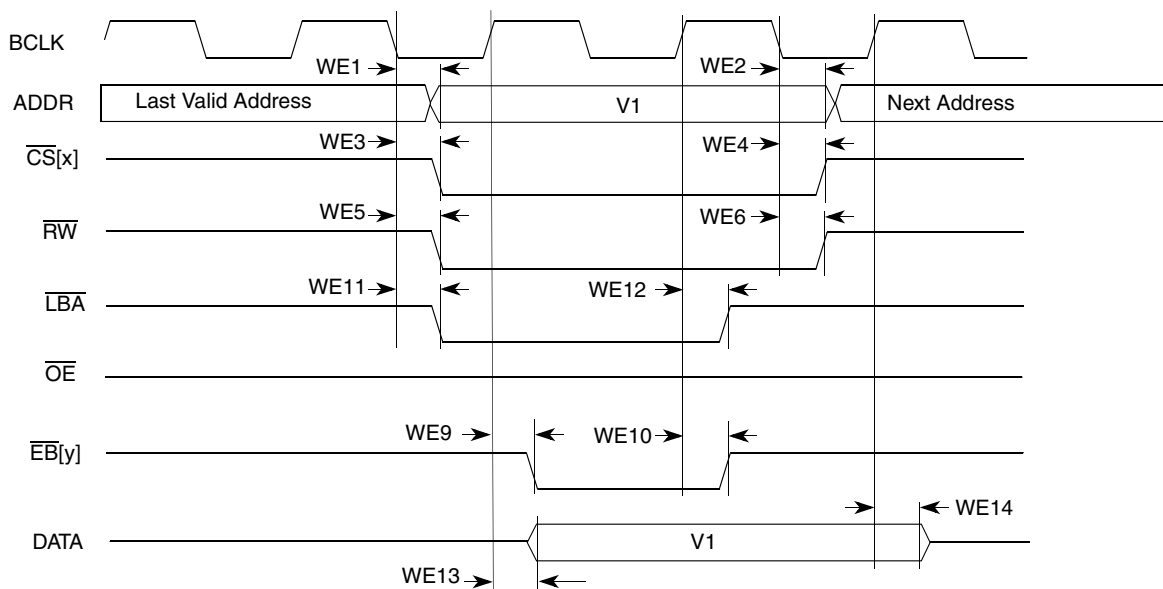
High is defined as 80% of signal value and low is defined as 20% of signal value.

Test conditions: load capacitance, 25 pF. Recommended drive strength for all controls, address, and BCLK is Max drive.

Figure 26, Figure 27, Figure 28, Figure 29, Figure 30, and Figure 31 depict some examples of basic WEIM accesses to external memory devices with the timing parameters mentioned in Table 29 for specific control parameter settings.



**Figure 26. Asynchronous Memory Timing Diagram for Read Access—WSC=1**



**Figure 27. Asynchronous Memory Timing Diagram for Write Access—  
WSC=1, EBWA=1, EBWN=1, LBN=1**

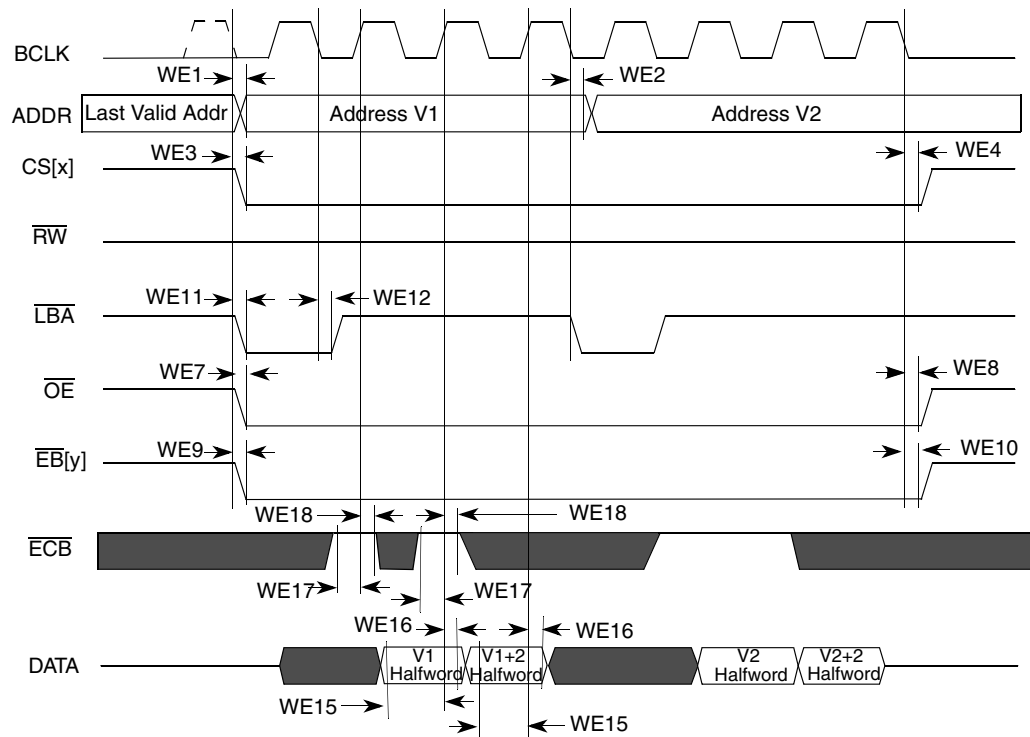


Figure 28. Synchronous Memory Timing Diagram for Two Non-Sequential Read Accesses—  
WSC=2, SYNC=1, DOL=0

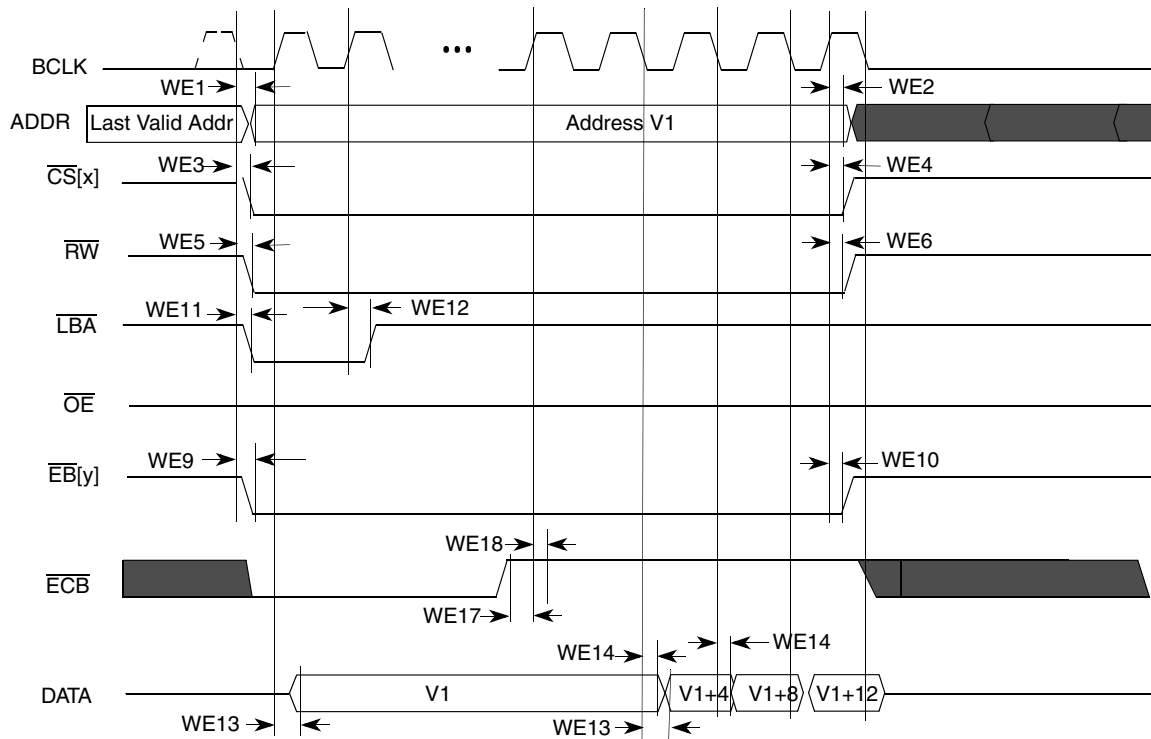
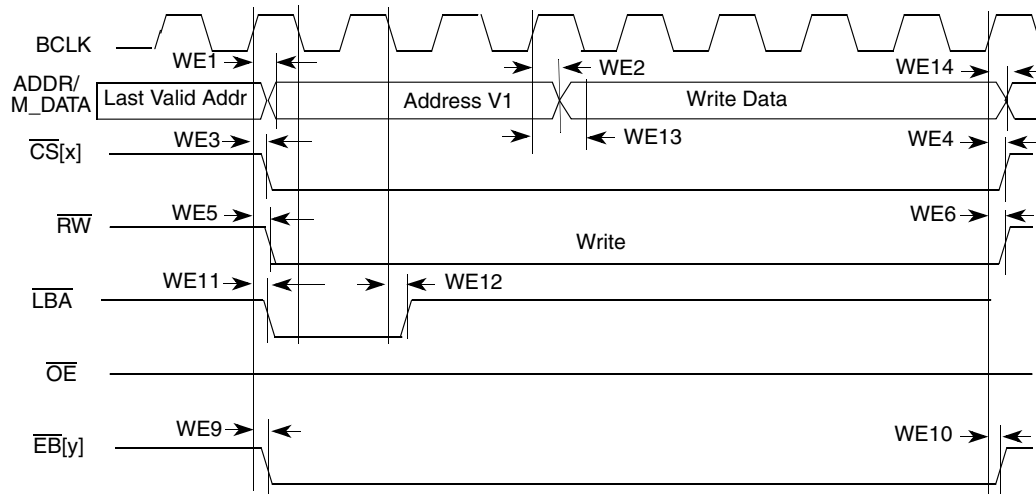
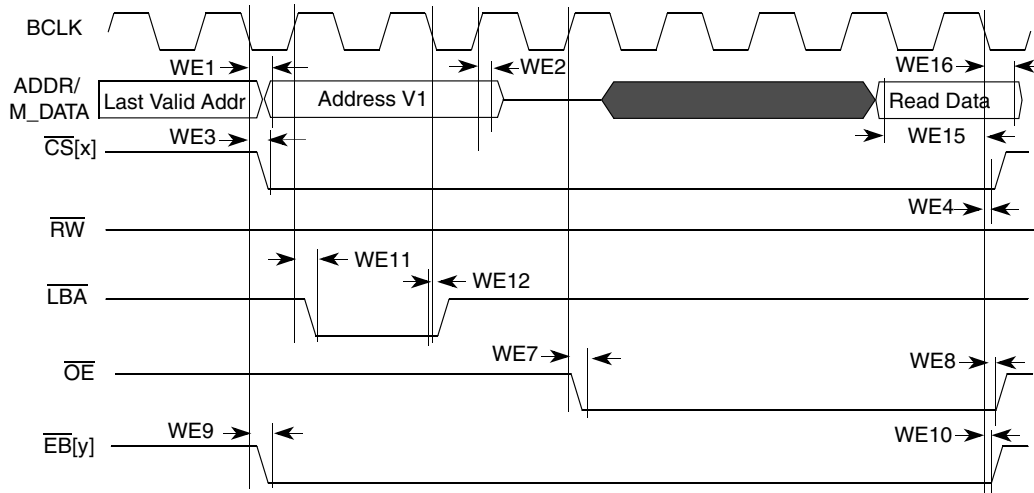


Figure 29. Synchronous Memory Timing Diagram for Burst Write Access—  
BCS=1, WSC=4, SYNC=1, DOL=0, PSR=1



**Figure 30. Muxed A/D Mode Timing Diagram for Asynchronous Write Access—  
WSC=7, LBA=1, LBN=1, LAH=1**



**Figure 31. Muxed A/D Mode Timing Diagram for Asynchronous Read Access—  
WSC=7, LBA=1, LBN=1, LAH=1, OEA=7**

#### 4.3.9.3 ESDCTL Electrical Specifications

Figure 32, Figure 33, Figure 34, Figure 35, Figure 36, and Figure 37 depict the timings pertaining to the ESDCTL module, which interfaces Mobile DDR or SDR SDRAM. Table 30, Table 31, Table 32, Table 33, Table 34, and Table 35 list the timing parameters.

## Electrical Characteristics

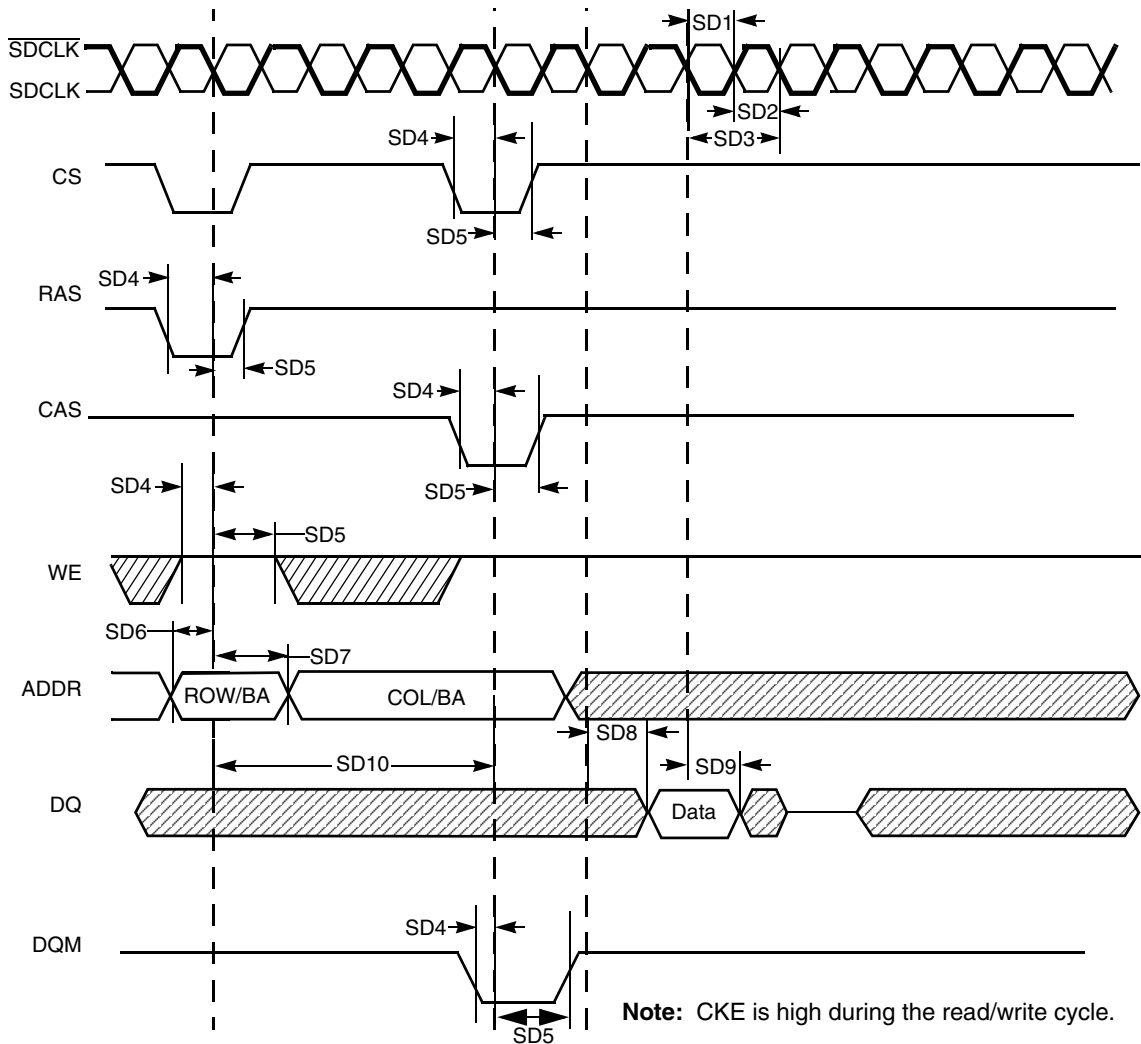


Figure 32. SDRAM Read Cycle Timing Diagram

Table 30. DDR/SDR SDRAM Read Cycle Timing Parameters

| ID  | Parameter                             | Symbol | Min | Max  | Unit |
|-----|---------------------------------------|--------|-----|------|------|
| SD1 | SDRAM clock high-level width          | tCH    | 3.4 | 4.1  | ns   |
| SD2 | SDRAM clock low-level width           | tCL    | 3.4 | 4.1  | ns   |
| SD3 | SDRAM clock cycle time                | tCK    | 7.5 | –    | ns   |
| SD4 | CS, RAS, CAS, WE, DQM, CKE setup time | tCMS   | 2.0 | –    | ns   |
| SD5 | CS, RAS, CAS, WE, DQM, CKE hold time  | tCMH   | 1.8 | –    | ns   |
| SD6 | Address setup time                    | tAS    | 2.0 | –    | ns   |
| SD7 | Address hold time                     | tAH    | 1.8 | –    | ns   |
| SD8 | SDRAM access time                     | tAC    | –   | 6.47 | ns   |

**Table 30. DDR/SDR SDRAM Read Cycle Timing Parameters (continued)**

| ID   | Parameter                           | Symbol | Min | Max | Unit  |
|------|-------------------------------------|--------|-----|-----|-------|
| SD9  | Data out hold time <sup>1</sup>     | tOH    | 1.8 | –   | ns    |
| SD10 | Active to read/write command period | tRC    | 10  | –   | clock |

<sup>1</sup> Timing parameters are relevant only to SDR SDRAM. For the specific DDR SDRAM data related timing parameters, see [Table 34](#) and [Table 35](#).

**NOTE**

SDR SDRAM CLK parameters are being measured from the 50% point—that is, high is defined as 50% of signal value and low is defined as 50% of signal value. SD1 + SD2 does not exceed 7.5 ns for 133 MHz.

**NOTE**

The timing parameters are similar to the ones used in SDRAM data sheets—that is, [Table 30](#) indicates SDRAM requirements. All output signals are driven by the ESDCTL at the negative edge of SDCLK and the parameters are measured at maximum memory frequency.

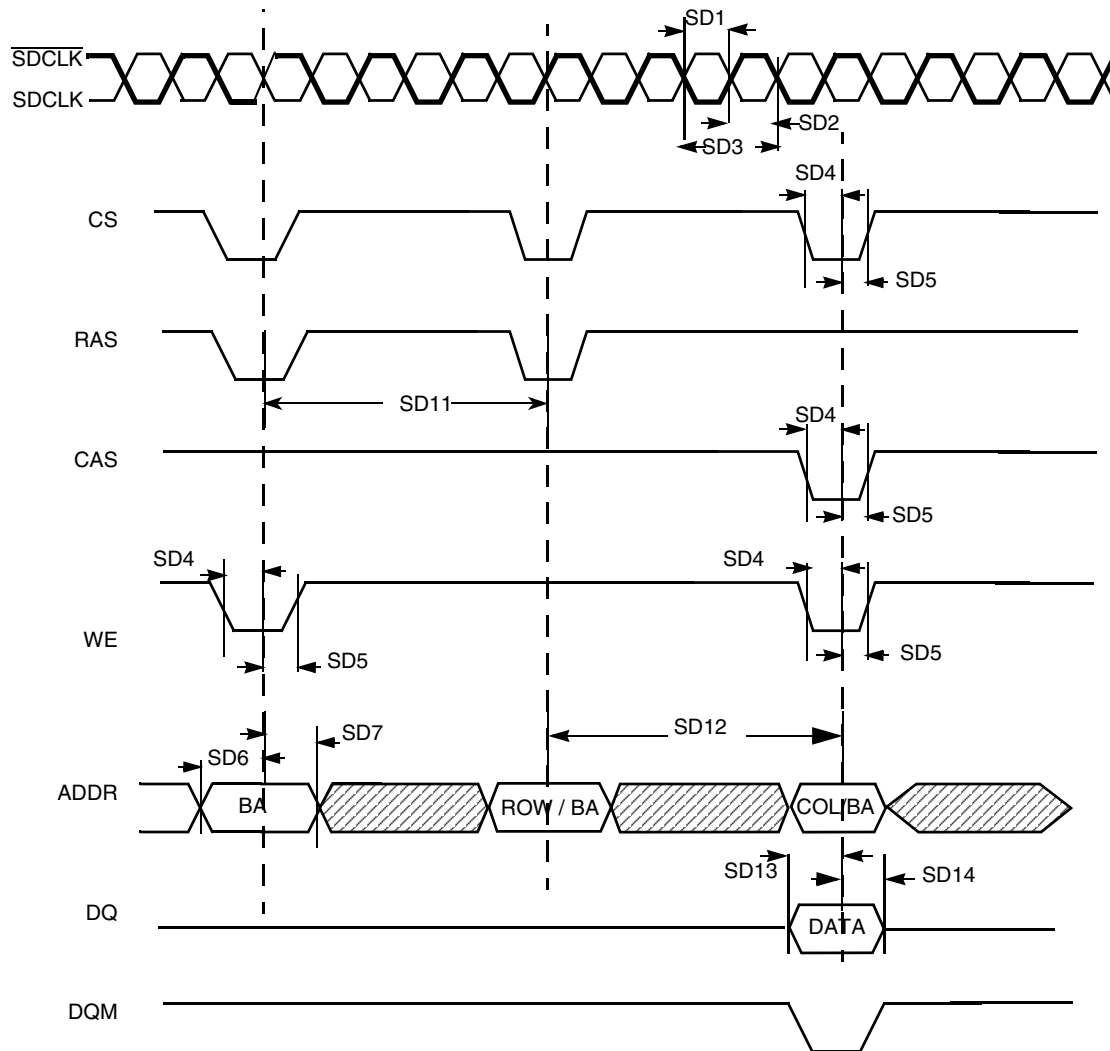


Figure 33. SDR SDRAM Write Cycle Timing Diagram

Table 31. SDR SDRAM Write Timing Parameters

| ID   | Parameter                                       | Symbol           | Min | Max | Unit  |
|------|-------------------------------------------------|------------------|-----|-----|-------|
| SD1  | SDRAM clock high-level width                    | t <sub>CH</sub>  | 3.4 | 4.1 | ns    |
| SD2  | SDRAM clock low-level width                     | t <sub>CL</sub>  | 3.4 | 4.1 | ns    |
| SD3  | SDRAM clock cycle time                          | t <sub>CK</sub>  | 7.5 | –   | ns    |
| SD4  | CS, RAS, CAS, WE, DQM, CKE setup time           | t <sub>CMS</sub> | 2.0 | –   | ns    |
| SD5  | CS, RAS, CAS, WE, DQM, CKE hold time            | t <sub>CMH</sub> | 1.8 | –   | ns    |
| SD6  | Address setup time                              | t <sub>AS</sub>  | 2.0 | –   | ns    |
| SD7  | Address hold time                               | t <sub>AH</sub>  | 1.8 | –   | ns    |
| SD11 | Precharge cycle period <sup>1</sup>             | t <sub>RP</sub>  | 1   | 4   | clock |
| SD12 | Active to read/write command delay <sup>1</sup> | t <sub>RCD</sub> | 1   | 8   | clock |

Table 31. SDR SDRAM Write Timing Parameters (continued)

| ID   | Parameter       | Symbol | Min | Max | Unit |
|------|-----------------|--------|-----|-----|------|
| SD13 | Data setup time | tDS    | 2.0 | –   | ns   |
| SD14 | Data hold time  | tDH    | 1.3 | –   | ns   |

<sup>1</sup> SD11 and SD12 are determined by SDRAM controller register settings.

**NOTE**

SDR SDRAM CLK parameters are being measured from the 50% point—that is, high is defined as 50% of signal value and low is defined as 50% of signal value.

**NOTE**

The timing parameters are similar to the ones used in SDRAM data sheets—that is, [Table 31](#) indicates SDRAM requirements. All output signals are driven by the ESDCTL at the negative edge of SDCLK and the parameters are measured at maximum memory frequency.

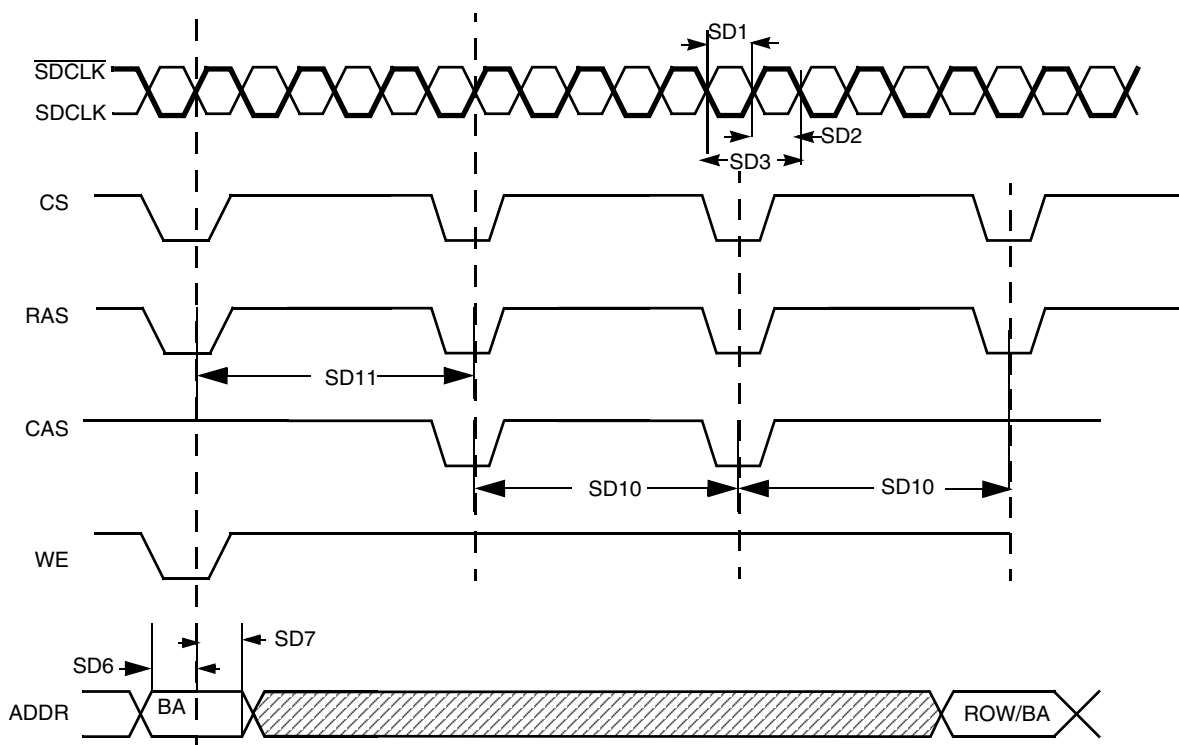


Figure 34. SDRAM Refresh Timing Diagram

Table 32. SDRAM Refresh Timing Parameters

| ID   | Parameter                                  | Symbol | Min | Max | Unit  |
|------|--------------------------------------------|--------|-----|-----|-------|
| SD1  | SDRAM clock high-level width               | tCH    | 3.4 | 4.1 | ns    |
| SD2  | SDRAM clock low-level width                | tCL    | 3.4 | 4.1 | ns    |
| SD3  | SDRAM clock cycle time                     | tCK    | 7.5 | —   | ns    |
| SD6  | Address setup time                         | tAS    | 1.8 | —   | ns    |
| SD7  | Address hold time                          | tAH    | 1.8 | —   | ns    |
| SD10 | Precharge cycle period <sup>1</sup>        | tRP    | 1   | 4   | clock |
| SD11 | Auto precharge command period <sup>1</sup> | tRC    | 2   | 20  | clock |

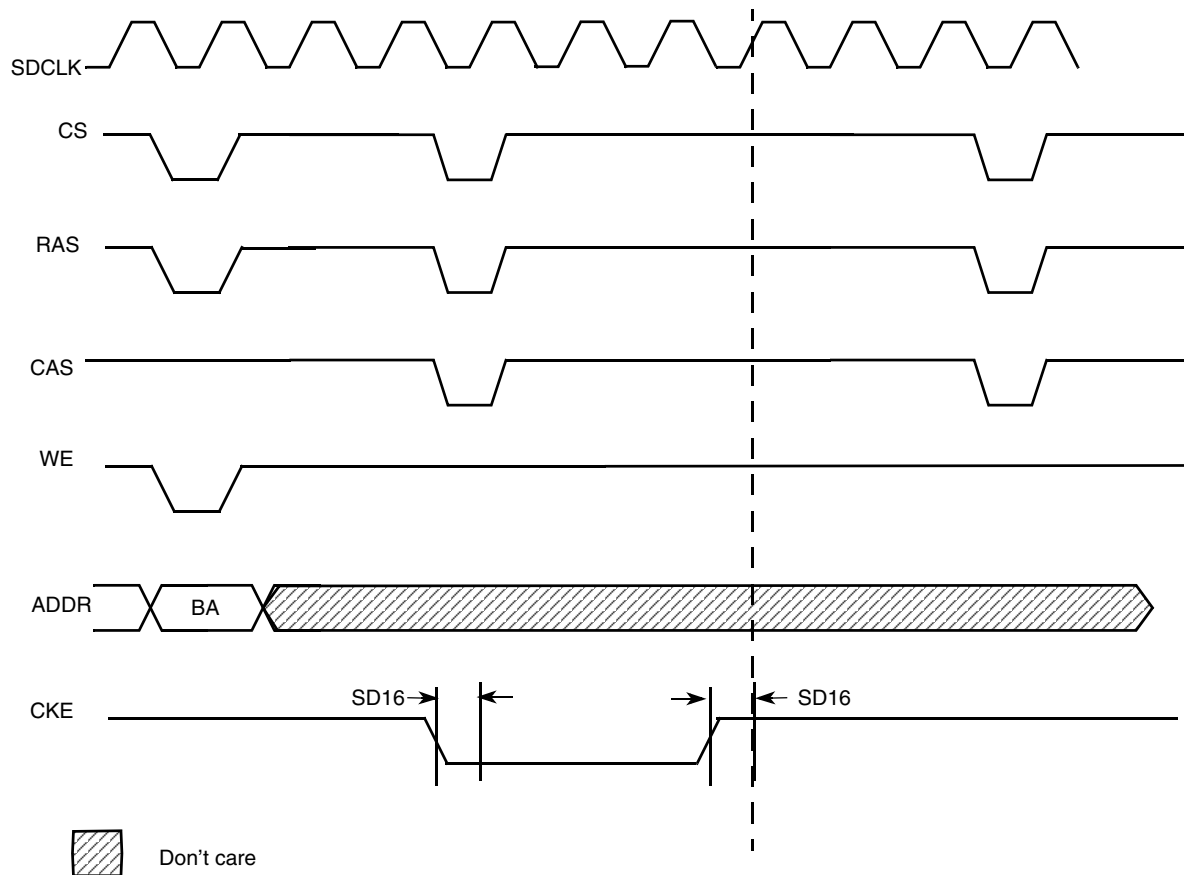
<sup>1</sup> SD10 and SD11 are determined by SDRAM controller register settings.

#### NOTE

SDR SDRAM CLK parameters are being measured from the 50% point—that is, high is defined as 50% of signal value and low is defined as 50% of signal value.

#### NOTE

The timing parameters are similar to the ones used in SDRAM data sheets—that is, [Table 32](#) indicates SDRAM requirements. All output signals are driven by the ESDCTL at the negative edge of SDCLK and the parameters are measured at maximum memory frequency.



**Figure 35. SDRAM Self-Refresh Cycle Timing Diagram**

### NOTE

The clock will continue to run unless both CKEs are low. Then the clock will be stopped in low state.

**Table 33. SDRAM Self-Refresh Cycle Timing Parameters**

| ID   | Parameter             | Symbol | Min | Max | Unit |
|------|-----------------------|--------|-----|-----|------|
| SD16 | CKE output delay time | tCKS   | 1.8 | –   | ns   |

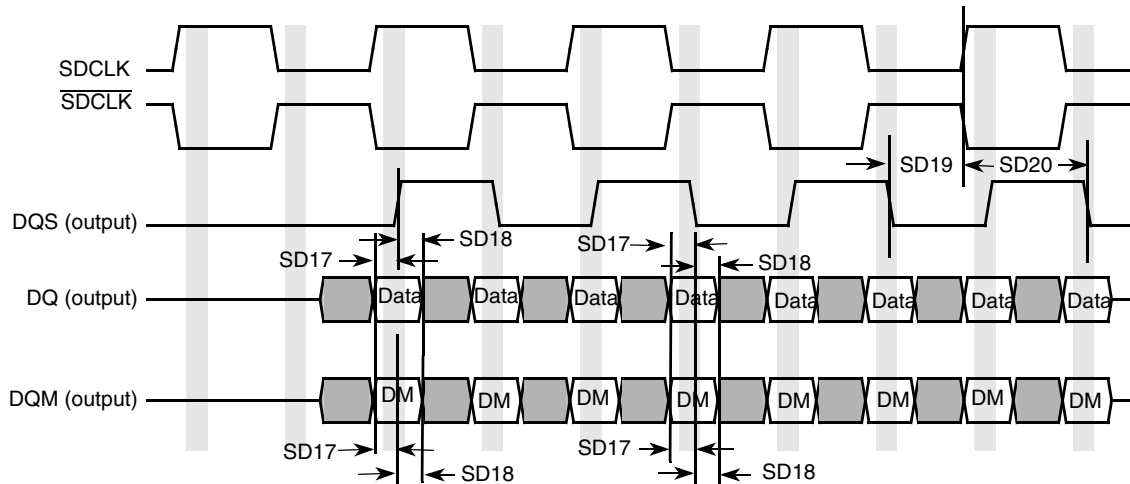


Figure 36. Mobile DDR SDRAM Write Cycle Timing Diagram

Table 34. Mobile DDR SDRAM Write Cycle Timing Parameters<sup>1</sup>

| ID   | Parameter                                                | Symbol | Min  | Max | Unit |
|------|----------------------------------------------------------|--------|------|-----|------|
| SD17 | DQ & DQM setup time to DQS                               | tDS    | 0.95 | –   | ns   |
| SD18 | DQ & DQM hold time to DQS                                | tDH    | 0.95 | –   | ns   |
| SD19 | Write cycle DQS falling edge to SDCLK output delay time. | tDSS   | 1.8  | –   | ns   |
| SD20 | Write cycle DQS falling edge to SDCLK output hold time.  | tDSH   | 1.8  | –   | ns   |

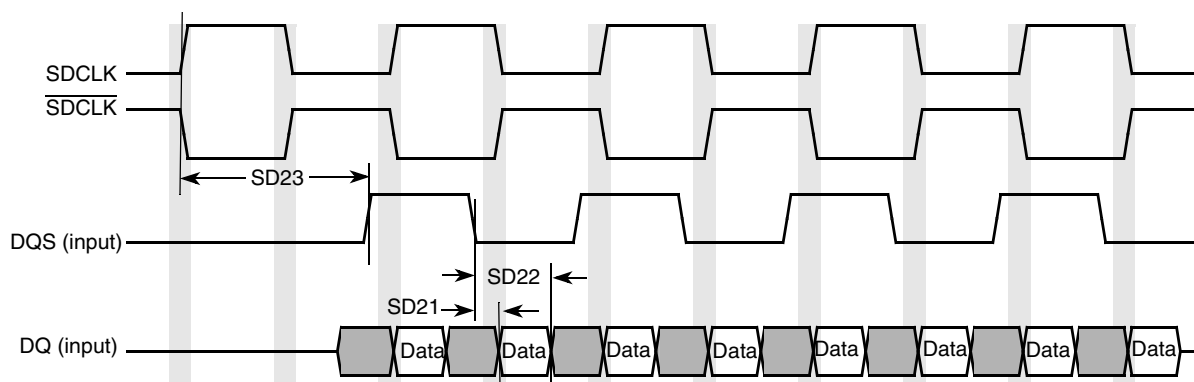
<sup>1</sup> Test condition: Measured using delay line 5 programmed as follows: ESDCDLY5[15:0] = 0x0703.

### NOTE

SDRAM CLK and DQS related parameters are being measured from the 50% point—that is, high is defined as 50% of signal value and low is defined as 50% of signal value.

### NOTE

The timing parameters are similar to the ones used in SDRAM data sheets—that is, Table 34 indicates SDRAM requirements. All output signals are driven by the ESDCTL at the negative edge of SDCLK and the parameters are measured at maximum memory frequency.



**Figure 37. Mobile DDR SDRAM DQ versus DQS and SDCLK Read Cycle Timing Diagram**

**Table 35. Mobile DDR SDRAM Read Cycle Timing Parameters**

| ID   | Parameter                                                                    | Symbol | Min | Max  | Unit |
|------|------------------------------------------------------------------------------|--------|-----|------|------|
| SD21 | DQS - DQ Skew (defines the Data valid window in read cycles related to DQS). | tDQSQ  | –   | 0.85 | ns   |
| SD22 | DQS DQ HOLD time from DQS                                                    | tQH    | 2.3 | –    | ns   |
| SD23 | DQS output access time from SDCLK posedge                                    | tDQSCK | –   | 6.7  | ns   |

#### NOTE

SDRAM CLK and DQS related parameters are being measured from the 50% point—that is, high is defined as 50% of signal value and low is defined as 50% of signal value.

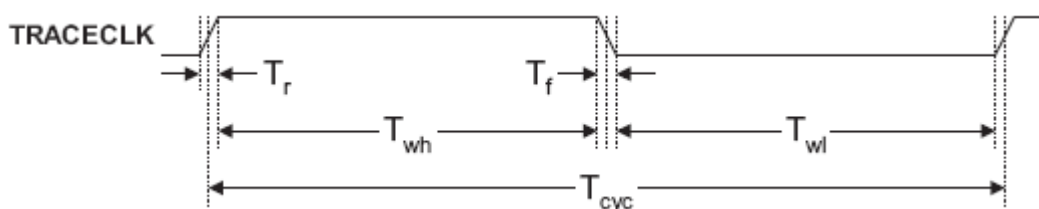
#### NOTE

The timing parameters are similar to the ones used in SDRAM data sheets—that is, [Table 35](#) indicates SDRAM requirements. All output signals are driven by the ESDCTL at the negative edge of SDCLK and the parameters are measured at maximum memory frequency.

### 4.3.10 ETM Electrical Specifications

ETM is an ARM protocol. The timing specifications in this section are given as a guide for a TPA that supports TRACECLK frequencies up to 133 MHz.

[Figure 38](#) depicts the TRACECLK timings of ETM, and [Table 36](#) lists the timing parameters.

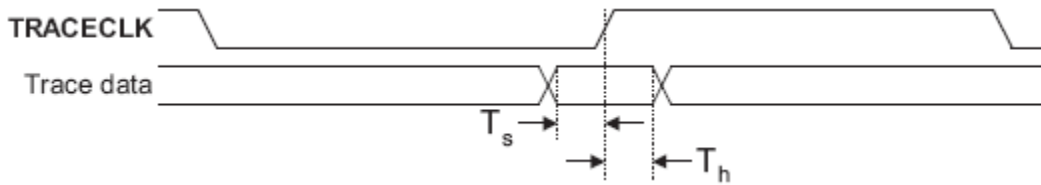


**Figure 38. ETM TRACECLK Timing Diagram**

**Table 36. ETM TRACECLK Timing Parameters**

| ID        | Parameter                | Min                 | Max | Unit |
|-----------|--------------------------|---------------------|-----|------|
| $T_{cyc}$ | Clock period             | Frequency dependent | –   | ns   |
| $T_{wl}$  | Low pulse width          | 2                   | –   | ns   |
| $T_{wh}$  | High pulse width         | 2                   | –   | ns   |
| $T_r$     | Clock and data rise time | –                   | 3   | ns   |
| $T_f$     | Clock and data fall time | –                   | 3   | ns   |

Figure 39 depicts the setup and hold requirements of the trace data pins with respect to TRACECLK, and Table 37 lists the timing parameters.

**Figure 39. Trace Data Timing Diagram****Table 37. ETM Trace Data Timing Parameters**

| ID    | Parameter  | Min | Max | Unit |
|-------|------------|-----|-----|------|
| $T_s$ | Data setup | 2   | –   | ns   |
| $T_h$ | Data hold  | 1   | –   | ns   |

#### 4.3.10.1 Half-Rate Clocking Mode

When half-rate clocking is used, the trace data signals are sampled by the TPA on both the rising and falling edges of TRACECLK, where TRACECLK is half the frequency of the clock shown in Figure 39.

#### 4.3.11 FIR Electrical Specifications

FIR implements asynchronous infrared protocols (FIR, MIR) that are defined by IrDA<sup>®</sup> (Infrared Data Association). Refer to <http://www.IrDA.org> for details on FIR and MIR protocols.

#### 4.3.12 Fusebox Electrical Specifications

**Table 38. Fusebox Timing Characteristics**

| Ref. Num | Description                         | Symbol        | Minimum | Typical | Maximum | Units   |
|----------|-------------------------------------|---------------|---------|---------|---------|---------|
| 1        | Program time for eFuse <sup>1</sup> | $t_{program}$ | 125     | –       | –       | $\mu s$ |

<sup>1</sup> The program length is defined by the value defined in the epm\_pgm\_length[2:0] bits of the IIM module. The value to program is based on a 32 kHz clock source ( $4 * 1/32 \text{ kHz} = 125 \mu s$ )

### 4.3.13 I<sup>2</sup>C Electrical Specifications

This section describes the electrical information of the I<sup>2</sup>C Module.

#### 4.3.13.1 I<sup>2</sup>C Module Timing

Figure 40 depicts the timing of I<sup>2</sup>C module. Table 39 lists the I<sup>2</sup>C module timing parameters where the I/O supply is 2.7 V. 1

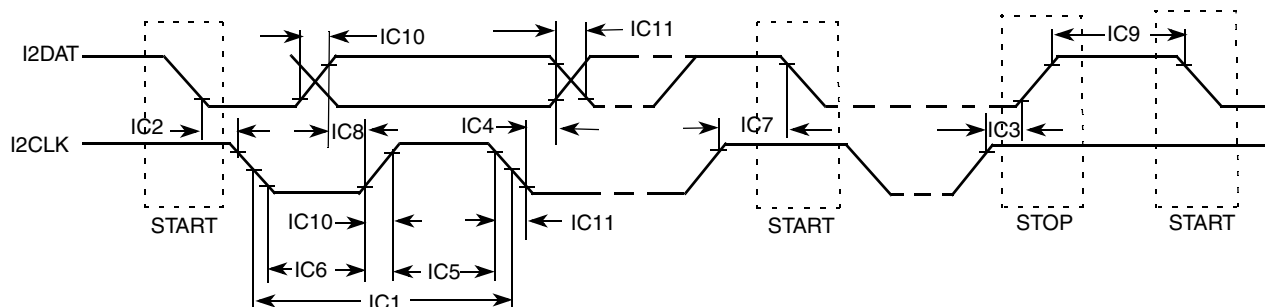


Figure 40. I<sup>2</sup>C Bus Timing Diagram

Table 39. I<sup>2</sup>C Module Timing Parameters—I<sup>2</sup>C Pin I/O Supply=2.7 V

| ID   | Parameter                                           | Standard Mode  |                   | Fast Mode                         |                  | Unit |
|------|-----------------------------------------------------|----------------|-------------------|-----------------------------------|------------------|------|
|      |                                                     | Min            | Max               | Min                               | Max              |      |
| IC1  | I2CLK cycle time                                    | 10             | —                 | 2.5                               | —                | μs   |
| IC2  | Hold time (repeated) START condition                | 4.0            | —                 | 0.6                               | —                | μs   |
| IC3  | Set-up time for STOP condition                      | 4.0            | —                 | 0.6                               | —                | μs   |
| IC4  | Data hold time                                      | 0 <sup>1</sup> | 3.45 <sup>2</sup> | 0 <sup>1</sup>                    | 0.9 <sup>2</sup> | μs   |
| IC5  | HIGH Period of I2CLK Clock                          | 4.0            | —                 | 0.6                               | —                | μs   |
| IC6  | LOW Period of the I2CLK Clock                       | 4.7            | —                 | 1.3                               | —                | μs   |
| IC7  | Set-up time for a repeated START condition          | 4.7            | —                 | 0.6                               | —                | μs   |
| IC8  | Data set-up time                                    | 250            | —                 | 100 <sup>3</sup>                  | —                | ns   |
| IC9  | Bus free time between a STOP and START condition    | 4.7            | —                 | 1.3                               | —                | μs   |
| IC10 | Rise time of both I2DAT and I2CLK signals           | —              | 1000              | 20+0.1C <sub>b</sub> <sup>4</sup> | 300              | ns   |
| IC11 | Fall time of both I2DAT and I2CLK signals           | —              | 300               | 20+0.1C <sub>b</sub> <sup>4</sup> | 300              | ns   |
| IC12 | Capacitive load for each bus line (C <sub>b</sub> ) | —              | 400               | —                                 | 400              | pF   |

<sup>1</sup> A device must internally provide a hold time of at least 300 ns for I2DAT signal in order to bridge the undefined region of the falling edge of I2CLK.

<sup>2</sup> The maximum hold time has to be met only if the device does not stretch the LOW period (ID IC6) of the I2CLK signal.

<sup>3</sup> A Fast-mode I<sup>2</sup>C-bus device can be used in a standard-mode I<sup>2</sup>C-bus system, but the requirement of set-up time (ID IC7) of 250 ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the I2CLK signal. If such a device does stretch the LOW period of the I2CLK signal, it must output the next data bit to the I2DAT line max\_rise\_time (ID No IC10) + data\_setup\_time (ID No IC8) = 1000 + 250 = 1250 ns (according to the Standard-mode I<sup>2</sup>C-bus specification) before the I2CLK line is released.

<sup>4</sup> C<sub>b</sub> = total capacitance of one bus line in pF.

## 4.3.14 IPU—Sensor Interfaces

### 4.3.14.1 Supported Camera Sensors

Table 40 lists the known supported camera sensors at the time of publication.

**Table 40. Supported Camera Sensors<sup>1</sup>**

| Vendor                 | Model                                                                                                                         |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Conexant               | CX11646, CX20490 <sup>2</sup> , CX20450 <sup>2</sup>                                                                          |
| Agilent                | HDCCP-2010, ADCS-1021 <sup>2</sup> , ADCS-1021 <sup>2</sup>                                                                   |
| Toshiba                | TC90A70                                                                                                                       |
| ICMedia                | ICM202A, ICM102 <sup>2</sup>                                                                                                  |
| iMagic                 | IM8801                                                                                                                        |
| Transchip              | TC5600, TC5600J, TC5640, TC5700, TC6000                                                                                       |
| Fujitsu                | MB86S02A                                                                                                                      |
| Micron                 | MI-SOC-0133                                                                                                                   |
| Matsushita             | MN39980                                                                                                                       |
| STMicro                | W6411, W6500, W6501 <sup>2</sup> , W6600 <sup>2</sup> , W6552 <sup>2</sup> , STV0974 <sup>2</sup>                             |
| OmniVision             | OV7620, OV6630                                                                                                                |
| Sharp                  | LZ0P3714 (CCD)                                                                                                                |
| Motorola               | MC30300 (Python) <sup>2</sup> , SCM20014 <sup>2</sup> , SCM20114 <sup>2</sup> , SCM22114 <sup>2</sup> , SCM20027 <sup>2</sup> |
| National Semiconductor | LM9618 <sup>2</sup>                                                                                                           |

<sup>1</sup> Freescale Semiconductor does not recommend one supplier over another and in no way suggests that these are the only camera suppliers.

<sup>2</sup> These sensors not validated at time of publication.

### 4.3.14.2 Functional Description

There are three timing modes supported by the IPU.

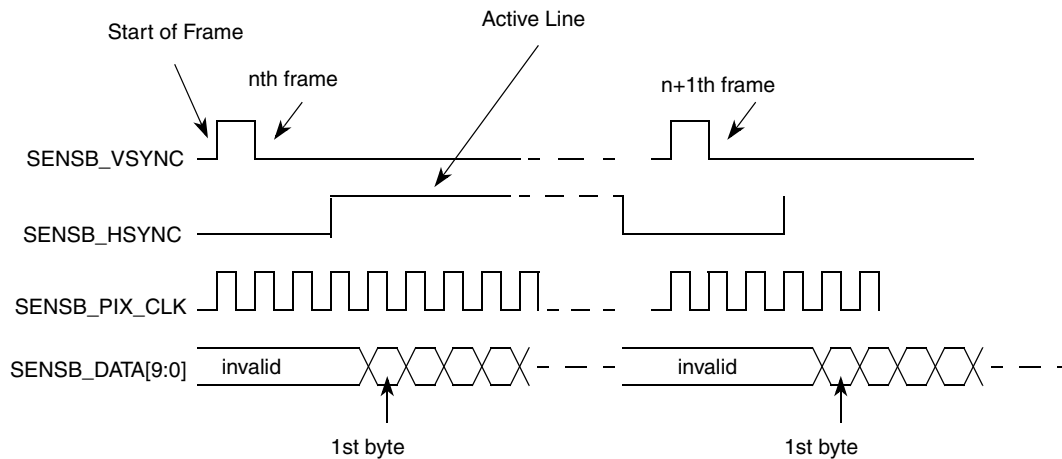
#### 4.3.14.2.1 Pseudo BT.656 Video Mode

Smart camera sensors, which include imaging processing, usually support video mode transfer. They use an embedded timing syntax to replace the SENSB\_VSYNC and SENSB\_HSYNC signals. The timing syntax is defined by the BT.656 standard.

This operation mode follows the recommendations of ITU BT.656 specifications. The only control signal used is SENSB\_PIX\_CLK. Start-of-frame and active-line signals are embedded in the data stream. An active line starts with a SAV code and ends with a EAV code. In some cases, digital blanking is inserted in between EAV and SAV code. The CSI decodes and filters out the timing-coding from the data stream, thus recovering SENSB\_VSYNC and SENSB\_HSYNC signals for internal use.

#### 4.3.14.2.2 Gated Clock Mode

The SENS\_B\_VSYNC, SENS\_B\_HSYNC, and SENS\_B\_PIX\_CLK signals are used in this mode. See [Figure 41](#).

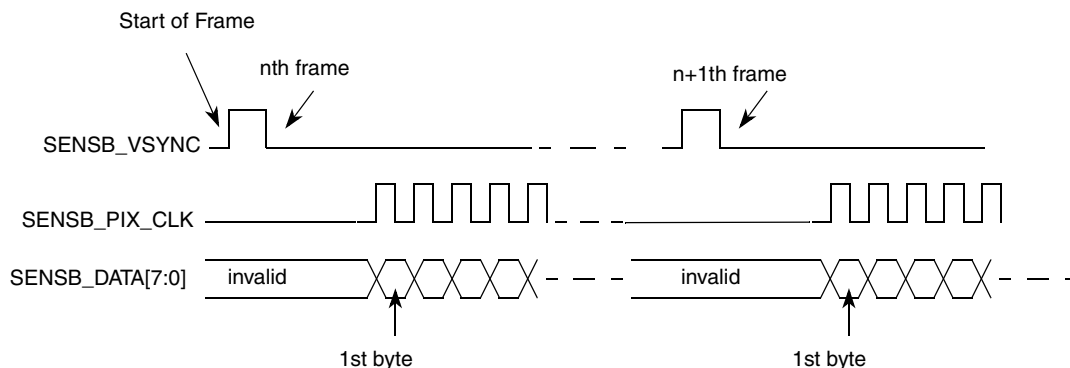


**Figure 41. Gated Clock Mode Timing Diagram**

A frame starts with a rising edge on SENS\_B\_VSYNC (all the timings correspond to straight polarity of the corresponding signals). Then SENS\_B\_HSYNC goes to high and hold for the entire line. Pixel clock is valid as long as SENS\_B\_HSYNC is high. Data is latched at the rising edge of the valid pixel clocks. SENS\_B\_HSYNC goes to low at the end of line. Pixel clocks then become invalid and the CSI stops receiving data from the stream. For next line the SENS\_B\_HSYNC timing repeats. For next frame the SENS\_B\_VSYNC timing repeats.

#### 4.3.14.2.3 Non-Gated Clock Mode

The timing is the same as the gated-clock mode (described in [Section 4.3.14.2.2, “Gated Clock Mode” on page 51](#)), except for the SENS\_B\_HSYNC signal, which is not used. See [Figure 42](#). All incoming pixel clocks are valid and will cause data to be latched into the input FIFO. The SENS\_B\_PIX\_CLK signal is inactive (states low) until valid data is going to be transmitted over the bus.



**Figure 42. Non-Gated Clock Mode Timing Diagram**

The timing described in Figure 42 is that of a Motorola sensor. Some other sensors may have a slightly different timing. The CSI can be programmed to support rising/falling-edge triggered SENS\_B\_VSYNC; active-high/low SENS\_B\_HSYNC; and rising/falling-edge triggered SENS\_B\_PIX\_CLK.

### 4.3.14.3 Electrical Characteristics

Figure 43 depicts the sensor interface timing, and Table 41 lists the timing parameters.

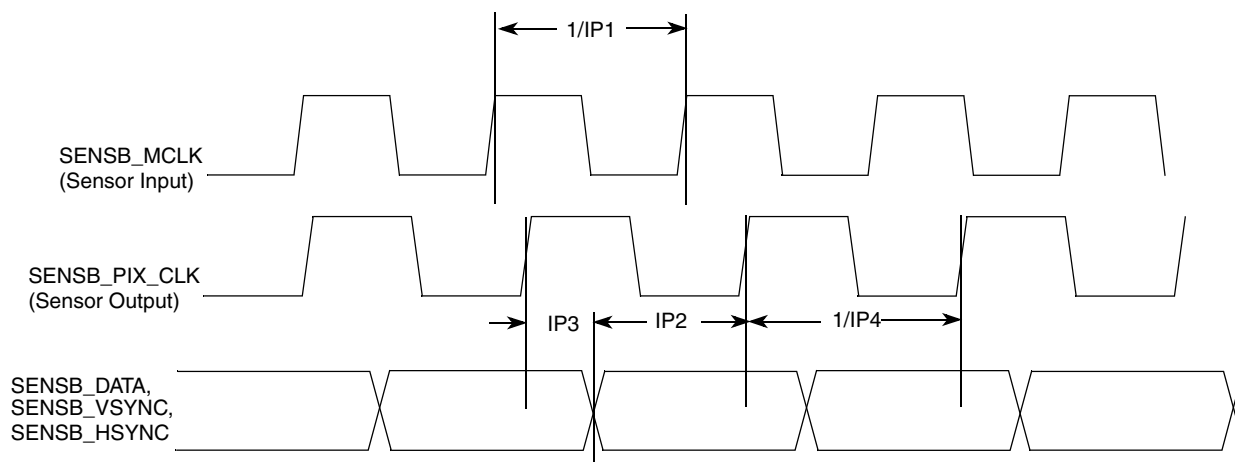


Figure 43. Sensor Interface Timing Diagram

Table 41. Sensor Interface Timing Parameters

| ID  | Parameter                             | Symbol | Min. | Max. | Units |
|-----|---------------------------------------|--------|------|------|-------|
| IP1 | Sensor input clock frequency          | Fmck   | 0.01 | 133  | MHz   |
| IP2 | Data and control setup time           | Tsu    | 5    | —    | ns    |
| IP3 | Data and control holdup time          | Thd    | 3    | —    | ns    |
| IP4 | Sensor output (pixel) clock frequency | Fpck   | 0.01 | 133  | MHz   |

### 4.3.15 IPU—Display Interfaces

#### 4.3.15.1 Supported Display Components

Table 42 lists the known supported display components at the time of publication.

**Table 42. Supported Display Components<sup>1</sup>**

| Type                            | Vendor                                                | Model                                                                                                                                                                                                          |
|---------------------------------|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TFT displays (memory-less)      | Sharp (HR-TFT Super Mobile LCD family)                | LQ035Q7 DB02, LM019LC1Sxx                                                                                                                                                                                      |
|                                 | Samsung (QCIF and QVGA TFT modules for mobile phones) | LTS180S1-HF1, LTS180S3-HF1, LTS350Q1-PE1, LTS350Q1-PD1, LTS220Q1-HE1 <sup>2</sup>                                                                                                                              |
|                                 | Toshiba (LTM series)                                  | LTM022P806 <sup>2</sup> , LTM04C380K <sup>2</sup> , LTM018A02A <sup>2</sup> , LTM020P332 <sup>2</sup> , LTM021P337 <sup>2</sup> , LTM019P334 <sup>2</sup> , LTM022A783 <sup>2</sup> , LTM022A05ZZ <sup>2</sup> |
|                                 | NEC                                                   | NL6448BC20-08E, NL8060BC31-27                                                                                                                                                                                  |
| Display controllers             | Epson                                                 | S1D15xxx series, S1D19xxx series, S1D13713, S1D13715                                                                                                                                                           |
|                                 | Solomon Systech                                       | SSD1301 (OLED), SSD1828 (LDCD)                                                                                                                                                                                 |
|                                 | Hitachi                                               | HD66766, HD66772                                                                                                                                                                                               |
|                                 | ATI                                                   | W2300                                                                                                                                                                                                          |
| Smart display modules           | Epson                                                 | L1F10043 T <sup>2</sup> , L1F10044 T <sup>2</sup> , L1F10045 T <sup>2</sup> , L2D22002 <sup>2</sup> , L2D20014 <sup>2</sup> , L2F50032 <sup>2</sup> , L2D25001 T <sup>2</sup>                                  |
|                                 | Hitachi                                               | 120 160 65K/4096 C-STN (#3284 LTD-1398-2) based on HD 66766 controller                                                                                                                                         |
|                                 | Densitron Europe LTD                                  | All displays with MPU 80/68K series interface and serial peripheral interface                                                                                                                                  |
|                                 | Sharp                                                 | LM019LC1Sxx                                                                                                                                                                                                    |
|                                 | Sony                                                  | ACX506AKM                                                                                                                                                                                                      |
| Digital video encoders (for TV) | Analog Devices                                        | ADV7174/7179                                                                                                                                                                                                   |
|                                 | Crystal (Cirrus Logic)                                | CS49xx series                                                                                                                                                                                                  |
|                                 | Focus                                                 | FS453/4                                                                                                                                                                                                        |

<sup>1</sup> Freescale Semiconductor does not recommend one supplier over another and in no way suggests that these are the only display component suppliers.

<sup>2</sup> These display components not validated at time of publication.

## 4.3.15.2 Synchronous Interfaces

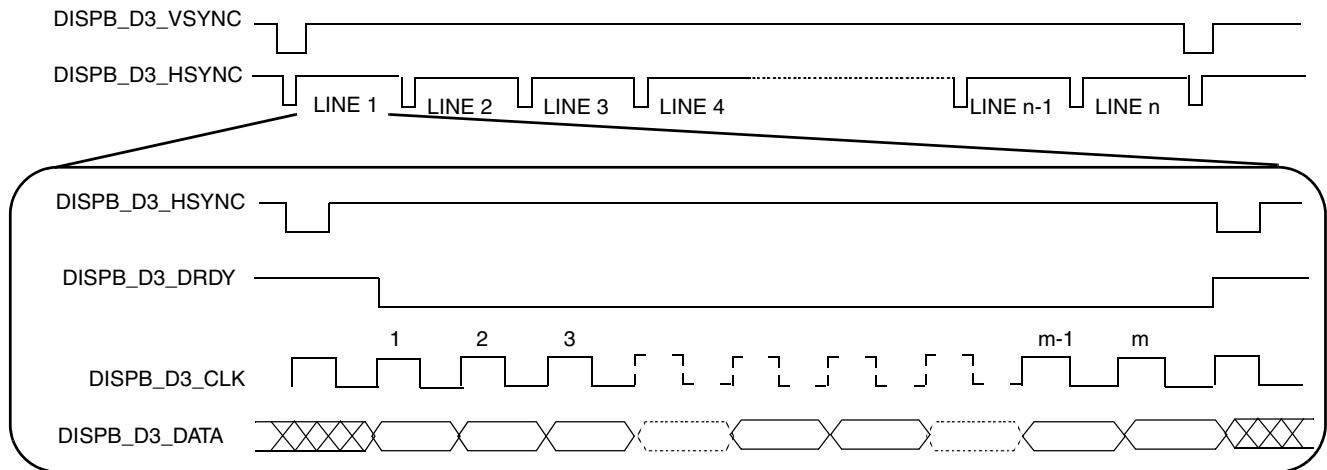
### 4.3.15.2.1 Interface to Active Matrix TFT LCD Panels, Functional Description

Figure 44 depicts the LCD interface timing for a generic active matrix color TFT panel. In this figure signals are shown with negative polarity. The sequence of events for active matrix interface timing is:

- DISPB\_D3\_CLK latches data into the panel on its negative edge (when positive polarity is selected). In active mode, DISPB\_D3\_CLK runs continuously.
- DISPB\_D3\_HSYNC causes the panel to start a new line.
- DISPB\_D3\_VSYNC causes the panel to start a new frame. It always encompasses at least one HSYNC pulse.

## Electrical Characteristics

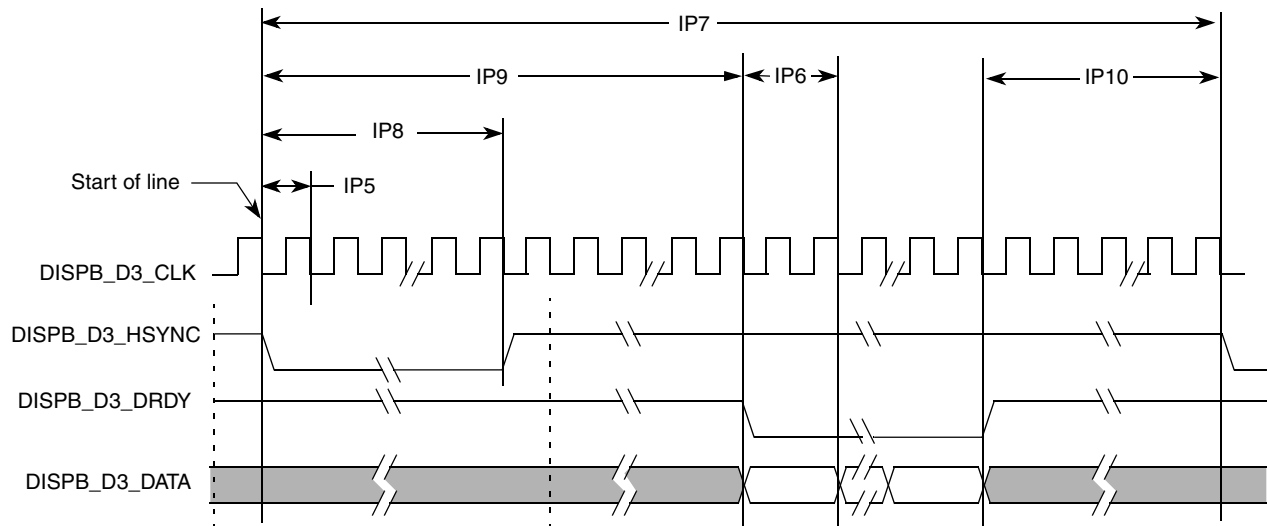
- DISPB\_D3\_DRDY acts like an output enable signal to the CRT display. This output enables the data to be shifted onto the display. When disabled, the data is invalid and the trace is off.



**Figure 44. Interface Timing Diagram for TFT (Active Matrix) Panels**

### 4.3.15.2.2 Interface to Active Matrix TFT LCD Panels, Electrical Characteristics

Figure 45 depicts the horizontal timing (timing of one line), including both the horizontal sync pulse and the data. All figure parameters shown are programmable. The timing images correspond to inverse polarity of the DISP\_B\_D3\_CLK signal and active-low polarity of the DISP\_B\_D3\_HSYNC, DISP\_B\_D3\_VSYNC and DISP\_B\_D3\_DRDY signals.



**Figure 45. TFT Panels Timing Diagram—Horizontal Sync Pulse**

Figure 46 depicts the vertical timing (timing of one frame). All figure parameters shown are programmable.

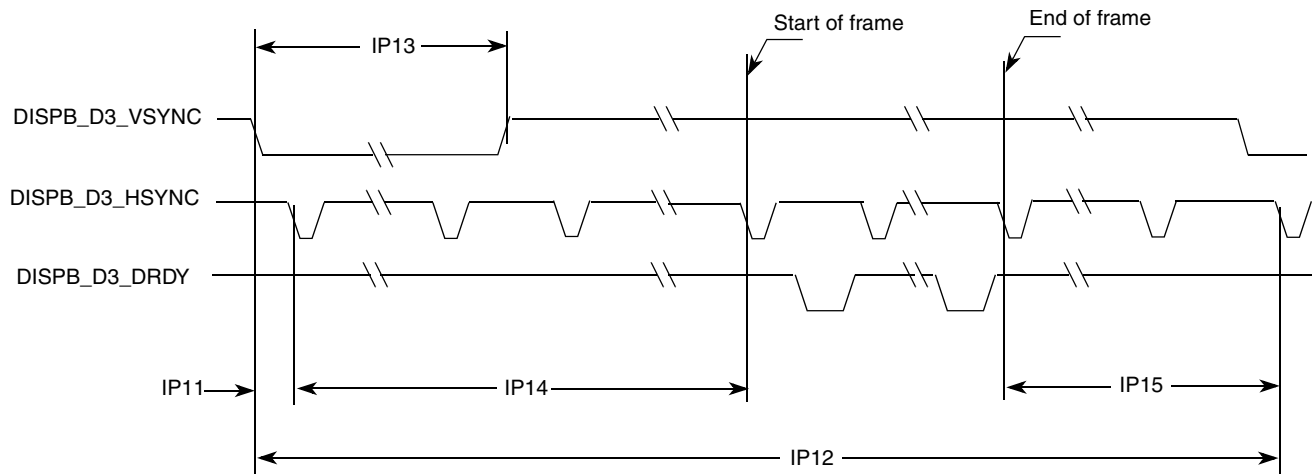


Figure 46. TFT Panels Timing Diagram—Vertical Sync Pulse

Table 43 shows timing parameters of signals presented in Figure 45 and Figure 46.

Table 43. Synchronous Display Interface Timing Parameters—Pixel Level

| ID   | Parameter                      | Symbol | Value                                                                                    | Units |
|------|--------------------------------|--------|------------------------------------------------------------------------------------------|-------|
| IP5  | Display interface clock period | Tdicp  | Tdicp <sup>1</sup>                                                                       | ns    |
| IP6  | Display pixel clock period     | Tdpcp  | (DISP3_IF_CLK_CNT_D+1) * Tdicp                                                           | ns    |
| IP7  | Screen width                   | Tsw    | (SCREEN_WIDTH+1) * Tdpcp                                                                 | ns    |
| IP8  | HSYNC width                    | Thsw   | (H_SYNC_WIDTH+1) * Tdpcp                                                                 | ns    |
| IP9  | Horizontal blank interval 1    | Thbi1  | BGXP * Tdpcp                                                                             | ns    |
| IP10 | Horizontal blank interval 2    | Thbi2  | (SCREEN_WIDTH - BGXP - FW) * Tdpcp                                                       | ns    |
| IP11 | HSYNC delay                    | Thsd   | H_SYNC_DELAY * Tdpcp                                                                     | ns    |
| IP12 | Screen height                  | Tsh    | (SCREEN_HEIGHT+1) * Tsw                                                                  | ns    |
| IP13 | VSYNC width                    | Tvsw   | if V_SYNC_WIDTH_L = 0 than<br>(V_SYNC_WIDTH+1) * Tdpcp<br>else<br>(V_SYNC_WIDTH+1) * Tsw | ns    |
| IP14 | Vertical blank interval 1      | Tvbi1  | BGYP * Tsw                                                                               | ns    |
| IP15 | Vertical blank interval 2      | Tvbi2  | (SCREEN_HEIGHT - BGYP - FH) * Tsw                                                        | ns    |

<sup>1</sup> Display interface clock period immediate value.

$$T_{dicp} = \begin{cases} T_{HSP\_CLK} \cdot \frac{DISP3\_IF\_CLK\_PER\_WR}{HSP\_CLK\_PERIOD}, & \text{for integer } \frac{DISP3\_IF\_CLK\_PER\_WR}{HSP\_CLK\_PERIOD} \\ T_{HSP\_CLK} \cdot \left( \left\lfloor \frac{DISP3\_IF\_CLK\_PER\_WR}{HSP\_CLK\_PERIOD} \right\rfloor + 0.5 \pm 0.5 \right), & \text{for fractional } \frac{DISP3\_IF\_CLK\_PER\_WR}{HSP\_CLK\_PERIOD} \end{cases}$$

Display interface clock period average value.

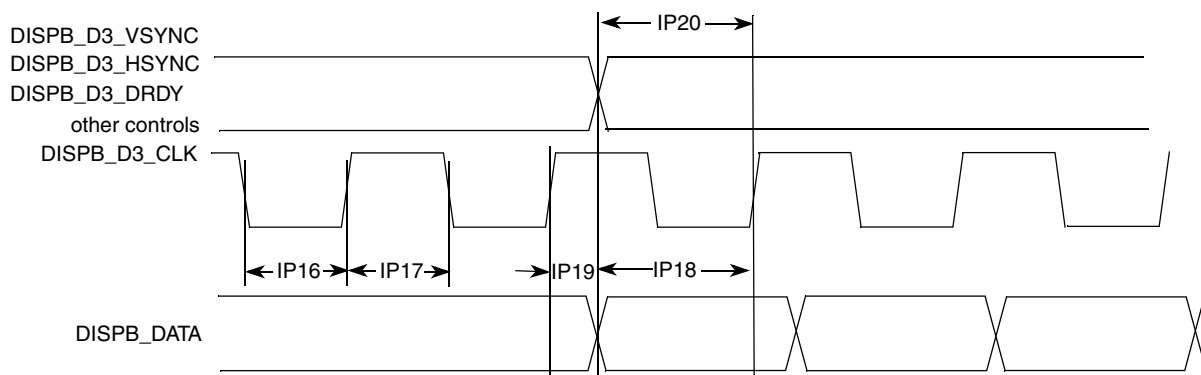
$$\bar{T}_{dicp} = T_{HSP\_CLK} \cdot \frac{DISP3\_IF\_CLK\_PER\_WR}{HSP\_CLK\_PERIOD}$$

**NOTE**

HSP\_CLK is the High-Speed Port Clock, which is the input to the Image Processing Unit (IPU). Its frequency is controlled by the Clock Control Module (CCM) settings. The HSP\_CLK frequency must be greater than or equal to the AHB clock frequency.

The SCREEN\_WIDTH, SCREEN\_HEIGHT, H\_SYNC\_WIDTH, V\_SYNC\_WIDTH, BGXP, BGYP and V\_SYNC\_WIDTH\_L parameters are programmed via the SDC\_HOR\_CONF, SDC\_VER\_CONF, SDC\_BG\_POS Registers. The FW and FH parameters are programmed for the corresponding DMA channel. The DISP3\_IF\_CLK\_PER\_WR, HSP\_CLK\_PERIOD and DISP3\_IF\_CLK\_CNT\_D parameters are programmed via the DI\_DISP3\_TIME\_CONF, DI\_HSP\_CLK\_PER and DI\_DISP\_ACC\_CC Registers.

Figure 47 depicts the synchronous display interface timing for access level, and Table 44 lists the timing parameters. The DISP3\_IF\_CLK\_DOWN\_WR and DISP3\_IF\_CLK\_UP\_WR parameters are set via the DI\_DISP3\_TIME\_CONF Register.



**Figure 47. Synchronous Display Interface Timing Diagram—Access Level**

**Table 44. Synchronous Display Interface Timing Parameters—Access Level**

| ID   | Parameter                                             | Symbol | Min                   | Typ <sup>1</sup>                       | Max                   | Units |
|------|-------------------------------------------------------|--------|-----------------------|----------------------------------------|-----------------------|-------|
| IP16 | Display interface clock low time                      | Tckl   | Tdicd-Tdicu-1.5       | Tdicd <sup>2</sup> -Tdicu <sup>3</sup> | Tdicd-Tdicu+1.5       | ns    |
| IP17 | Display interface clock high time                     | Tckh   | Tdicp-Tdicd+Tdicu-1.5 | Tdicp-Tdicd+Tdicu                      | Tdicp-Tdicd+Tdicu+1.5 | ns    |
| IP18 | Data setup time                                       | Tdsu   | Tdicd-3.5             | Tdicu                                  | —                     | ns    |
| IP19 | Data holdup time                                      | Tdhhd  | Tdicp-Tdicd-3.5       | Tdicp-Tdicu                            | —                     | ns    |
| IP20 | Control signals setup time to display interface clock | Tcsu   | Tdicd-3.5             | Tdicu                                  | —                     | ns    |

<sup>1</sup> The exact conditions have not been finalized, but will likely match the current customer requirement for their specific display. These conditions may be device specific.

<sup>2</sup> Display interface clock down time

$$T_{dicd} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot \text{DISP3\_IF\_CLK\_DOWN\_WR}}{\text{HSP\_CLK\_PERIOD}} \right]$$

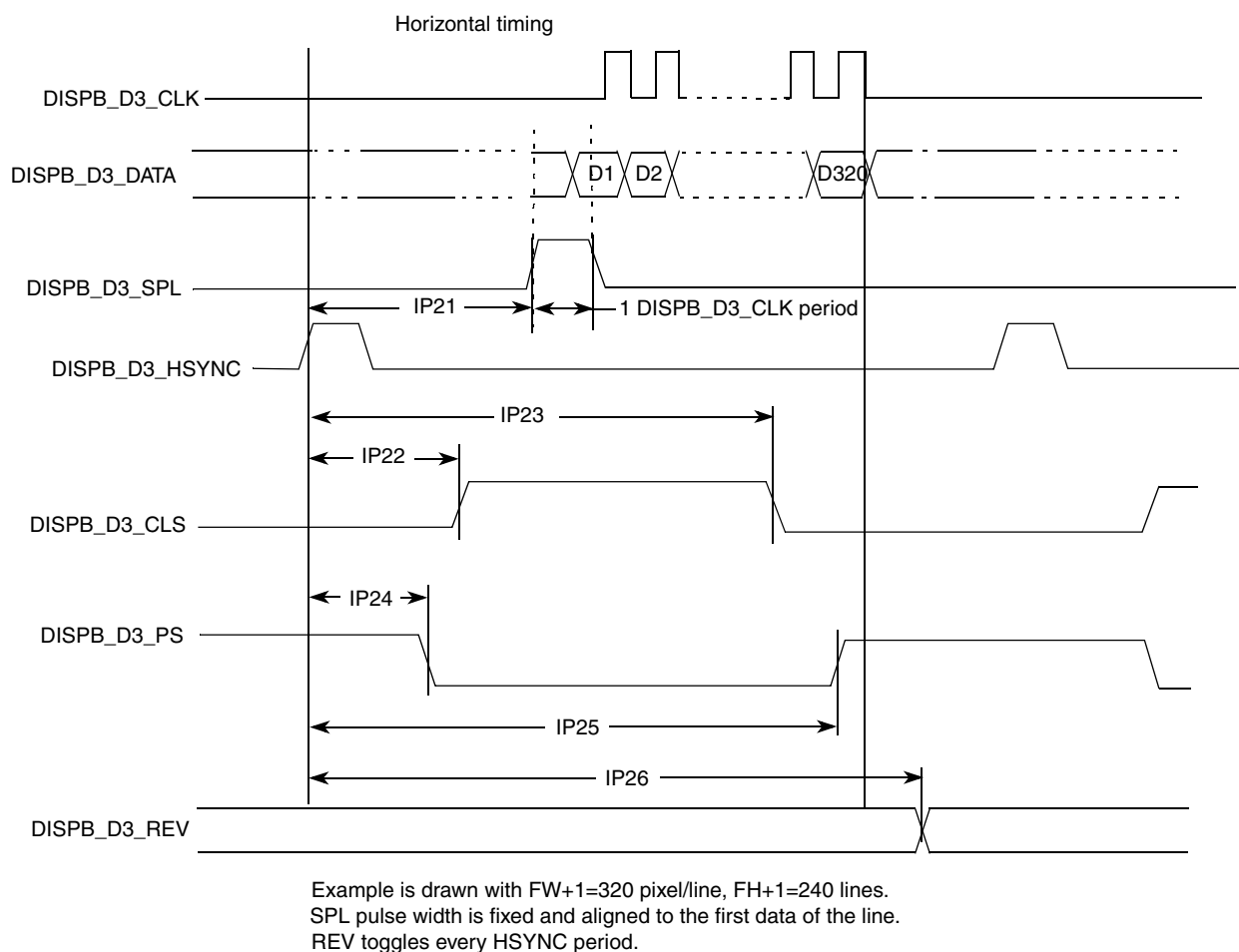
<sup>3</sup> Display interface clock up time

$$T_{dicu} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot \text{DISP3\_IF\_CLK\_UP\_WR}}{HSP\_CLK\_PERIOD} \right]$$

where CEIL(X) rounds the elements of X to the nearest integers towards infinity.

### 4.3.15.3 Interface to Sharp HR-TFT Panels

Figure 48 depicts the Sharp HR-TFT panel interface timing, and Table 45 lists the timing parameters. The CLS\_RISE\_DELAY, CLS\_FALL\_DELAY, PS\_FALL\_DELAY, PS\_RISE\_DELAY, REV\_TOGGLE\_DELAY parameters are defined in the SDC\_SHARP\_CONF\_1 and SDC\_SHARP\_CONF\_2 registers. For other Sharp interface timing characteristics, refer to Section 4.3.15.2.2, “Interface to Active Matrix TFT LCD Panels, Electrical Characteristics” on page 54. The timing images correspond to straight polarity of the Sharp signals.



**Figure 48. Sharp HR-TFT Panel Interface Timing Diagram—Pixel Level**

**Table 45. Sharp Synchronous Display Interface Timing Parameters—Pixel Level**

| ID   | Parameter                 | Symbol | Value                        | Units |
|------|---------------------------|--------|------------------------------|-------|
| IP21 | SPL rise time             | Tsplr  | $(BGXP - 1) * Tdpcp$         | ns    |
| IP22 | CLS rise time             | Tclsr  | $CLS\_RISE\_DELAY * Tdpcp$   | ns    |
| IP23 | CLS fall time             | Tclsf  | $CLS\_FALL\_DELAY * Tdpcp$   | ns    |
| IP24 | CLS rise and PS fall time | Tpsf   | $PS\_FALL\_DELAY * Tdpcp$    | ns    |
| IP25 | PS rise time              | Tpsr   | $PS\_RISE\_DELAY * Tdpcp$    | ns    |
| IP26 | REV toggle time           | Trev   | $REV\_TOGGLE\_DELAY * Tdpcp$ | ns    |

#### 4.3.15.4 Synchronous Interface to Dual-Port Smart Displays

Functionality and electrical characteristics of the synchronous interface to dual-port smart displays are identical to parameters of the synchronous interface. See [Section 4.3.15.2.2, “Interface to Active Matrix TFT LCD Panels, Electrical Characteristics”](#) on page 54.

##### 4.3.15.4.1 Interface to a TV Encoder, Functional Description

The interface has an 8-bit data bus, transferring a single 8-bit value (Y/U/V) in each cycle. The bits D7–D0 of the value are mapped to bits LD17–LD10 of the data bus, respectively. [Figure 49](#) depicts the interface timing.

- The frequency of the clock DISPB\_D3\_CLK is 27 MHz (within 10%).
- The DISPB\_D3\_HSYNC, DISPB\_D3\_VSYNC and DISPB\_D3\_DRDY signals are active low.
- The transition to the next row is marked by the negative edge of the DISPB\_D3\_HSYNC signal. It remains low for a single clock cycle.
- The transition to the next field/frame is marked by the negative edge of the DISPB\_D3\_VSYNC signal. It remains low for at least one clock cycle.
  - At a transition to an odd field (of the next frame), the negative edges of DISPB\_D3\_VSYNC and DISPB\_D3\_HSYNC coincide.
  - At a transition to an even field (of the same frame), they do not coincide.
- The active intervals—during which data is transferred—are marked by the DISPB\_D3\_HSYNC signal being high.

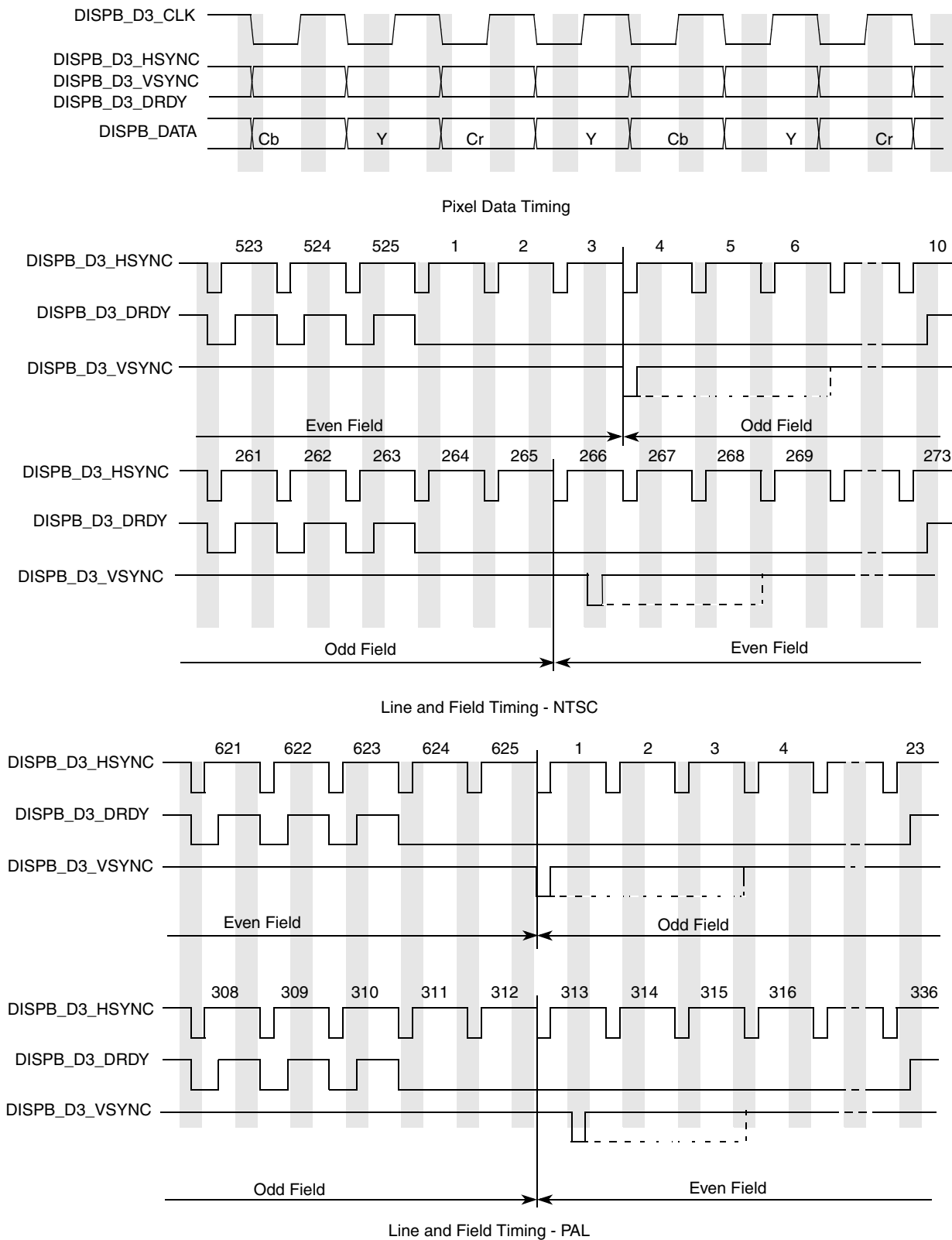


Figure 49. TV Encoder Interface Timing Diagram

#### 4.3.15.4.2 Interface to a TV Encoder, Electrical Characteristics

The timing characteristics of the TV encoder interface are identical to the synchronous display characteristics. See [Section 4.3.15.2.2, “Interface to Active Matrix TFT LCD Panels, Electrical Characteristics”](#) on page 54.

#### 4.3.15.5 Asynchronous Interfaces

##### 4.3.15.5.1 Parallel Interfaces, Functional Description

The IPU supports the following asynchronous parallel interfaces:

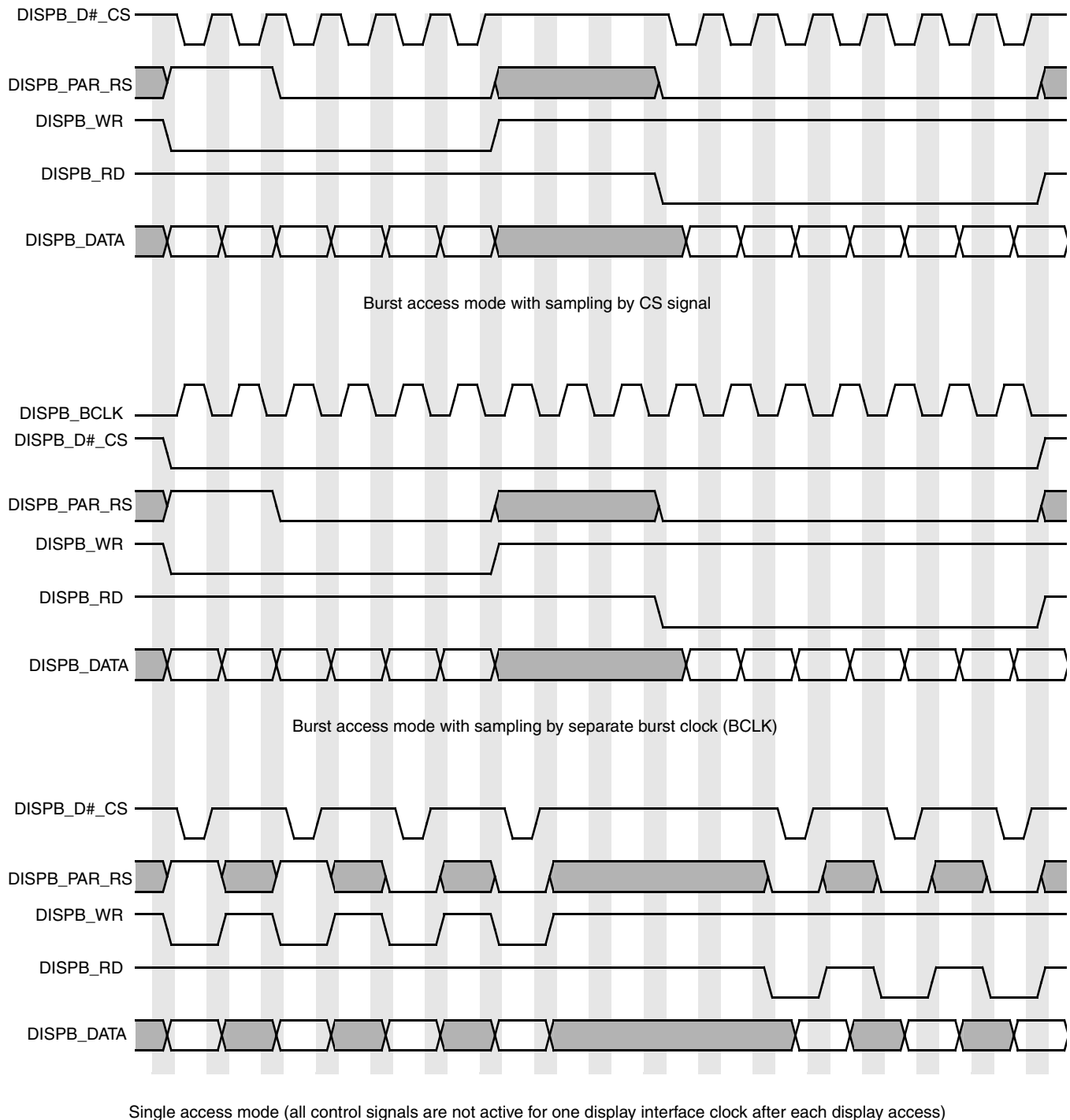
- System 80 interface
  - Type 1 (sampling with the chip select signal) with and without byte enable signals.
  - Type 2 (sampling with the read and write signals) with and without byte enable signals.
- System 68k interface
  - Type 1 (sampling with the chip select signal) with or without byte enable signals.
  - Type 2 (sampling with the read and write signals) with or without byte enable signals.

For each of four system interfaces, there are three burst modes:

1. Burst mode without a separate clock. The burst length is defined by the corresponding parameters of the IDMAC (when data is transferred from the system memory) or by the HBURST signal (when the MCU directly accesses the display via the slave AHB bus). For system 80 and system 68k type 1 interfaces, data is sampled by the CS signal and other control signals changes only when transfer direction is changed during the burst. For type 2 interfaces, data is sampled by the WR/RD signals (system 80) or by the ENABLE signal (system 68k) and the CS signal stays active during the whole burst.
2. Burst mode with the separate clock DISPB\_BCLK. In this mode, data is sampled with the DISPB\_BCLK clock. The CS signal stays active during whole burst transfer. Other controls are changed simultaneously with data when the bus state (read, write or wait) is altered. The CS signals and other controls move to non-active state after burst has been completed.
3. Single access mode. In this mode, slave AHB and DMA burst are broken to single accesses. The data is sampled with CS or other controls according the interface type as described above. All controls (including CS) become non-active for one display interface clock after each access. This mode corresponds to the ATI single access mode.

Both system 80 and system 68k interfaces are supported for all described modes as depicted in [Figure 50](#), [Figure 51](#), [Figure 52](#), and [Figure 53](#). These timing images correspond to active-low DISPB\_D#\_CS, DISPB\_D#\_WR and DISPB\_D#\_RD signals.

Additionally, the IPU allows a programmable pause between two burst. The pause is defined in the HSP\_CLK cycles. It allows to avoid timing violation between two sequential bursts or two accesses to different displays. The range of this pause is from 4 to 19 HSP\_CLK cycles.



**Figure 50. Asynchronous Parallel System 80 Interface (Type 1) Burst Mode Timing Diagram**

Electrical Characteristics

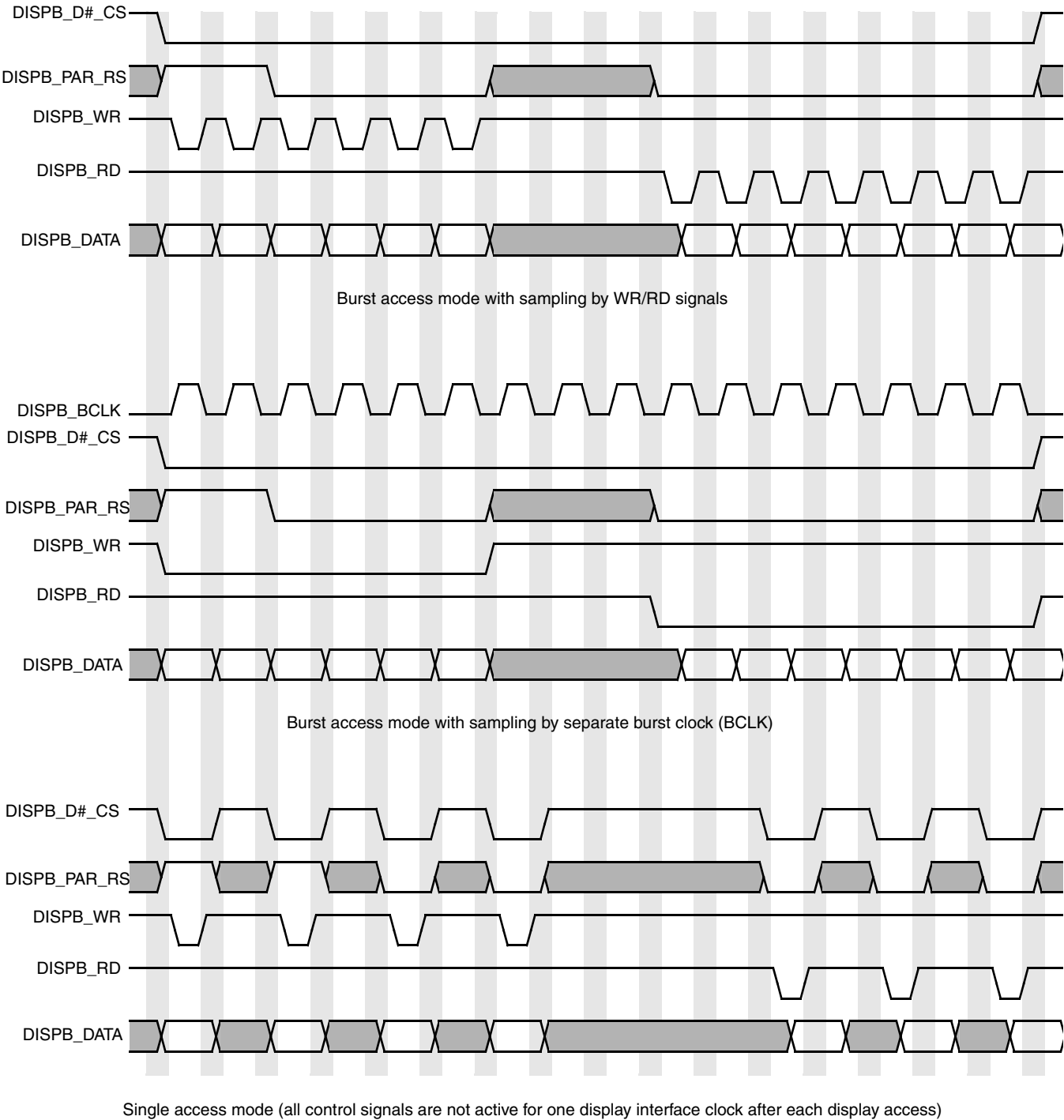
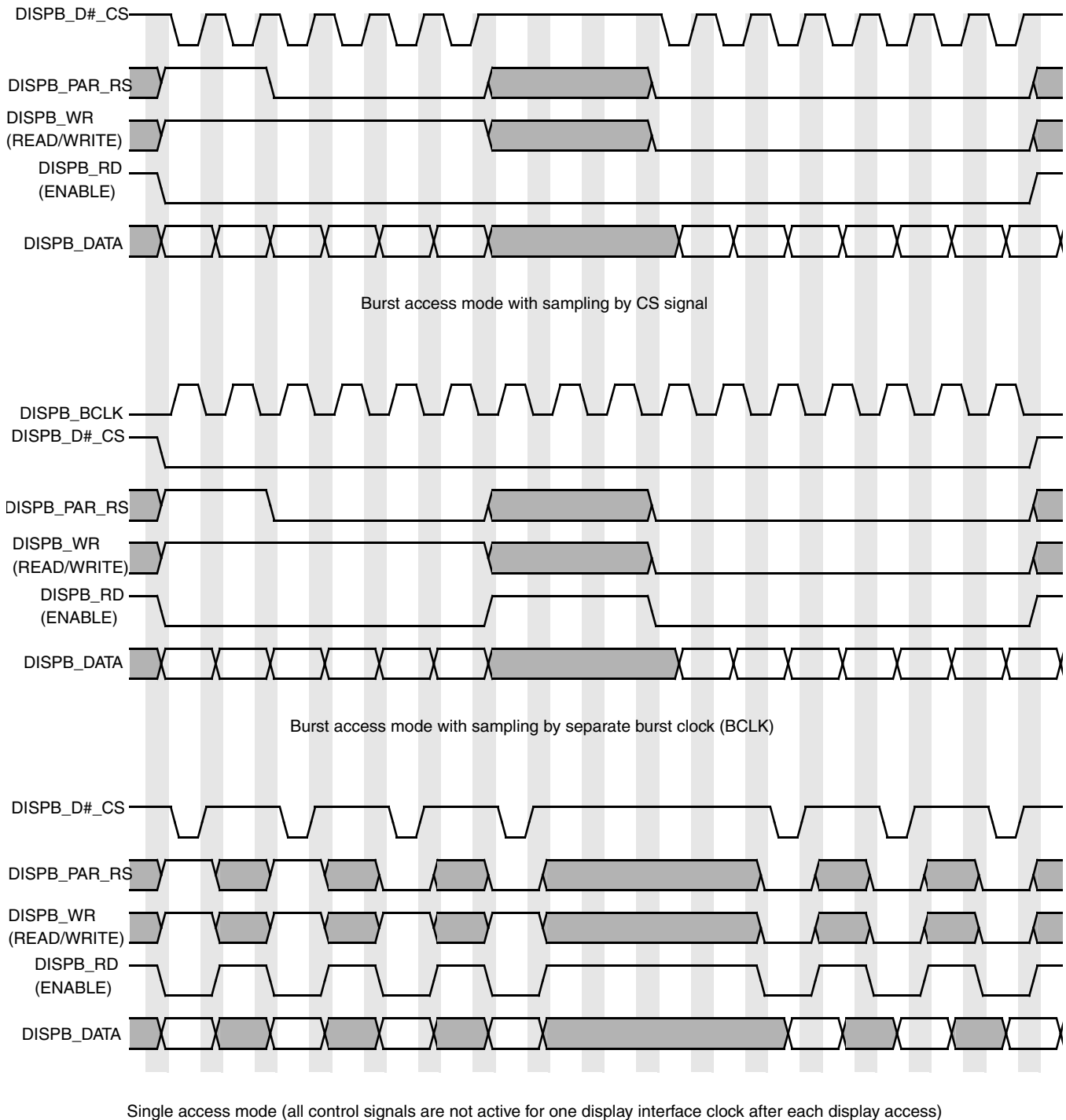
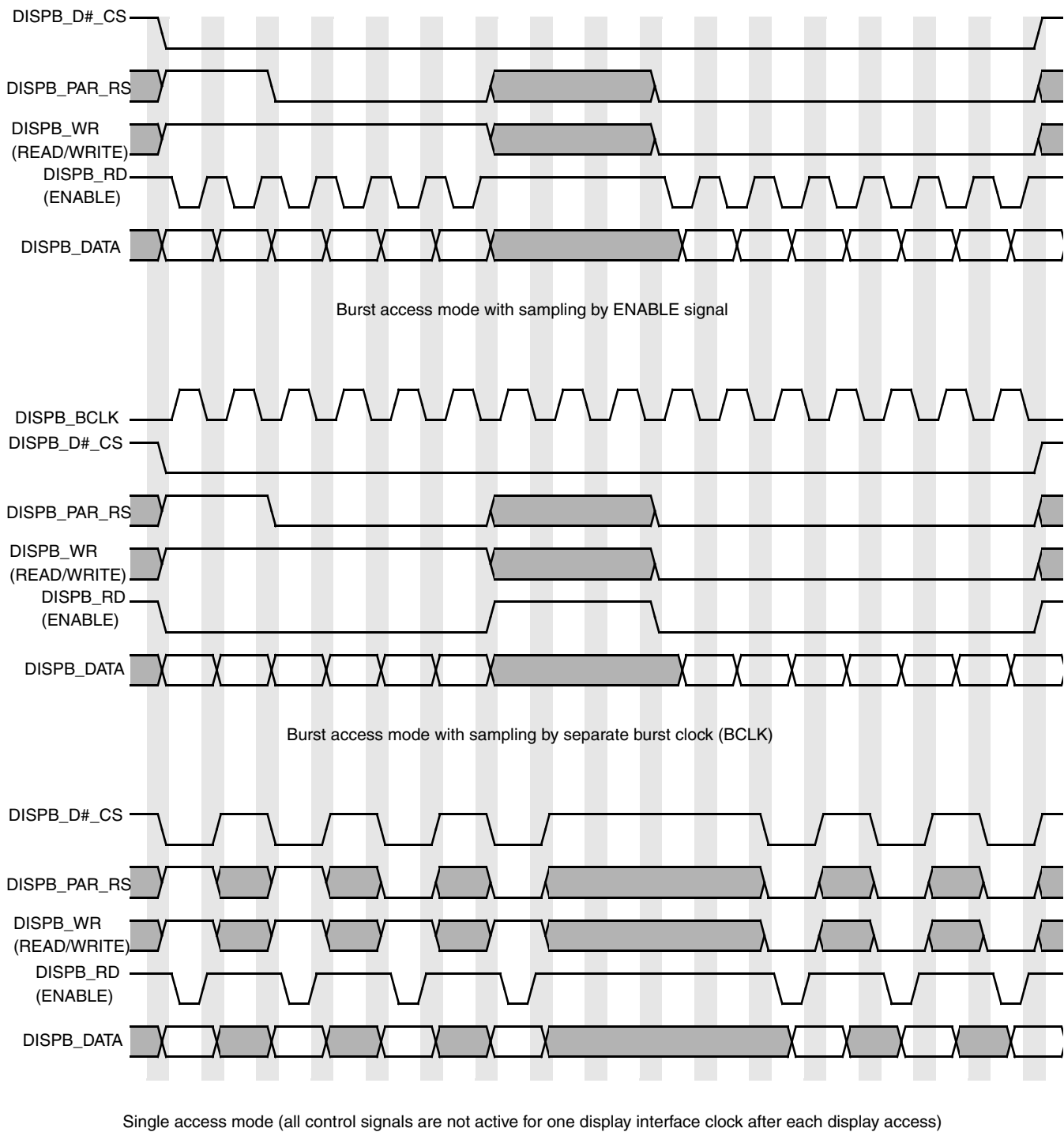


Figure 51. Asynchronous Parallel System 80 Interface (Type 2) Burst Mode Timing Diagram



**Figure 52. Asynchronous Parallel System 68k Interface (Type 1) Burst Mode Timing Diagram**



**Figure 53. Asynchronous Parallel System 68k Interface (Type 2) Burst Mode Timing Diagram**

Display read operation can be performed with wait states when each read access takes up to 4 display interface clock cycles according to the **DISP0\_RD\_WAIT\_ST** parameter in the **DI\_DISP0\_TIME\_CONF\_3**, **DI\_DISP1\_TIME\_CONF\_3**, **DI\_DISP2\_TIME\_CONF\_3** Registers. [Figure 54](#) shows timing of the parallel interface with read wait states.

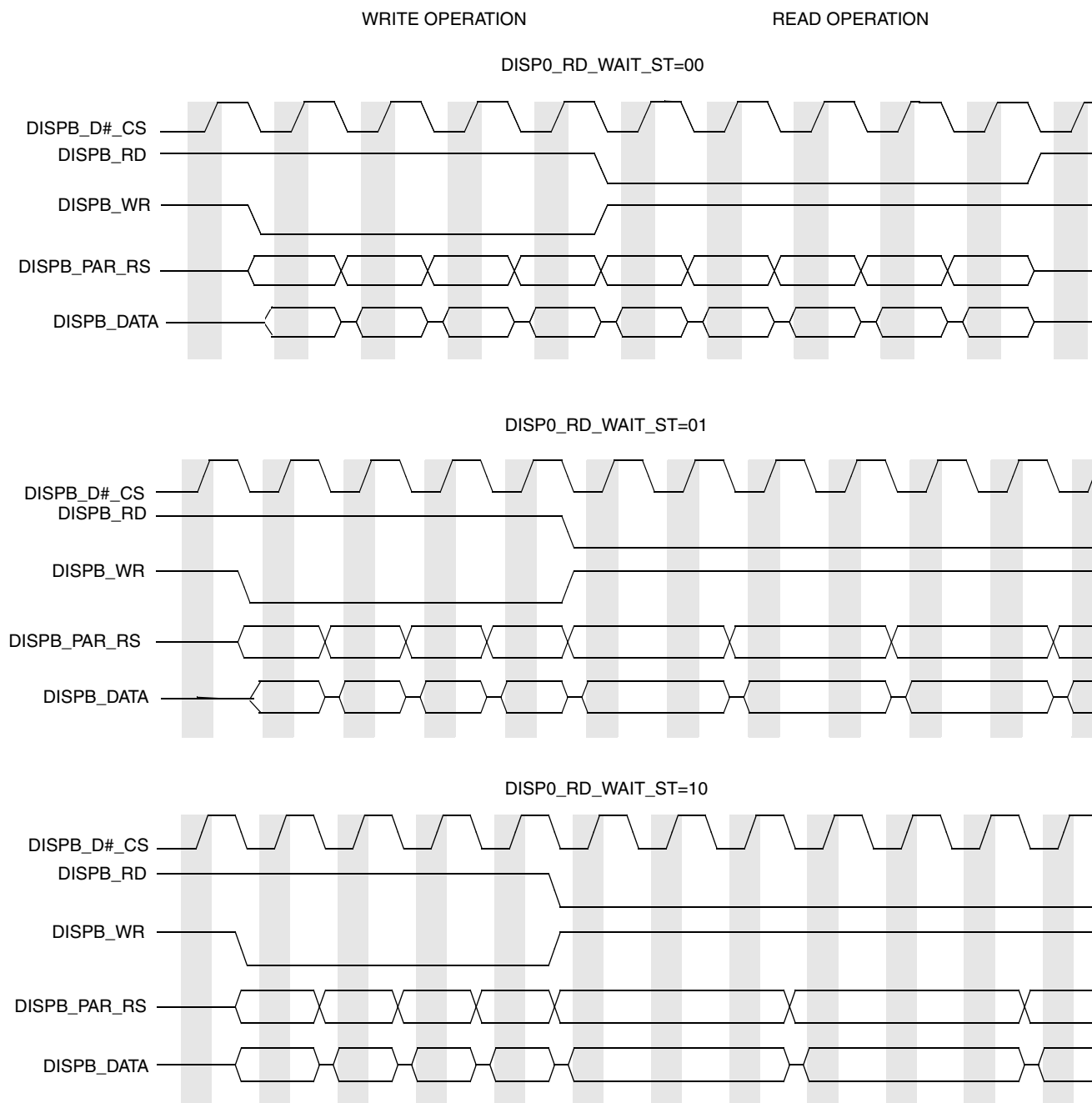


Figure 54. Parallel Interface Timing Diagram—Read Wait States

#### 4.3.15.5.2 Parallel Interfaces, Electrical Characteristics

Figure 55, Figure 57, Figure 56, and Figure 58 depict timing of asynchronous parallel interfaces based on the system 80 and system 68k interfaces. Table 46 lists the timing parameters at display access level. All timing images are based on active low control signals (signals polarity is controlled via the `DI_DISP_SIG_POL` Register).

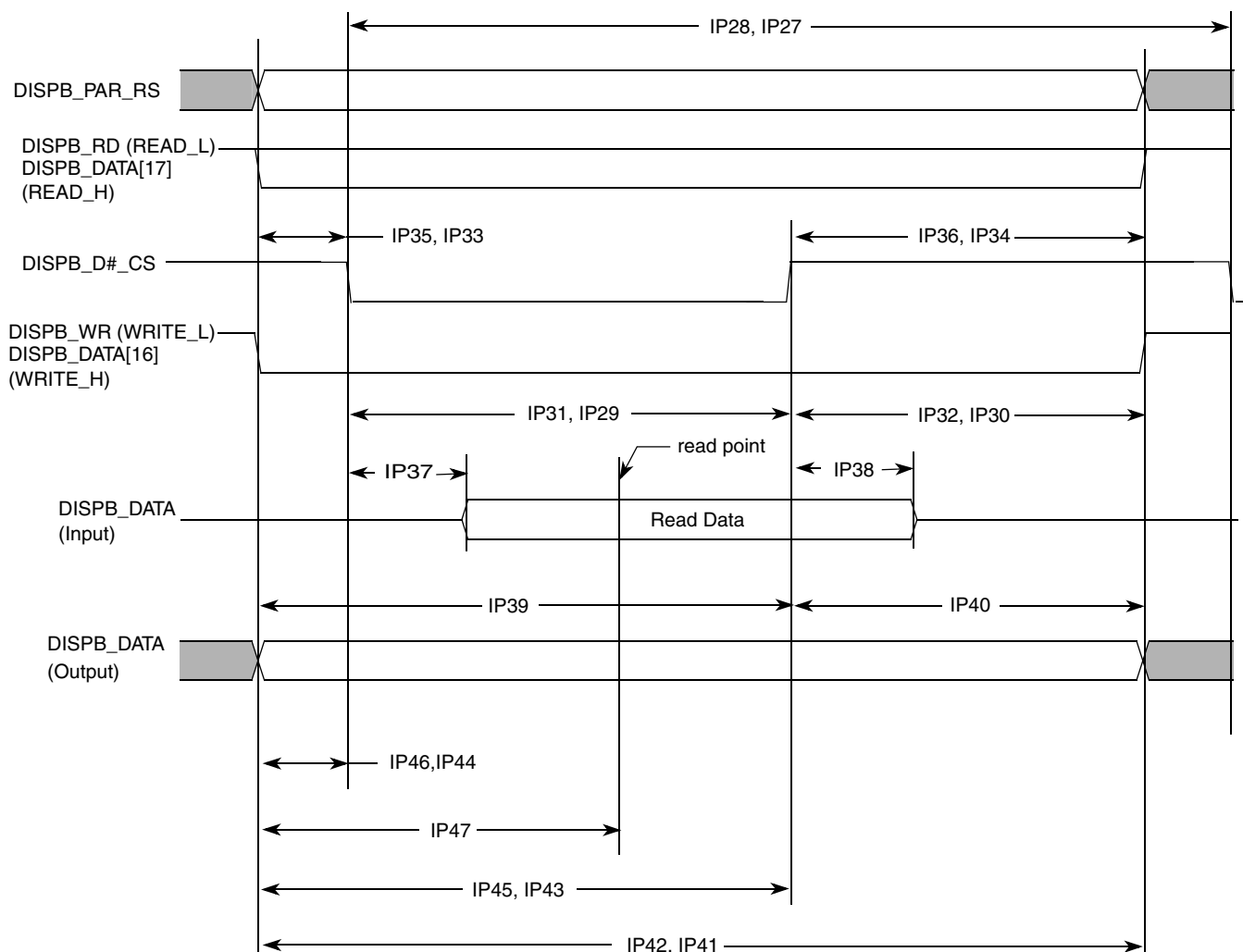


Figure 55. Asynchronous Parallel System 80 Interface (Type 1) Timing Diagram

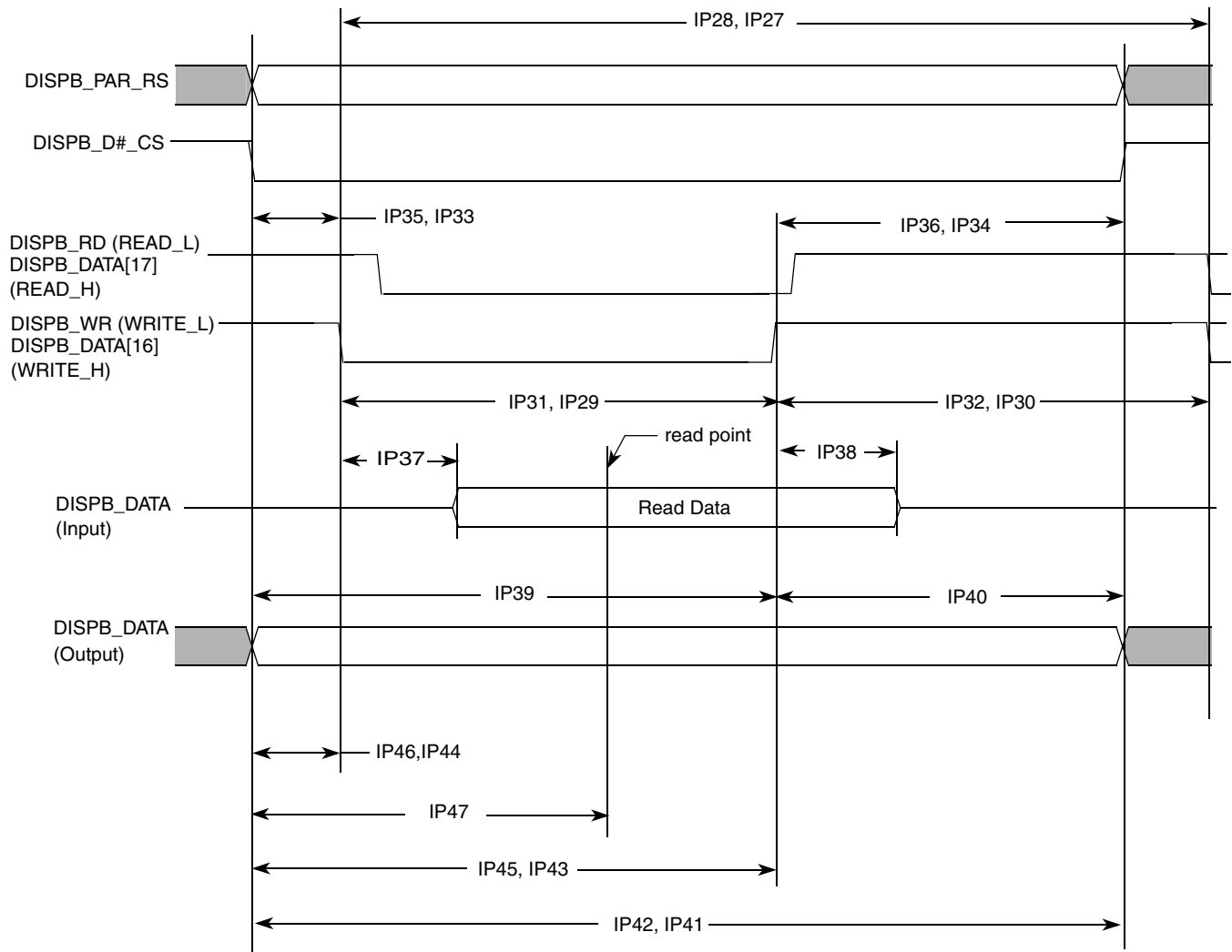


Figure 56. Asynchronous Parallel System 80 Interface (Type 2) Timing Diagram

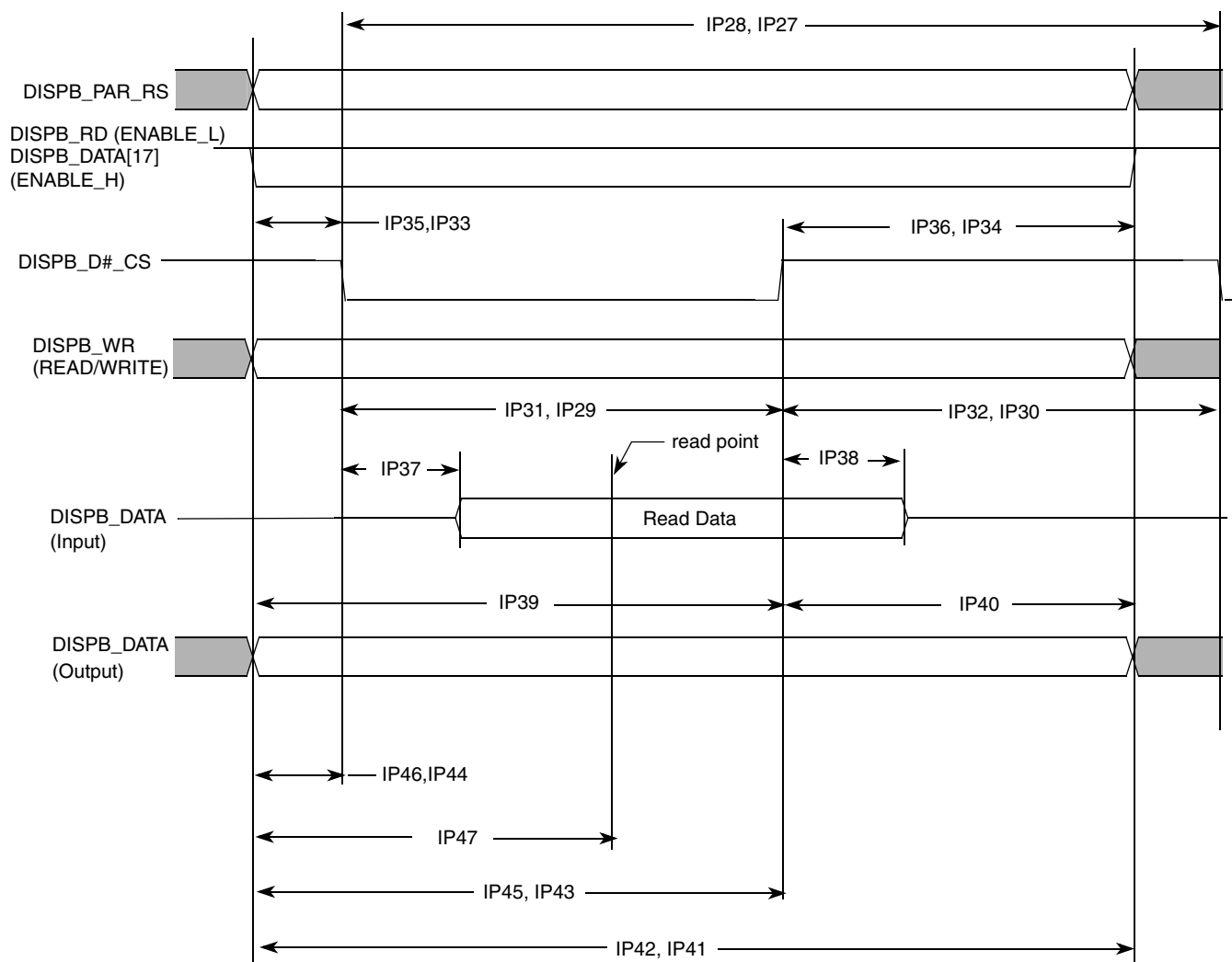


Figure 57. Asynchronous Parallel System 68k Interface (Type 1) Timing Diagram

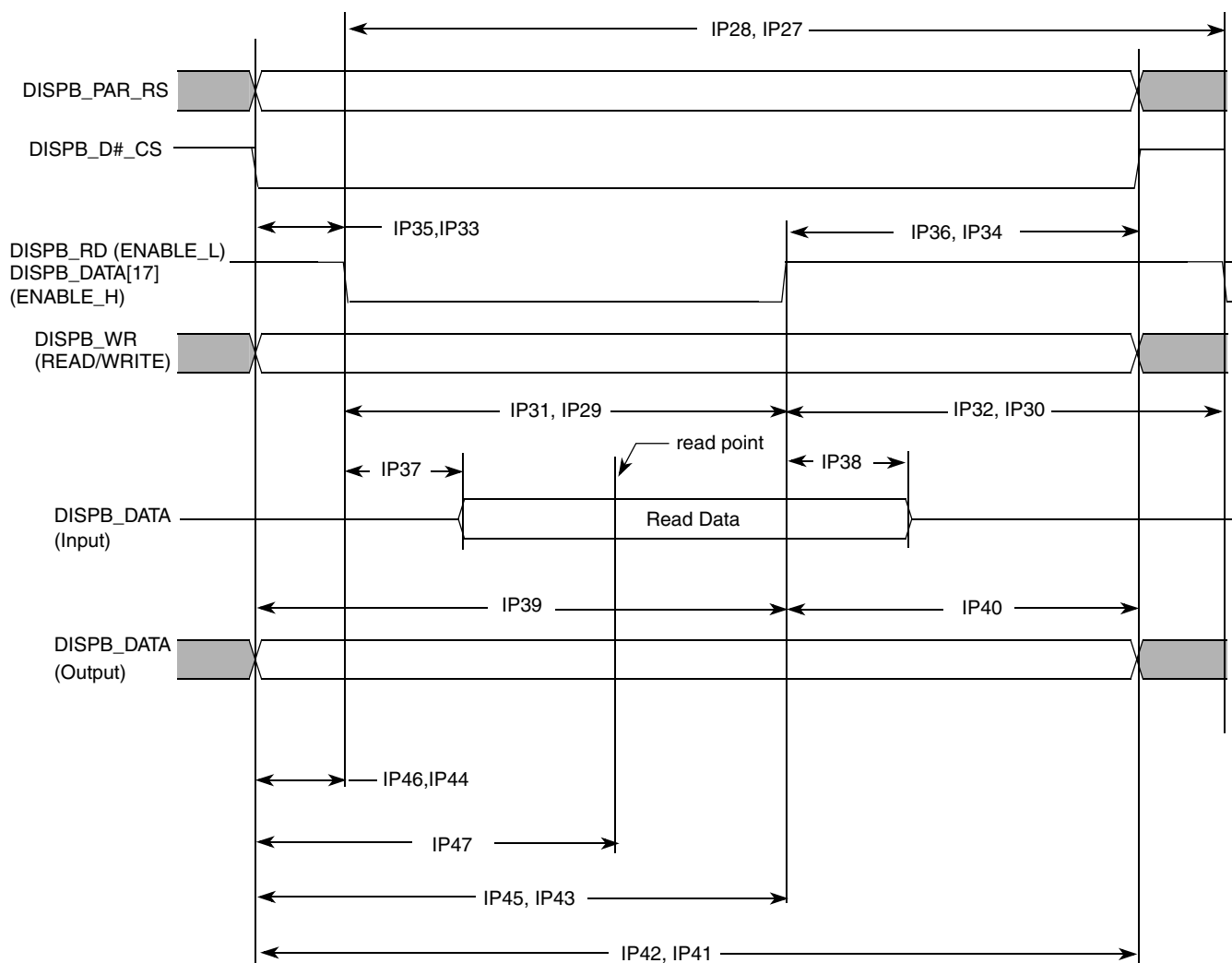


Figure 58. Asynchronous Parallel System 68k Interface (Type 2) Timing Diagram

Table 46. Asynchronous Parallel Interface Timing Parameters—Access Level

| ID   | Parameter                     | Symbol | Min.                     | Typ. <sup>1</sup>                        | Max.                     | Units |
|------|-------------------------------|--------|--------------------------|------------------------------------------|--------------------------|-------|
| IP27 | Read system cycle time        | Tcycr  | Tdicpr-1.5               | Tdicpr <sup>2</sup>                      | Tdicpr+1.5               | ns    |
| IP28 | Write system cycle time       | Tcycw  | Tdicpw-1.5               | Tdicpw <sup>3</sup>                      | Tdicpw+1.5               | ns    |
| IP29 | Read low pulse width          | Trl    | Tdicdr-Tdicur-1.5        | Tdicdr <sup>4</sup> -Tdicur <sup>5</sup> | Tdicdr-Tdicur+1.5        | ns    |
| IP30 | Read high pulse width         | Trh    | Tdicpr-Tdicdr+Tdicur-1.5 | Tdicpr-Tdicdr+Tdicur                     | Tdicpr-Tdicdr+Tdicur+1.5 | ns    |
| IP31 | Write low pulse width         | Twl    | Tdicdw-Tdicuw-1.5        | Tdicdw <sup>6</sup> -Tdicuw <sup>7</sup> | Tdicdw-Tdicuw+1.5        | ns    |
| IP32 | Write high pulse width        | Twh    | Tdicpw-Tdicdw+Tdicuw-1.5 | Tdicpw-Tdicdw+Tdicuw                     | Tdicpw-Tdicdw+Tdicuw+1.5 | ns    |
| IP33 | Controls setup time for read  | Tdcsr  | Tdicur-1.5               | Tdicur                                   | —                        | ns    |
| IP34 | Controls hold time for read   | Tdchr  | Tdicpr-Tdicdr-1.5        | Tdicpr-Tdicdr                            | —                        | ns    |
| IP35 | Controls setup time for write | Tdcsw  | Tdicuw-1.5               | Tdicuw                                   | —                        | ns    |

Table 46. Asynchronous Parallel Interface Timing Parameters—Access Level (continued)

| ID   | Parameter                                | Symbol | Min.                 | Typ. <sup>1</sup> | Max.                                              | Units |
|------|------------------------------------------|--------|----------------------|-------------------|---------------------------------------------------|-------|
| IP36 | Controls hold time for write             | Tdchw  | Tdicpw-Tdicdw-1.5    | Tdicpw-Tdicdw     | —                                                 | ns    |
| IP37 | Slave device data delay <sup>8</sup>     | Tracc  | 0                    | —                 | Tdrp <sup>9</sup> -Tlbd <sup>10</sup> -Tdicur-1.5 | ns    |
| IP38 | Slave device data hold time <sup>8</sup> | Troh   | Tdrp-Tlbd-Tdicdr+1.5 | —                 | Tdicpr-Tdicdr-1.5                                 | ns    |
| IP39 | Write data setup time                    | Tds    | Tdicdw-1.5           | Tdicdw            | —                                                 | ns    |
| IP40 | Write data hold time                     | Tdh    | Tdicpw-Tdicdw-1.5    | Tdicpw-Tdicdw     | —                                                 | ns    |
| IP41 | Read period <sup>2</sup>                 | Tdicpr | Tdicpr-1.5           | Tdicpr            | Tdicpr+1.5                                        | ns    |
| IP42 | Write period <sup>3</sup>                | Tdicpw | Tdicpw-1.5           | Tdicpw            | Tdicpw+1.5                                        | ns    |
| IP43 | Read down time <sup>4</sup>              | Tdicdr | Tdicdr-1.5           | Tdicdr            | Tdicdr+1.5                                        | ns    |
| IP44 | Read up time <sup>5</sup>                | Tdicur | Tdicur-1.5           | Tdicur            | Tdicur+1.5                                        | ns    |
| IP45 | Write down time <sup>6</sup>             | Tdicdw | Tdicdw-1.5           | Tdicdw            | Tdicdw+1.5                                        | ns    |
| IP46 | Write up time <sup>7</sup>               | Tdicuw | Tdicuw-1.5           | Tdicuw            | Tdicuw+1.5                                        | ns    |
| IP47 | Read time point <sup>9</sup>             | Tdrp   | Tdrp-1.5             | Tdrp              | Tdrp+1.5                                          | ns    |

<sup>1</sup>The exact conditions have not been finalized, but will likely match the current customer requirement for their specific display. These conditions may be device specific.

<sup>2</sup> Display interface clock period value for read:

$$T_{dicpr} = T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{DISP\#\_IF\_CLK\_PER\_RD}{HSP\_CLK\_PERIOD} \right]$$

<sup>3</sup> Display interface clock period value for write:

$$T_{dicpw} = T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{DISP\#\_IF\_CLK\_PER\_WR}{HSP\_CLK\_PERIOD} \right]$$

<sup>4</sup> Display interface clock down time for read:

$$T_{dicdr} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_DOWN\_RD}{HSP\_CLK\_PERIOD} \right]$$

<sup>5</sup> Display interface clock up time for read:

$$T_{dicur} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_UP\_RD}{HSP\_CLK\_PERIOD} \right]$$

<sup>6</sup> Display interface clock down time for write:

$$T_{dicdw} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_DOWN\_WR}{HSP\_CLK\_PERIOD} \right]$$

<sup>7</sup> Display interface clock up time for write:

$$T_{dicuw} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_UP\_WR}{HSP\_CLK\_PERIOD} \right]$$

<sup>8</sup> This parameter is a requirement to the display connected to the IPU

<sup>9</sup> Data read point

$$T_{drp} = T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{DISP\#\_READ\_EN}{HSP\_CLK\_PERIOD} \right]$$

<sup>10</sup> Loopback delay Tlbd is the cumulative propagation delay of read controls and read data. It includes an IPU output delay, a device-level output delay, board delays, a device-level input delay, an IPU input delay. This value is device specific.

The DISP#\_IF\_CLK\_PER\_WR, DISP#\_IF\_CLK\_PER\_RD, HSP\_CLK\_PERIOD, DISP#\_IF\_CLK\_DOWN\_WR, DISP#\_IF\_CLK\_UP\_WR, DISP#\_IF\_CLK\_DOWN\_RD, DISP#\_IF\_CLK\_UP\_RD and DISP#\_READ\_EN parameters are programmed via the DI\_DISP#\_TIME\_CONF\_1, DI\_DISP#\_TIME\_CONF\_2 and DI\_HSP\_CLK\_PER Registers.

#### 4.3.15.5.3 Serial Interfaces, Functional Description

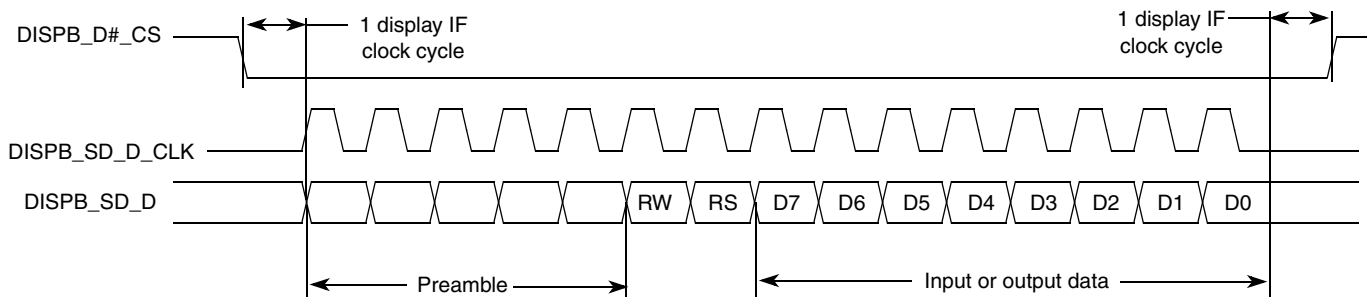
The IPU supports the following types of asynchronous serial interfaces:

- 3-wire (with bidirectional data line)
- 4-wire (with separate data input and output lines)
- 5-wire type 1 (with sampling RS by the serial clock)
- 5-wire type 2 (with sampling RS by the chip select signal)

Figure 59 depicts timing of the 3-wire serial interface. The timing images correspond to active-low DISPB\_D#\_CS signal and the straight polarity of the DISPB\_SD\_D\_CLK signal.

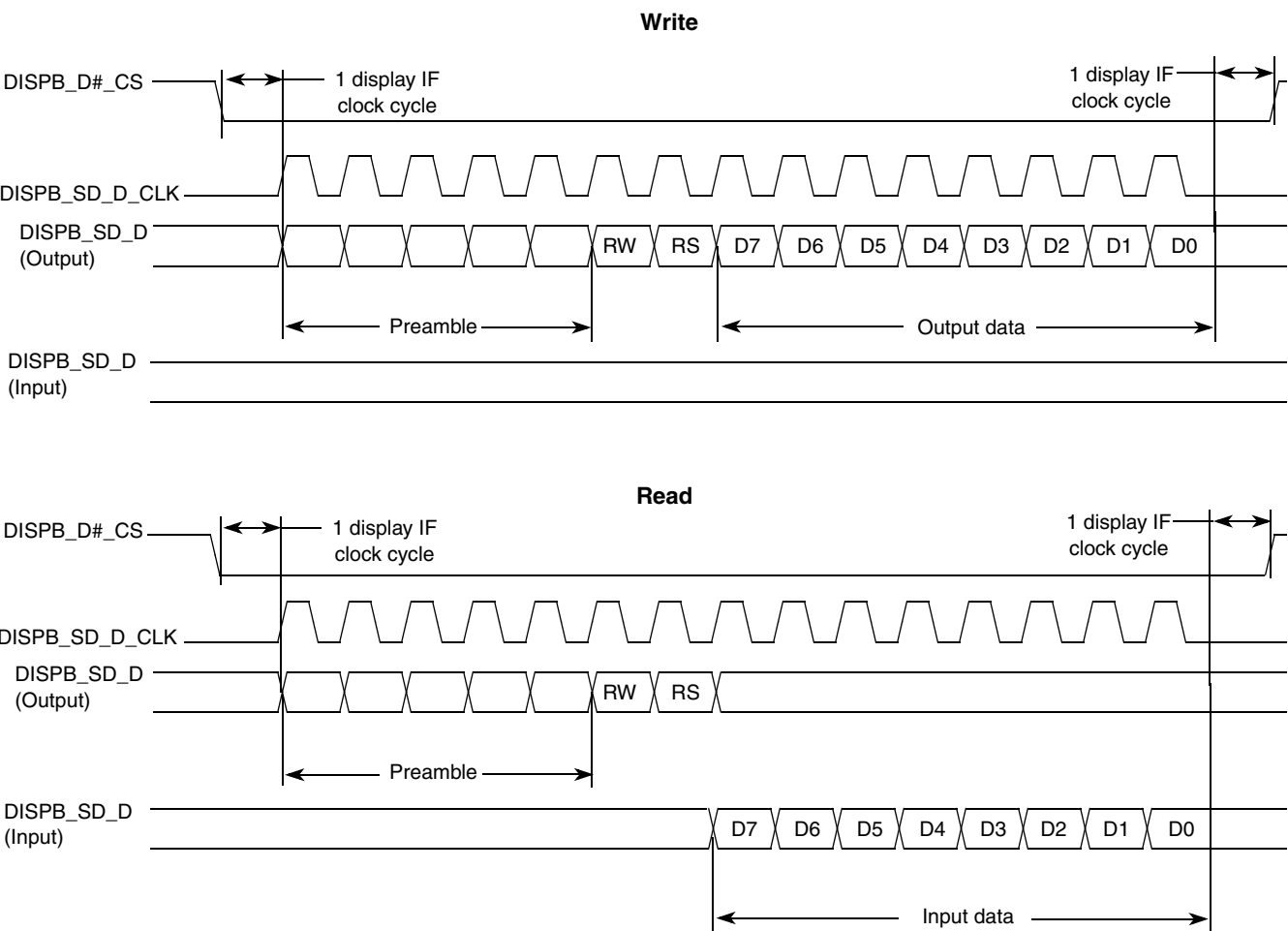
For this interface, a bidirectional data line is used outside the device. The IPU still uses separate input and output data lines (IPP\_IND\_DISP\_B\_SD\_D and IPP\_DO\_DISP\_B\_SD\_D). The I/O mux should provide joining the internal data lines to the bidirectional external line according to the IPP\_OBE\_DISP\_B\_SD\_D signal provided by the IPU.

Each data transfer can be preceded by an optional preamble with programmable length and contents. The preamble is followed by read/write (RW) and address (RS) bits. The order of these bits is programmable. The RW bit can be disabled. The following data can consist of one word or of a whole burst. The interface parameters are controlled by the DI\_SER\_DISP1\_CONF and DI\_SER\_DISP2\_CONF Registers.



**Figure 59. 3-wire Serial Interface Timing Diagram**

Figure 60 depicts timing of the 4-wire serial interface. For this interface, there are separate input and output data lines both inside and outside the device.



**Figure 60. 4-wire Serial Interface Timing Diagram**

Figure 61 depicts timing of the 5-wire serial interface (Type 1). For this interface, a separate RS line is added. When a burst is transmitted within single active chip select interval, the RS can be changed at boundaries of words.

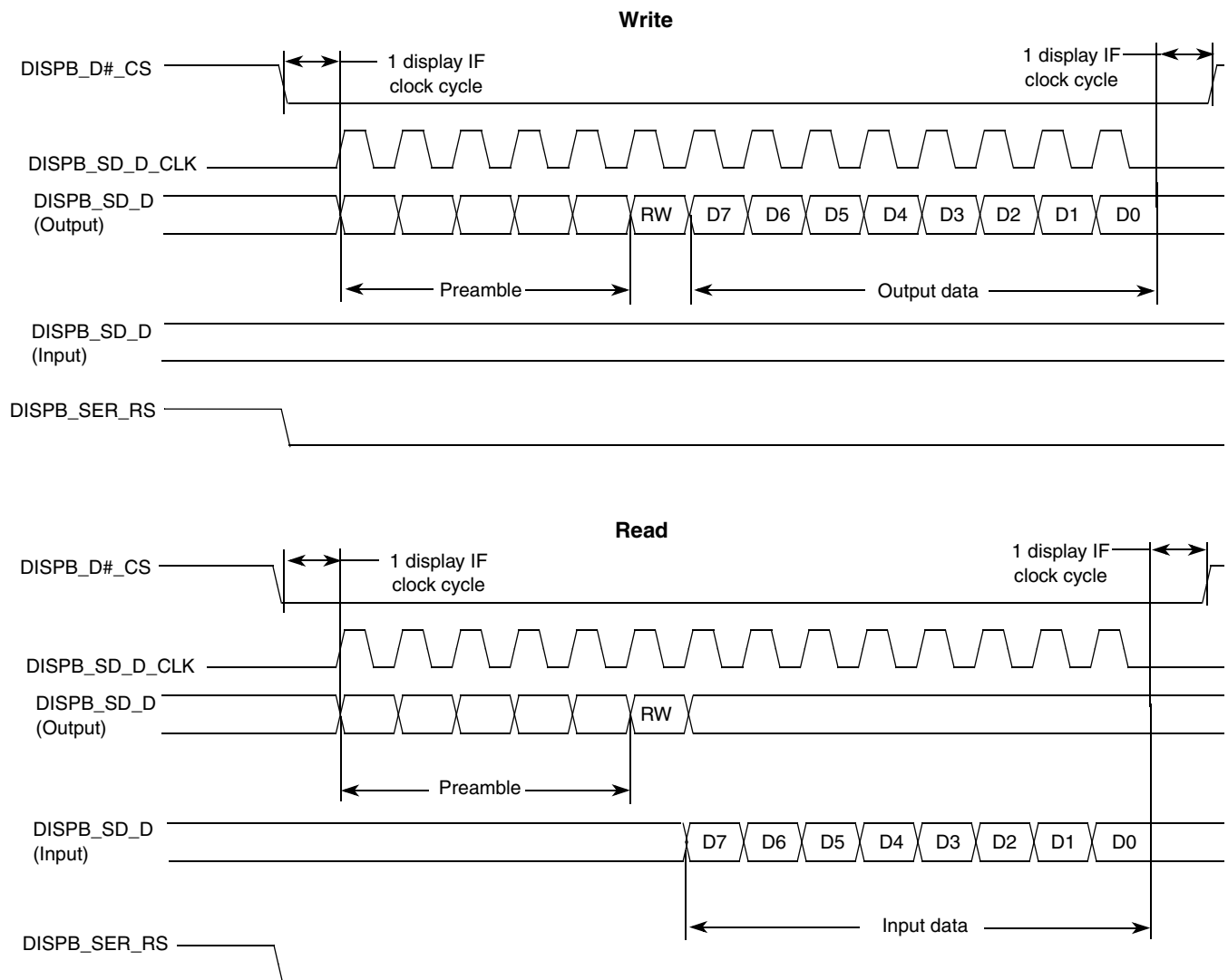


Figure 61. 5-wire Serial Interface (Type 1) Timing Diagram

Figure 62 depicts timing of the 5-wire serial interface (Type 2). For this interface, a separate RS line is added. When a burst is transmitted within single active chip select interval, the RS can be changed at boundaries of words.

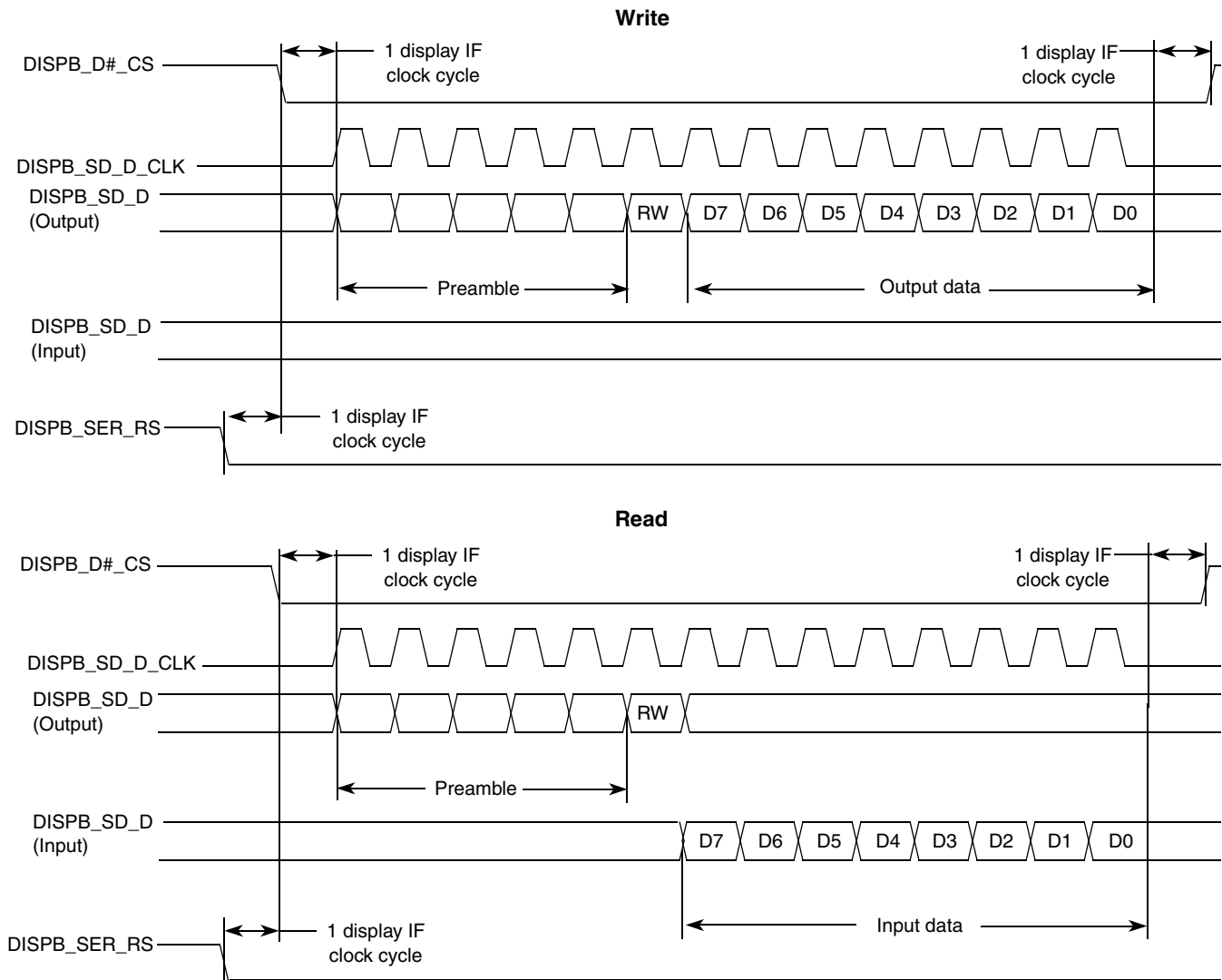


Figure 62. 5-wire Serial Interface (Type 2) Timing Diagram

#### 4.3.15.5.4 Serial Interfaces, Electrical Characteristics

Figure 63 depicts timing of the serial interface. Table 47 lists the timing parameters at display access level.

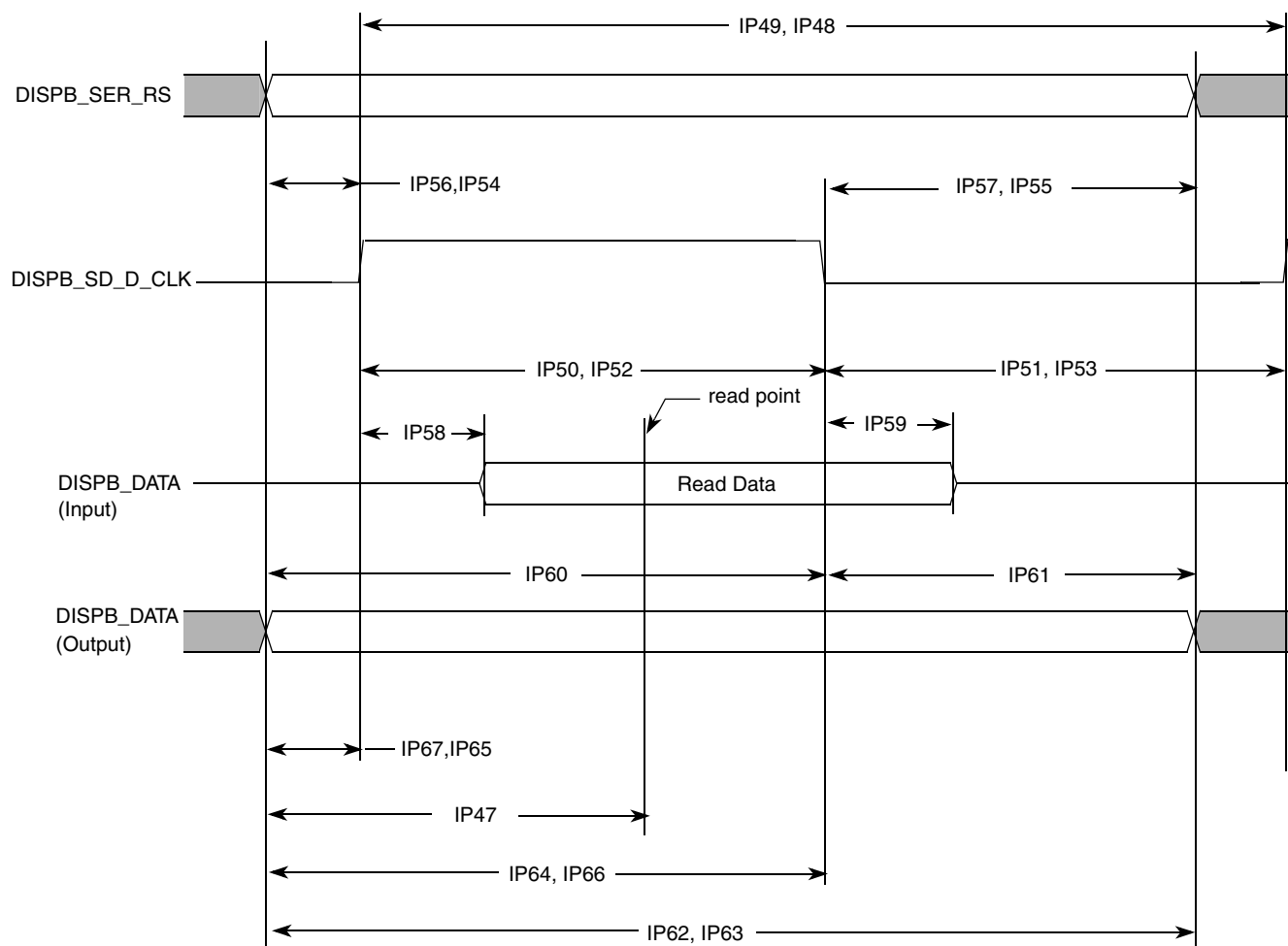


Figure 63. Asynchronous Serial Interface Timing Diagram

Table 47. Asynchronous Serial Interface Timing Parameters—Access Level

| ID   | Parameter                    | Symbol | Min.                     | Typ. <sup>1</sup>                        | Max.                     | Units |
|------|------------------------------|--------|--------------------------|------------------------------------------|--------------------------|-------|
| IP48 | Read system cycle time       | Tcycr  | Tdicpr-1.5               | Tdicpr <sup>2</sup>                      | Tdicpr+1.5               | ns    |
| IP49 | Write system cycle time      | Tcycw  | Tdicpw-1.5               | Tdicpw <sup>3</sup>                      | Tdicpw+1.5               | ns    |
| IP50 | Read clock low pulse width   | Trl    | Tdicdr-Tdicur-1.5        | Tdicdr <sup>4</sup> -Tdicur <sup>5</sup> | Tdicdr-Tdicur+1.5        | ns    |
| IP51 | Read clock high pulse width  | Trh    | Tdicpr-Tdicdr+Tdicur-1.5 | Tdicpr-Tdicdr+Tdicur                     | Tdicpr-Tdicdr+Tdicur+1.5 | ns    |
| IP52 | Write clock low pulse width  | Twl    | Tdicdw-Tdicuw-1.5        | Tdicdw <sup>6</sup> -Tdicuw <sup>7</sup> | Tdicdw-Tdicuw+1.5        | ns    |
| IP53 | Write clock high pulse width | Twh    | Tdicpw-Tdicdw+Tdicuw-1.5 | Tdicpw-Tdicdw+Tdicuw                     | Tdicpw-Tdicdw+Tdicuw+1.5 | ns    |
| IP54 | Controls setup time for read | Tdcsr  | Tdicur-1.5               | Tdicur                                   | —                        | ns    |
| IP55 | Controls hold time for read  | Tdchr  | Tdicpr-Tdicdr-1.5        | Tdicpr-Tdicdr                            | —                        | ns    |

Table 47. Asynchronous Serial Interface Timing Parameters—Access Level (continued)

| ID   | Parameter                                | Symbol | Min.                 | Typ. <sup>1</sup> | Max.                                              | Units |
|------|------------------------------------------|--------|----------------------|-------------------|---------------------------------------------------|-------|
| IP56 | Controls setup time for write            | Tdcsw  | Tdicuw-1.5           | Tdicuw            | —                                                 | ns    |
| IP57 | Controls hold time for write             | Tdchw  | Tdicpw-Tdicdw-1.5    | Tdicpw-Tdicdw     | —                                                 | ns    |
| IP58 | Slave device data delay <sup>8</sup>     | Tracc  | 0                    | —                 | Tdrp <sup>9</sup> -Tlbd <sup>10</sup> -Tdicur-1.5 | ns    |
| IP59 | Slave device data hold time <sup>8</sup> | Troh   | Tdrp-Tlbd-Tdicdr+1.5 | —                 | Tdicpr-Tdicdr-1.5                                 | ns    |
| IP60 | Write data setup time                    | Tds    | Tdicdw-1.5           | Tdicdw            | —                                                 | ns    |
| IP61 | Write data hold time                     | Tdh    | Tdicpw-Tdicdw-1.5    | Tdicpw-Tdicdw     | —                                                 | ns    |
| IP62 | Read period <sup>2</sup>                 | Tdicpr | Tdicpr-1.5           | Tdicpr            | Tdicpr+1.5                                        | ns    |
| IP63 | Write period <sup>3</sup>                | Tdicpw | Tdicpw-1.5           | Tdicpw            | Tdicpw+1.5                                        | ns    |
| IP64 | Read down time <sup>4</sup>              | Tdicdr | Tdicdr-1.5           | Tdicdr            | Tdicdr+1.5                                        | ns    |
| IP65 | Read up time <sup>5</sup>                | Tdicur | Tdicur-1.5           | Tdicur            | Tdicur+1.5                                        | ns    |
| IP66 | Write down time <sup>6</sup>             | Tdicdw | Tdicdw-1.5           | Tdicdw            | Tdicdw+1.5                                        | ns    |
| IP67 | Write up time <sup>7</sup>               | Tdicuw | Tdicuw-1.5           | Tdicuw            | Tdicuw+1.5                                        | ns    |
| IP68 | Read time point <sup>9</sup>             | Tdrp   | Tdrp-1.5             | Tdrp              | Tdrp+1.5                                          | ns    |

<sup>1</sup> The exact conditions have not been finalized, but will likely match the current customer requirement for their specific display. These conditions may be device specific.

<sup>2</sup> Display interface clock period value for read:

$$T_{dicpr} = T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{DISP\#\_IF\_CLK\_PER\_RD}{HSP\_CLK\_PERIOD} \right]$$

<sup>3</sup> Display interface clock period value for write:

$$T_{dicpw} = T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{DISP\#\_IF\_CLK\_PER\_WR}{HSP\_CLK\_PERIOD} \right]$$

<sup>4</sup> Display interface clock down time for read:

$$T_{dicdr} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_DOWN\_RD}{HSP\_CLK\_PERIOD} \right]$$

<sup>5</sup> Display interface clock up time for read:

$$T_{dicur} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_UP\_RD}{HSP\_CLK\_PERIOD} \right]$$

<sup>6</sup> Display interface clock down time for write:

$$T_{dicdw} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_DOWN\_WR}{HSP\_CLK\_PERIOD} \right]$$

<sup>7</sup> Display interface clock up time for write:

$$T_{dicuw} = \frac{1}{2} T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{2 \cdot DISP\#\_IF\_CLK\_UP\_WR}{HSP\_CLK\_PERIOD} \right]$$

<sup>8</sup> This parameter is a requirement to the display connected to the IPU.

<sup>9</sup> Data read point:

$$T_{drp} = T_{HSP\_CLK} \cdot \text{ceil} \left[ \frac{DISP\#\_READ\_EN}{HSP\_CLK\_PERIOD} \right]$$

<sup>10</sup> Loopback delay Tlbd is the cumulative propagation delay of read controls and read data. It includes an IPU output delay, a device-level output delay, board delays, a device-level input delay, an IPU input delay. This value is device specific.

The DISP#\_IF\_CLK\_PER\_WR, DISP#\_IF\_CLK\_PER\_RD, HSP\_CLK\_PERIOD, DISP#\_IF\_CLK\_DOWN\_WR, DISP#\_IF\_CLK\_UP\_WR, DISP#\_IF\_CLK\_DOWN\_RD, DISP#\_IF\_CLK\_UP\_RD and DISP#\_READ\_EN parameters are programmed via the DI\_DISP#\_TIME\_CONF\_1, DI\_DISP#\_TIME\_CONF\_2 and DI\_HSP\_CLK\_PER Registers.

#### 4.3.16 Memory Stick Host Controller (MSHC)

Figure 64, Figure 65, and Figure 66 depict the MSHC timings, and Table 48 and Table 49 list the timing parameters.

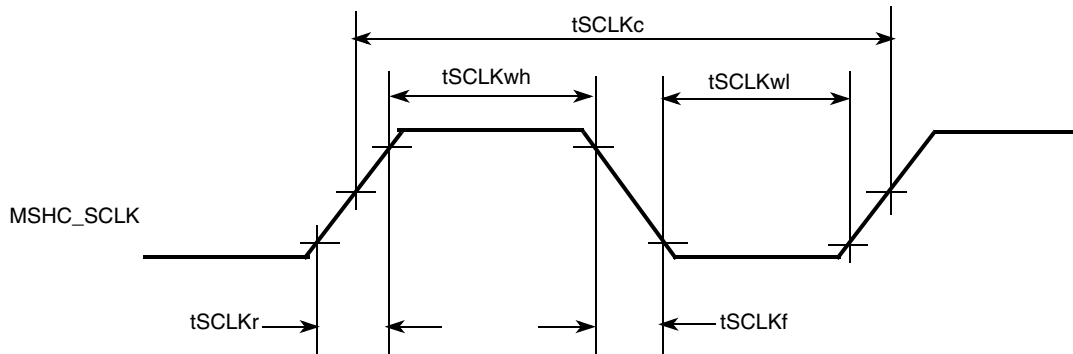


Figure 64. MSHC\_CLK Timing Diagram

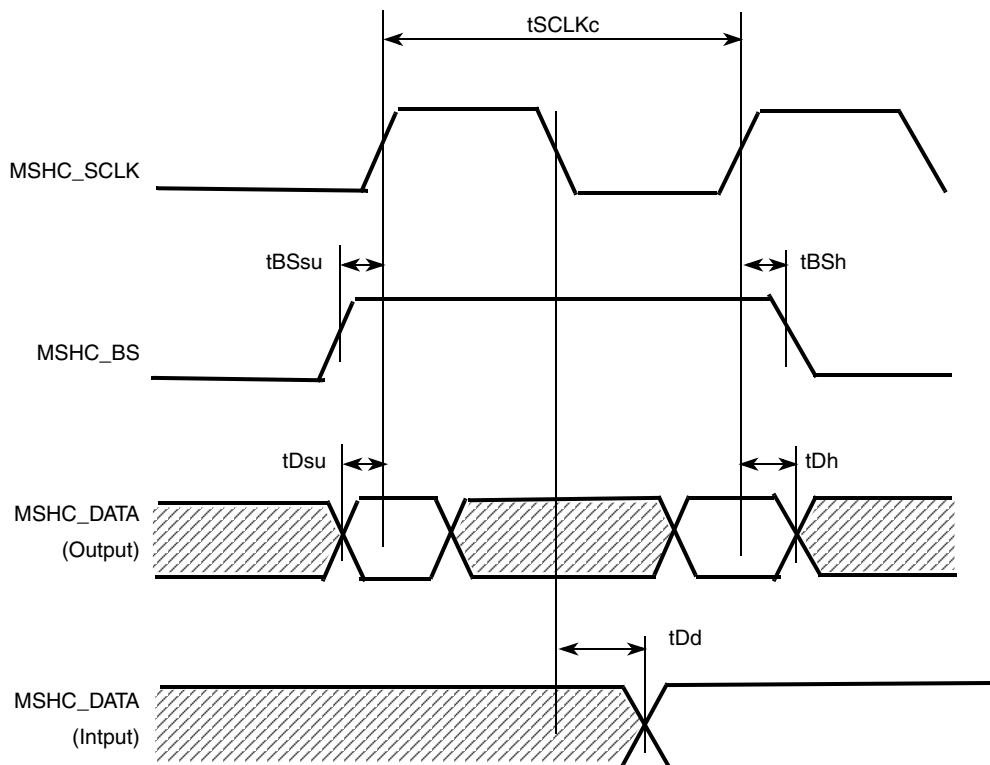


Figure 65. Transfer Operation Timing Diagram (Serial)

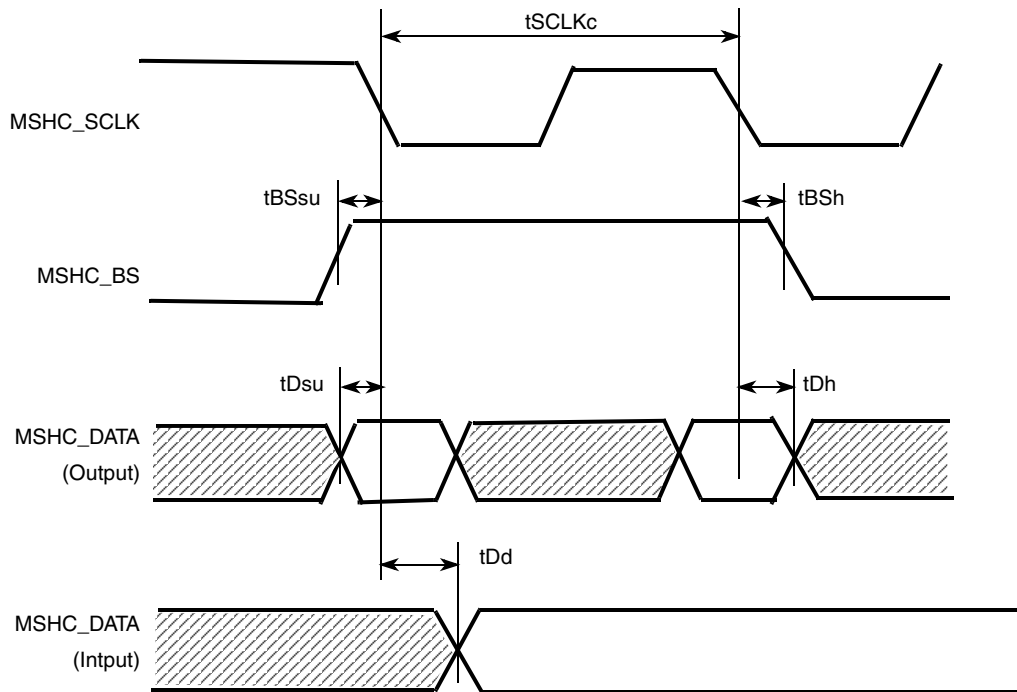


Figure 66. Transfer Operation Timing Diagram (Parallel)

**NOTE**

The Memory Stick Host Controller is designed to meet the timing requirements per Sony's *Memory Stick Pro Format Specifications* document. Tables in this section details the specifications requirements for parallel and serial modes, and not the i.MX31/i.MX31L timing.

**Table 48. Serial Interface Timing Parameters<sup>1</sup>**

| Signal    | Parameter         | Symbol  | Standards |      | Unit |
|-----------|-------------------|---------|-----------|------|------|
|           |                   |         | Min.      | Max. |      |
| MSHC_SCLK | Cycle             | tSCLKc  | 50        | –    | ns   |
|           | H pulse length    | tSCLKwh | 15        | –    | ns   |
|           | L pulse length    | tSCLKwl | 15        | –    | ns   |
|           | Rise time         | tSCLKr  | –         | 10   | ns   |
|           | Fall time         | tSCLKf  | –         | 10   | ns   |
| MSHC_BS   | Setup time        | tBSsu   | 5         | –    | ns   |
|           | Hold time         | tBSH    | 5         | –    | ns   |
| MSHC_DATA | Setup time        | tDsu    | 5         | –    | ns   |
|           | Hold time         | tDh     | 5         | –    | ns   |
|           | Output delay time | tDd     | –         | 15   | ns   |

<sup>1</sup> Timing is guaranteed for NVCC from 2.7 through 3.1 V and up to a maximum overdrive NVCC of 3.3 V. See NVCC restrictions described in [Table 7, "Operating Ranges," on page 12.](#)

**Table 49. Parallel Interface Timing Parameters<sup>1</sup>**

| Signal    | Parameter         | Symbol  | Standards |     | Unit |
|-----------|-------------------|---------|-----------|-----|------|
|           |                   |         | Min       | Max |      |
| MSHC_SCLK | Cycle             | tSCLKc  | 25        | –   | ns   |
|           | H pulse length    | tSCLKwh | 5         | –   | ns   |
|           | L pulse length    | tSCLKwl | 5         | –   | ns   |
|           | Rise time         | tSCLKr  | –         | 10  | ns   |
|           | Fall time         | tSCLKf  | –         | 10  | ns   |
| MSHC_BS   | Setup time        | tBSsu   | 8         | –   | ns   |
|           | Hold time         | tBSsh   | 1         | –   | ns   |
| MSHC_DATA | Setup time        | tDsu    | 8         | –   | ns   |
|           | Hold time         | tDh     | 1         | –   | ns   |
|           | Output delay time | tDd     | –         | 15  | ns   |

<sup>1</sup> Timing is guaranteed for NVCC from 2.7 through 3.1 V and up to a maximum overdrive NVCC of 3.3 V. See NVCC restrictions described in [Table 7, "Operating Ranges," on page 12](#).

#### 4.3.17 Personal Computer Memory Card International Association (PCMCIA)

[Figure 67](#) and [Figure 68](#) depict the timings pertaining to the PCMCIA module, each of which is an example of one clock of strobe set-up time and one clock of strobe hold time. [Table 50](#) lists the timing parameters.

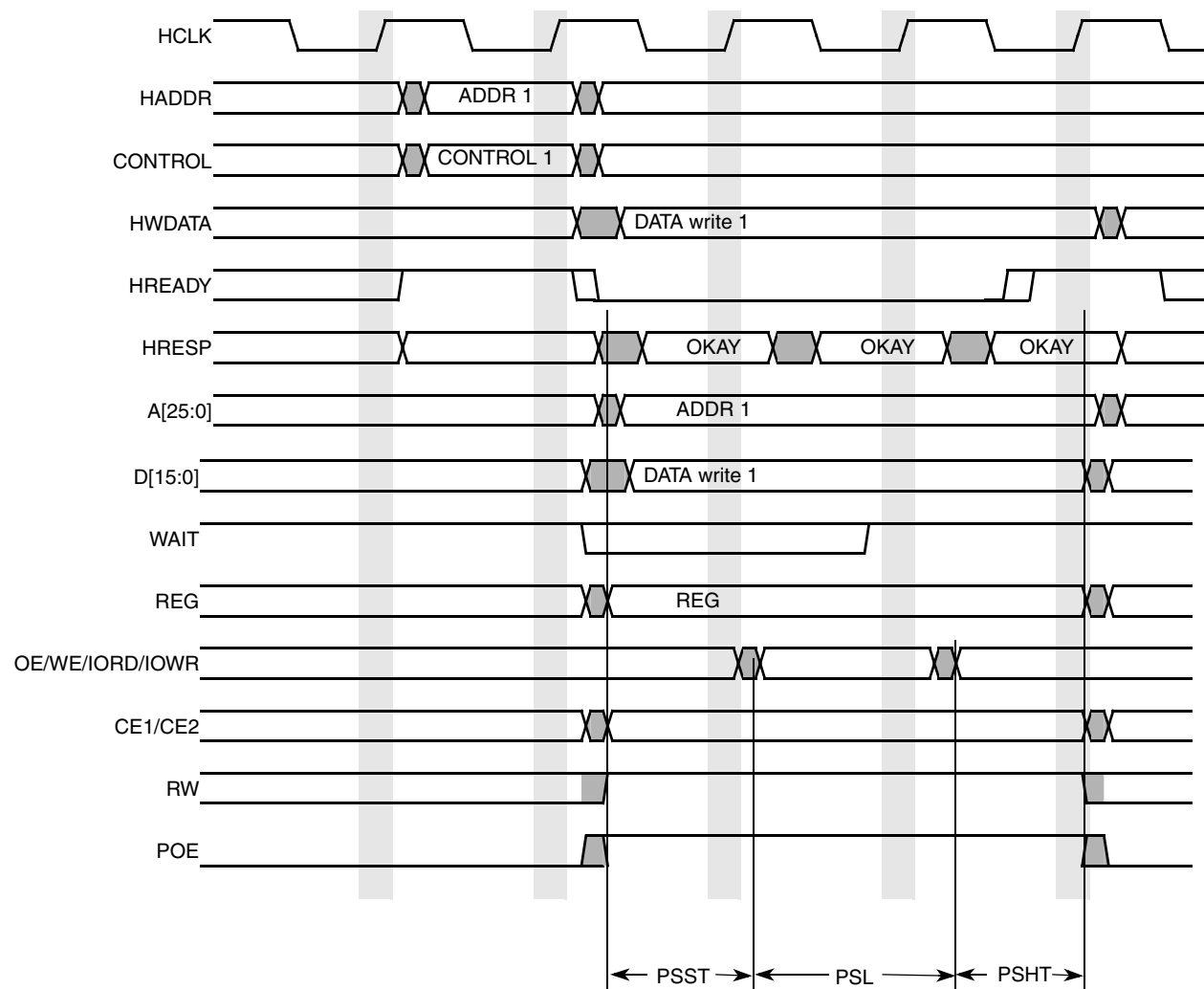


Figure 67. Write Accesses Timing Diagram—PSHT=1, PSST=1

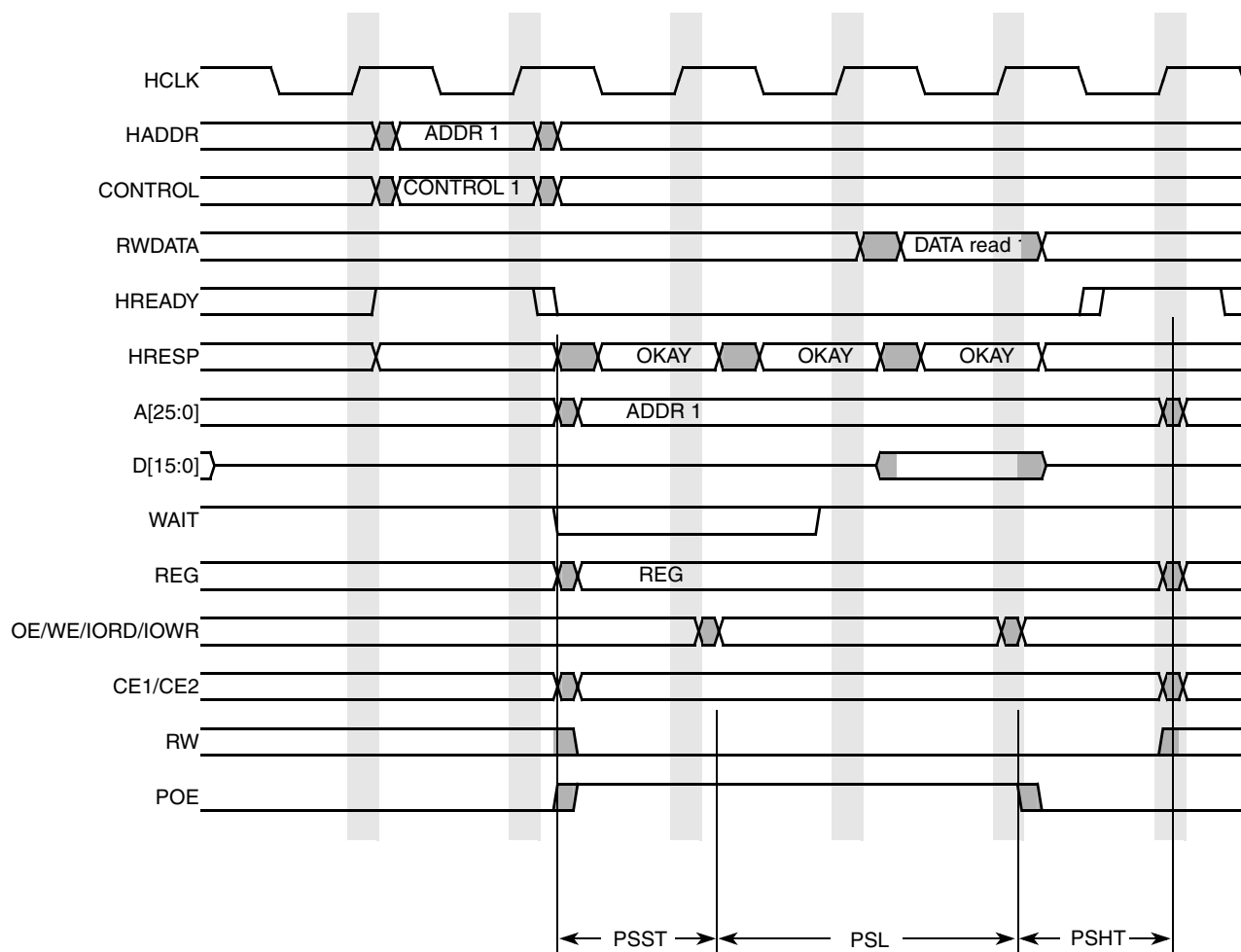


Figure 68. Read Accesses Timing Diagram—PSHT=1, PSST=1

Table 50. PCMCIA Write and Read Timing Parameters

| Symbol | Parameter                 | Min | Max | Unit  |
|--------|---------------------------|-----|-----|-------|
| PSHT   | PCMCIA strobe hold time   | 0   | 63  | clock |
| PSST   | PCMCIA strobe set up time | 1   | 63  | clock |
| PSL    | PCMCIA strobe length      | 1   | 128 | clock |

### 4.3.18 PWM Electrical Specifications

This section describes the electrical information of the PWM. The PWM can be programmed to select one of three clock signals as its source frequency. The selected clock signal is passed through a prescaler before being input to the counter. The output is available at the pulse-width modulator output (PWMO) external pin.

### 4.3.18.1 PWM Timing

Figure 69 depicts the timing of the PWM, and Table 51 lists the PWM timing characteristics.

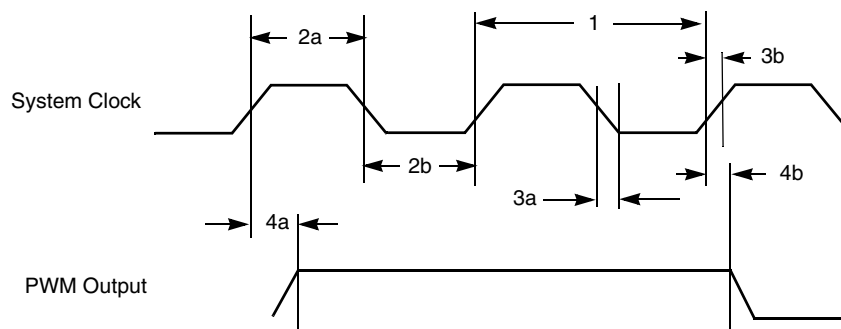


Figure 69. PWM Timing

Table 51. PWM Output Timing Parameters

| ID | Parameter                         | Min   | Max     | Unit |
|----|-----------------------------------|-------|---------|------|
| 1  | System CLK frequency <sup>1</sup> | 0     | ipg_clk | MHz  |
| 2a | Clock high time                   | 12.29 | –       | ns   |
| 2b | Clock low time                    | 9.91  | –       | ns   |
| 3a | Clock fall time                   | –     | 0.5     | ns   |
| 3b | Clock rise time                   | –     | 0.5     | ns   |
| 4a | Output delay time                 | –     | 9.37    | ns   |
| 4b | Output setup time                 | 8.71  | –       | ns   |

<sup>1</sup> CL of PWMO = 30 pF

### 4.3.19 SDHC Electrical Specifications

This section describes the electrical information of the SDHC.

#### 4.3.19.1 SDHC Timing

Figure 70 depicts the timings of the SDHC, and Table 52 lists the timing parameters.

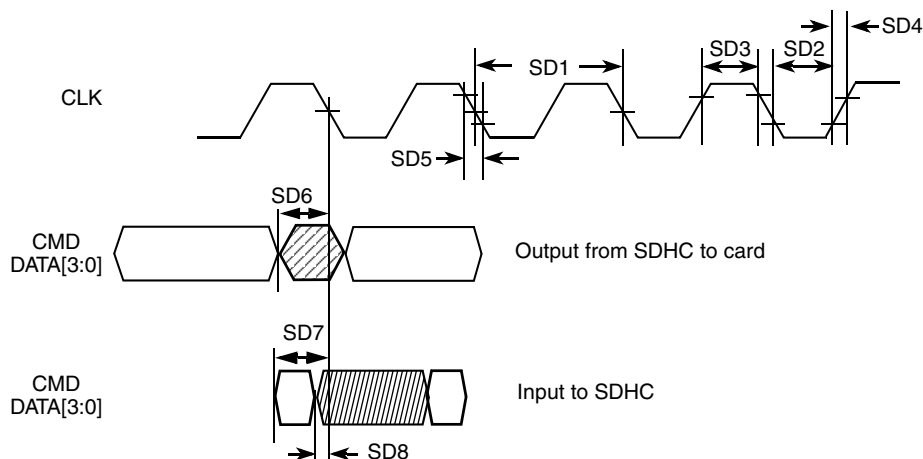


Figure 70. SDHC Timing Diagram

Table 52. SDHC Interface Timing Parameters

| ID                                                    | Parameter                             | Symbol     | Min  | Max   | Unit |
|-------------------------------------------------------|---------------------------------------|------------|------|-------|------|
| Card Input Clock                                      |                                       |            |      |       |      |
| SD1                                                   | Clock Frequency (Low Speed)           | $f_{PP}^1$ | 0    | 400   | kHz  |
|                                                       | Clock Frequency (SD/SDIO Full Speed)  | $f_{PP}^2$ | 0    | 25    | MHz  |
|                                                       | Clock Frequency (MMC Full Speed)      | $f_{PP}^3$ | 0    | 20    | MHz  |
|                                                       | Clock Frequency (Identification Mode) | $f_{OD}^4$ | 100  | 400   | kHz  |
| SD2                                                   | Clock Low Time                        | $t_{WL}$   | 10   | —     | ns   |
| SD3                                                   | Clock High Time                       | $t_{WH}$   | 10   | —     | ns   |
| SD4                                                   | Clock Rise Time                       | $t_{TLH}$  | —    | 10    | ns   |
| SD5                                                   | Clock Fall Time                       | $t_{THL}$  | —    | 10    | ns   |
| SDHC output / Card inputs CMD, DAT (Reference to CLK) |                                       |            |      |       |      |
| SD6                                                   | SDHC output delay                     | $t_{ODL}$  | -6.5 | 3     | ns   |
| SDHC input / Card outputs CMD, DAT (Reference to CLK) |                                       |            |      |       |      |
| SD7                                                   | SDHC input setup                      | $t_{IS}$   | —    | 18.5  | ns   |
| SD8                                                   | SDHC input hold                       | $t_{IH}$   | —    | -11.5 | ns   |

<sup>1</sup> In low speed mode, card clock must be lower than 400 kHz, voltage ranges from 2.7 to 3.3 V.

<sup>2</sup> In normal data transfer mode for SD/SDIO card, clock frequency can be any value between 0 – 25 MHz.

<sup>3</sup> In normal data transfer mode for MMC card, clock frequency can be any value between 0 – 20 MHz.

<sup>4</sup> In card identification mode, card clock must be 100 kHz ~ 400 kHz, voltage ranges from 2.7 to 3.3 V.

#### 4.3.20 SIM Electrical Specifications

Each SIM card interface consist of a total of 12 pins (for 2 separate ports of 6 pins each. Mostly one port with 5 pins is used).

The interface is meant to be used with synchronous SIM cards. This means that the SIM module provides a clock for the SIM card to use. The frequency of this clock is normally 372 times the data rate on the TX/RX pins, however SIM module can work with CLK equal to 16 times the data rate on TX/RX pins.

There is no timing relationship between the clock and the data. The clock that the SIM module provides to the aim card will be used by the SIM card to recover the clock from the data much like a standard UART. All six (or 5 in case bi directional TXRX is used) of the pins for each half of the SIM module are asynchronous to each other.

There are no required timing relationships between the signals in normal mode, but there are some in two specific cases: reset and power down sequences.

### 4.3.20.1 General Timing Requirements

Figure 71 shows the timing of the SIM module, and Figure 53 lists the timing parameters.

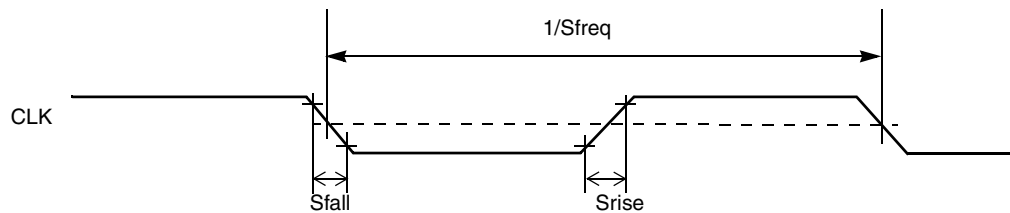


Figure 71. SIM Clock Timing Diagram

Table 53. SIM Timing Specification—High Drive Strength

| Num | Description                            | Symbol      | Min  | Max                             | Unit |
|-----|----------------------------------------|-------------|------|---------------------------------|------|
| 1   | SIM Clock Frequency (CLK) <sup>1</sup> | $S_{freq}$  | 0.01 | 5 (Some new cards may reach 10) | MHz  |
| 2   | SIM CLK Rise Time <sup>2</sup>         | $S_{rise}$  | —    | 20                              | ns   |
| 3   | SIM CLK Fall Time <sup>3</sup>         | $S_{fall}$  | —    | 20                              | ns   |
| 4   | SIM Input Transition Time (RX, SIMPD)  | $S_{trans}$ | —    | 25                              | ns   |

<sup>1</sup> 50% duty cycle clock

<sup>2</sup> With C = 50pF

<sup>3</sup> With C = 50pF

### 4.3.20.2 Reset Sequence

#### 4.3.20.2.1 Cards with Internal Reset

The sequence of reset for this kind of SIM Cards is as follows (see Figure 72):

- After powerup, the clock signal is enabled on SGCLK (time T0)
- After 200 clock cycles, RX must be high.
- The card must send a response on RX acknowledging the reset between 400 and 40000 clock cycles after T0.

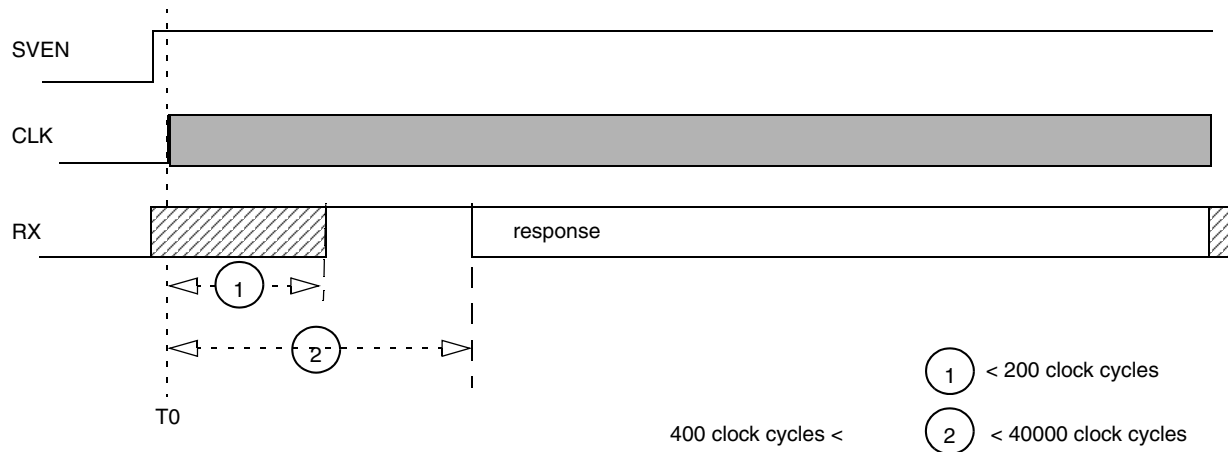


Figure 72. Internal-Reset Card Reset Sequence

#### 4.3.20.2.2 Cards with Active Low Reset

The sequence of reset for this kind of card is as follows (see Figure 73):

1. After powerup, the clock signal is enabled on CLK (time T0)
2. After 200 clock cycles, RX must be high.
3. RST must remain Low for at least 40000 clock cycles after T0 (no response is to be received on RX during those 40000 clock cycles)
4. RST is set High (time T1)
5. RST must remain High for at least 40000 clock cycles after T1 and a response must be received on RX between 400 and 40000 clock cycles after T1.

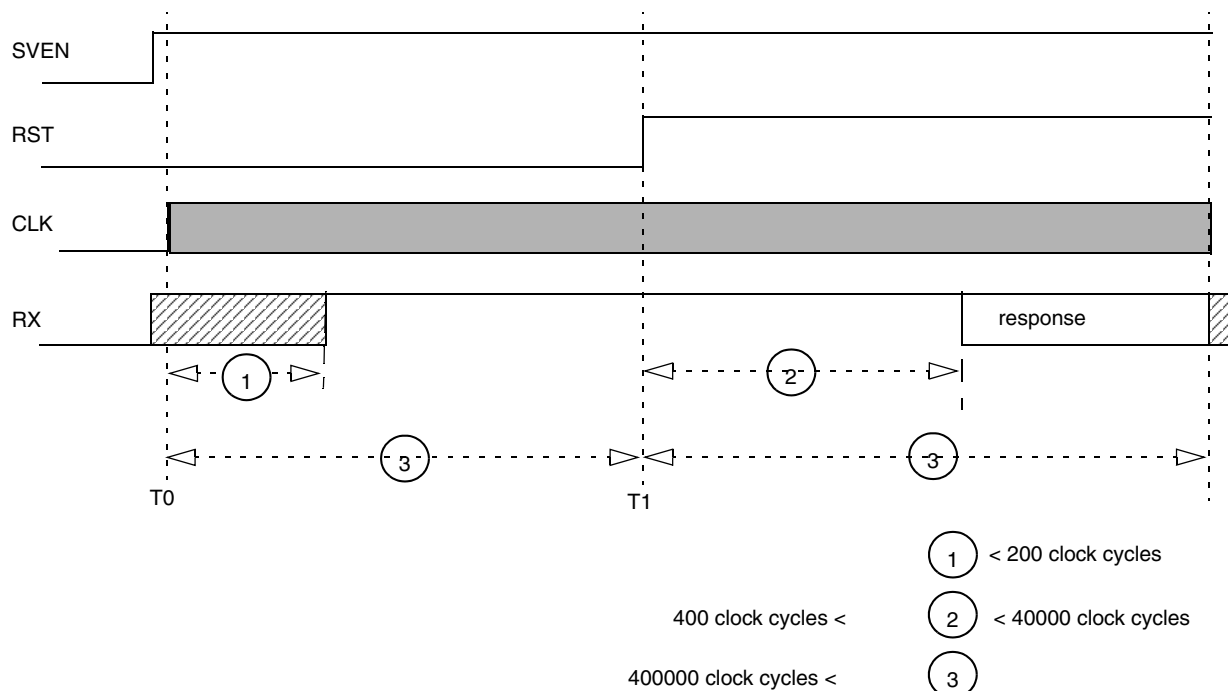


Figure 73. Active-Low-Reset Card Reset Sequence

### 4.3.20.3 Power Down Sequence

Power down sequence for SIM interface is as follows:

1. SIMPD port detects the removal of the SIM Card
2. RST goes Low
3. CLK goes Low
4. TX goes Low
5. VEN goes Low

Each of this steps is done in one CKIL period (usually 32 kHz). Power down can be started because of a SIM Card removal detection or launched by the processor. [Figure 74](#) and [Table 54](#) show the usual timing requirements for this sequence, with  $F_{ckil}$  = CKIL frequency value.

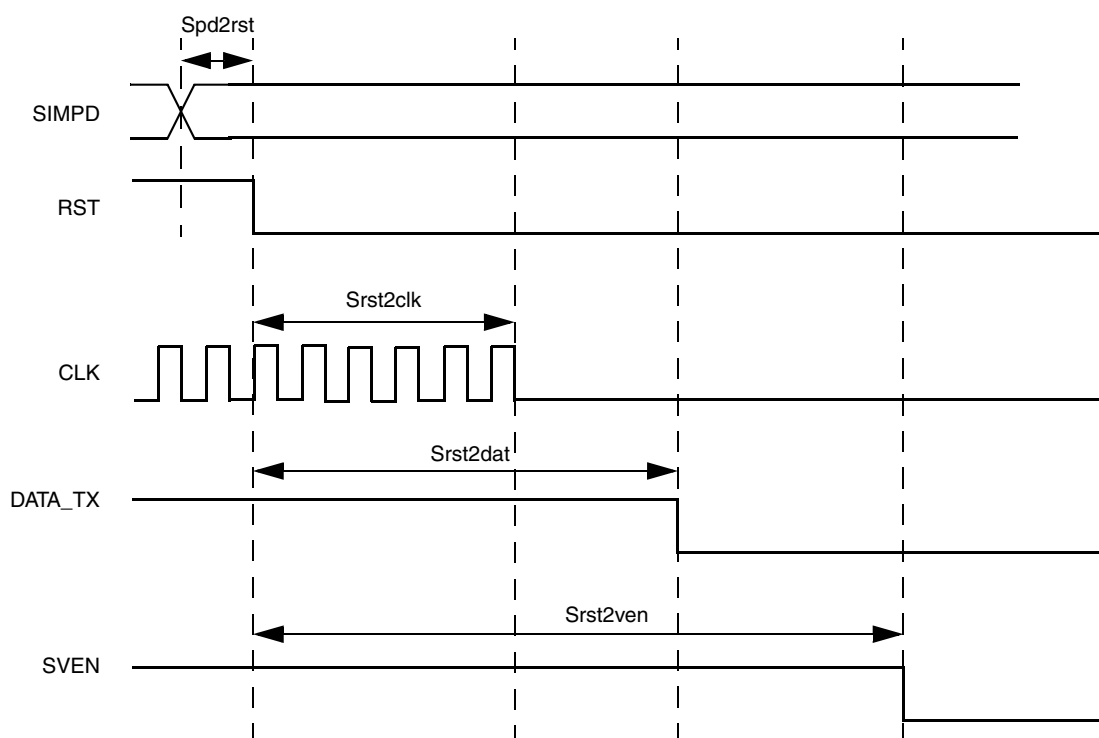


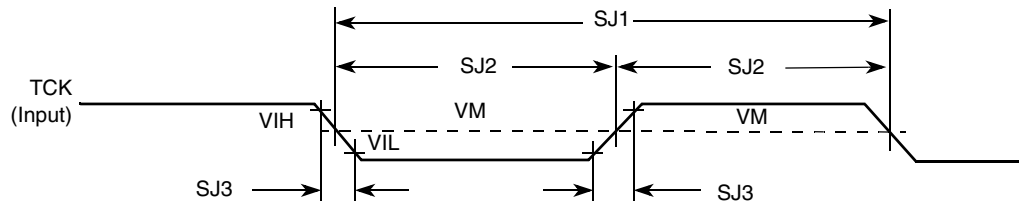
Figure 74. SmartCard Interface Power Down AC Timing

Table 54. Timing Requirements for Power Down Sequence

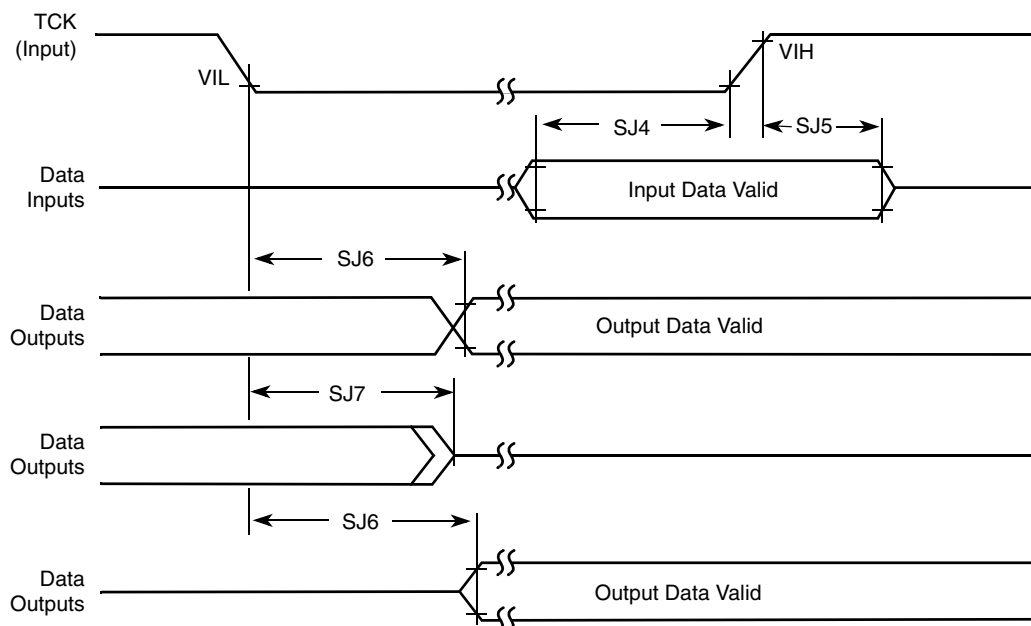
| Num | Description                          | Symbol        | Min                    | Max | Unit    |
|-----|--------------------------------------|---------------|------------------------|-----|---------|
| 1   | SIM reset to SIM clock stop          | $S_{rst2clk}$ | $0.9 \cdot 1/F_{CKIL}$ | 0.8 | $\mu s$ |
| 2   | SIM reset to SIM TX data low         | $S_{rst2dat}$ | $1.8 \cdot 1/F_{CKIL}$ | 1.2 | $\mu s$ |
| 3   | SIM reset to SIM Voltage Enable Low  | $S_{rst2ven}$ | $2.7 \cdot 1/F_{CKIL}$ | 1.8 | $\mu s$ |
| 4   | SIM Presence Detect to SIM reset Low | $S_{pd2rst}$  | $0.9 \cdot 1/F_{CKIL}$ | 25  | ns      |

### 4.3.21 SJC Electrical Specifications

This section details the electrical characteristics for the SJC module. [Figure 75](#) depicts the SJC test clock input timing. [Figure 76](#) depicts the SJC boundary scan timing, [Figure 77](#) depicts the SJC test access port, [Figure 78](#) depicts the SJC  $\overline{\text{TRST}}$  timing, and [Table 55](#) lists the SJC timing parameters.

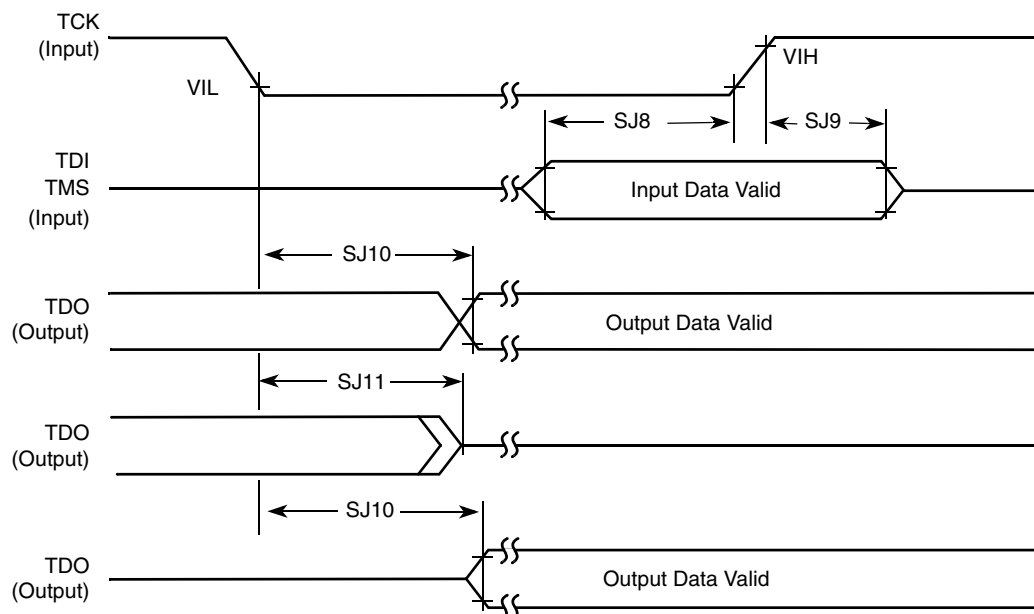


**Figure 75. Test Clock Input Timing Diagram**

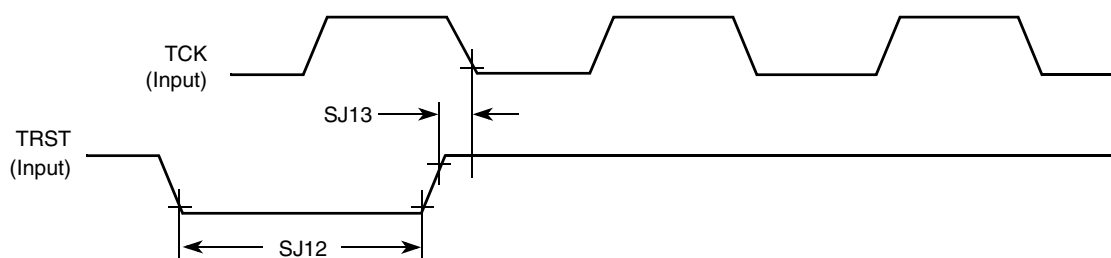


**Figure 76. Boundary Scan (JTAG) Timing Diagram**

## Electrical Characteristics



**Figure 77. Test Access Port Timing Diagram**



**Figure 78. TRST Timing Diagram**

**Table 55. SJC Timing Parameters**

| ID   | Parameter                                 | All Frequencies  |     | Unit |
|------|-------------------------------------------|------------------|-----|------|
|      |                                           | Min              | Max |      |
| SJ1  | TCK cycle time                            | 100 <sup>1</sup> | –   | ns   |
| SJ2  | TCK clock pulse width measured at $V_M^2$ | 40               | –   | ns   |
| SJ3  | TCK rise and fall times                   | –                | 3   | ns   |
| SJ4  | Boundary scan input data set-up time      | 10               | –   | ns   |
| SJ5  | Boundary scan input data hold time        | 50               | –   | ns   |
| SJ6  | TCK low to output data valid              | –                | 50  | ns   |
| SJ7  | TCK low to output high impedance          | –                | 50  | ns   |
| SJ8  | TMS, TDI data set-up time                 | 10               | –   | ns   |
| SJ9  | TMS, TDI data hold time                   | 50               | –   | ns   |
| SJ10 | TCK low to TDO data valid                 | –                | 44  | ns   |

Table 55. SJC Timing Parameters (continued)

| ID   | Parameter                                       | All Frequencies |     | Unit |
|------|-------------------------------------------------|-----------------|-----|------|
|      |                                                 | Min             | Max |      |
| SJ11 | TCK low to TDO high impedance                   | –               | 44  | ns   |
| SJ12 | $\overline{\text{TRST}}$ assert time            | 100             | –   | ns   |
| SJ13 | $\overline{\text{TRST}}$ set-up time to TCK low | 40              | –   | ns   |

<sup>1</sup> On cases where SDMA TAP is put in the chain, the max TCK frequency is limited by max ratio of 1:8 of SDMA core frequency to TCK limitation. This implies max frequency of 8.25 MHz (or 121.2 ns) for 66 MHz IPG clock.

<sup>2</sup>  $V_M$  - mid point voltage

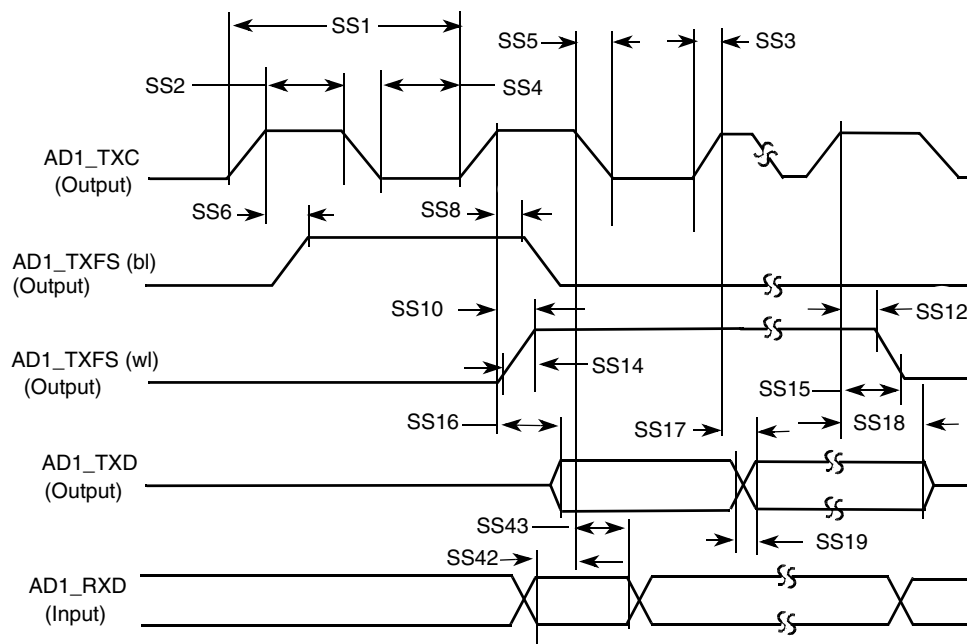
### 4.3.22 SSI Electrical Specifications

This section describes the electrical information of SSI. Note the following pertaining to timing information:

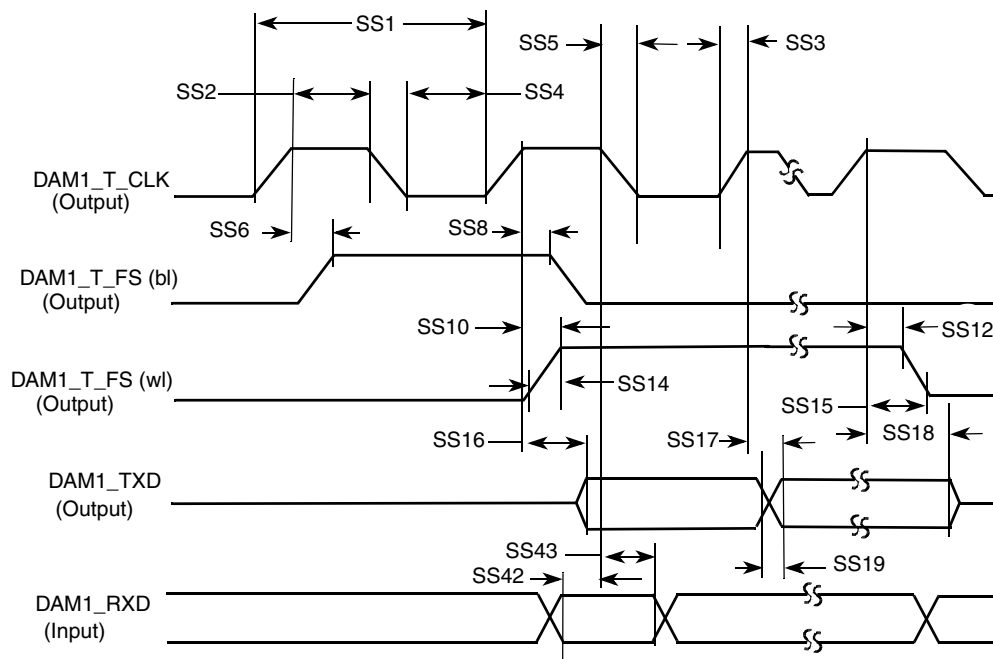
- All the timings for the SSI are given for a non-inverted serial clock polarity (TSCKP/RSCKP = 0) and a non-inverted frame sync (TFSI/RFSI = 0). If the polarity of the clock and/or the frame sync have been inverted, all the timing remains valid by inverting the clock signal STCK/SRCK and/or the frame sync STFS/SRFS shown in the tables and in the figures.
- All timings are on AUDMUX signals when SSI is being used for data transfer.
- “Tx” and “Rx” refer to the Transmit and Receive sections of the SSI.
- For internal Frame Sync operation using external clock, the FS timing will be same as that of Tx Data (for example, during AC97 mode of operation).

#### 4.3.22.1 SSI Transmitter Timing with Internal Clock

Figure 79 depicts the SSI transmitter timing with internal clock, and Table 56 lists the timing parameters.



**Note:** SRXD Input in Synchronous mode only



**Note:** SRXD Input in Synchronous mode only

**Figure 79. SSI Transmitter with Internal Clock Timing Diagram**

**Table 56. SSI Transmitter with Internal Clock Timing Parameters**

| ID                                   | Parameter                                      | Min  | Max  | Unit |
|--------------------------------------|------------------------------------------------|------|------|------|
| Internal Clock Operation             |                                                |      |      |      |
| SS1                                  | (Tx/Rx) CK clock period                        | 81.4 | –    | ns   |
| SS2                                  | (Tx/Rx) CK clock high period                   | 36.0 | –    | ns   |
| SS3                                  | (Tx/Rx) CK clock rise time                     | –    | 6    | ns   |
| SS4                                  | (Tx/Rx) CK clock low period                    | 36.0 | –    | ns   |
| SS5                                  | (Tx/Rx) CK clock fall time                     | –    | 6    | ns   |
| SS6                                  | (Tx) CK high to FS (bl) high                   | –    | 15.0 | ns   |
| SS8                                  | (Tx) CK high to FS (bl) low                    | –    | 15.0 | ns   |
| SS10                                 | (Tx) CK high to FS (wl) high                   | –    | 15.0 | ns   |
| SS12                                 | (Tx) CK high to FS (wl) low                    | –    | 15.0 | ns   |
| SS14                                 | (Tx/Rx) Internal FS rise time                  | –    | 6    | ns   |
| SS15                                 | (Tx/Rx) Internal FS fall time                  | –    | 6    | ns   |
| SS16                                 | (Tx) CK high to STXD valid from high impedance | –    | 15.0 | ns   |
| SS17                                 | (Tx) CK high to STXD high/low                  | –    | 15.0 | ns   |
| SS18                                 | (Tx) CK high to STXD high impedance            | –    | 15.0 | ns   |
| SS19                                 | STXD rise/fall time                            | –    | 6    | ns   |
| Synchronous Internal Clock Operation |                                                |      |      |      |
| SS42                                 | SRXD setup before (Tx) CK falling              | 10.0 | –    | ns   |
| SS43                                 | SRXD hold after (Tx) CK falling                | 0    | –    | ns   |
| SS52                                 | Loading                                        | –    | 25   | pF   |

The diagram shows the timing for two channels, AD1 and DAM1. Each channel has four signals: TXC (Output), TXFS (bl) (Output), TXFS (wl) (Output), and RXD (Input). The RXD signal is shown as a differential pair. The TXC signal is a square wave. The TXFS (bl) signal is a square wave that is high during the TXC pulse. The TXFS (wl) signal is a square wave that is high during the TXC pulse. The RXD signal is a square wave that is high during the TXC pulse. The timing intervals are labeled SS1 through SS51. The diagram shows the relationship between the TXC, TXFS, and RXD signals and the timing intervals.

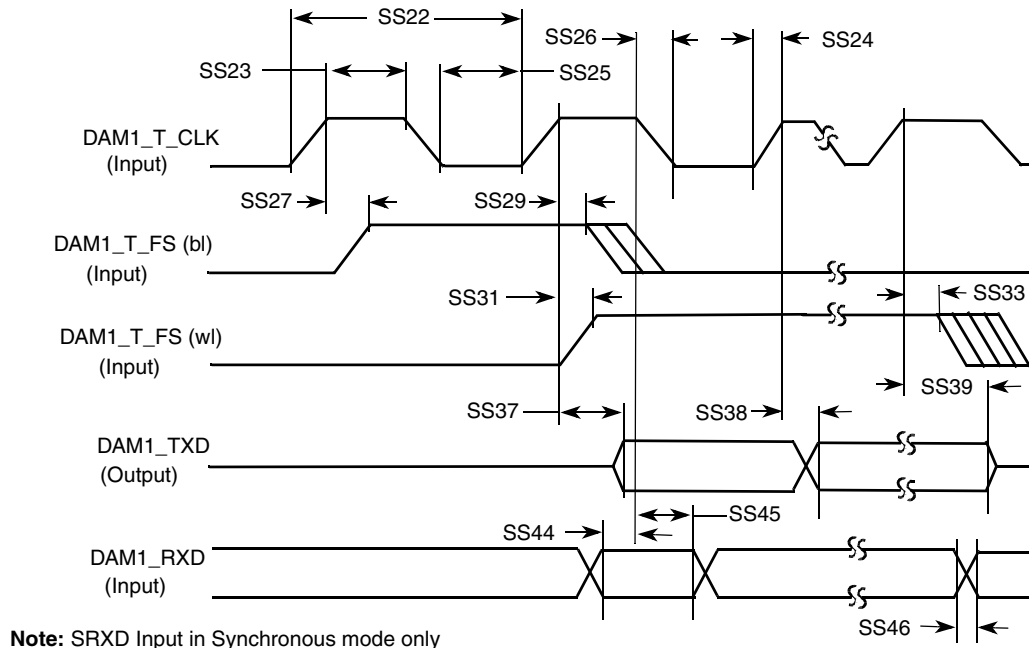
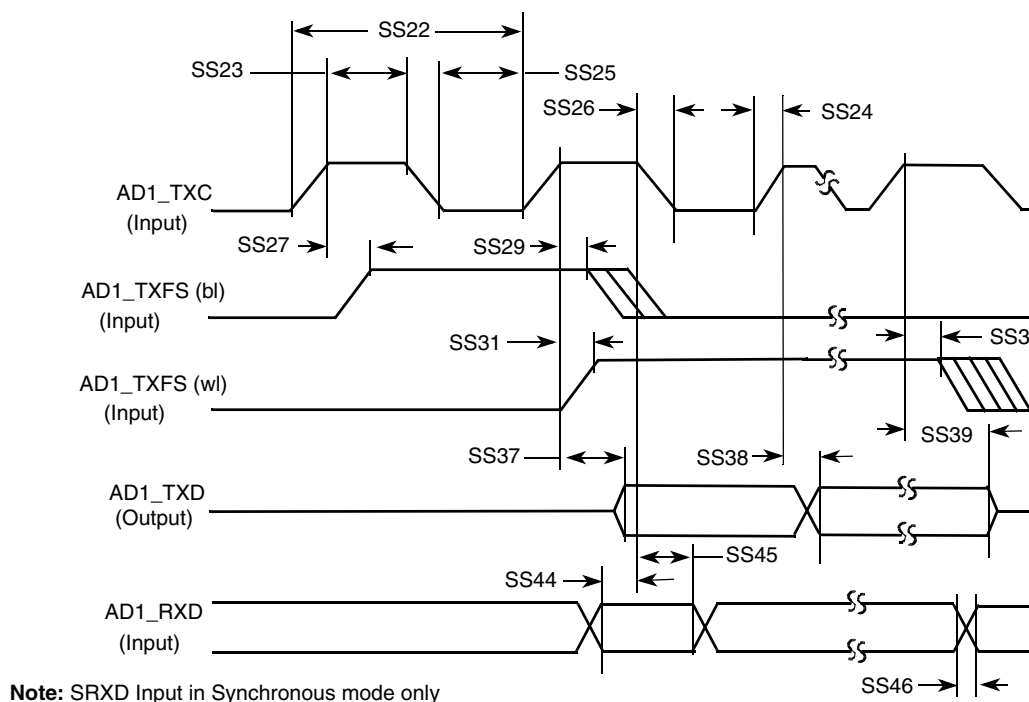
**i.MX31/i.MX31L Advance Information, Rev. 2.3**

**Table 57. SSI Receiver with Internal Clock Timing Parameters**

| ID                           | Parameter                          | Min   | Max  | Unit |
|------------------------------|------------------------------------|-------|------|------|
| Internal Clock Operation     |                                    |       |      |      |
| SS1                          | (Tx/Rx) CK clock period            | 81.4  | –    | ns   |
| SS2                          | (Tx/Rx) CK clock high period       | 36.0  | –    | ns   |
| SS3                          | (Tx/Rx) CK clock rise time         | –     | 6    | ns   |
| SS4                          | (Tx/Rx) CK clock low period        | 36.0  | –    | ns   |
| SS5                          | (Tx/Rx) CK clock fall time         | –     | 6    | ns   |
| SS7                          | (Rx) CK high to FS (bl) high       | –     | 15.0 | ns   |
| SS9                          | (Rx) CK high to FS (bl) low        | –     | 15.0 | ns   |
| SS11                         | (Rx) CK high to FS (wl) high       | –     | 15.0 | ns   |
| SS13                         | (Rx) CK high to FS (wl) low        | –     | 15.0 | ns   |
| SS20                         | SRXD setup time before (Rx) CK low | 10.0  | –    | ns   |
| SS21                         | SRXD hold time after (Rx) CK low   | 0     | –    | ns   |
| Oversampling Clock Operation |                                    |       |      |      |
| SS47                         | Oversampling clock period          | 15.04 | –    | ns   |
| SS48                         | Oversampling clock high period     | 6     | –    | ns   |
| SS49                         | Oversampling clock rise time       | –     | 3    | ns   |
| SS50                         | Oversampling clock low period      | 6     | –    | ns   |
| SS51                         | Oversampling clock fall time       | –     | 3    | ns   |

### 4.3.22.3 SSI Transmitter Timing with External Clock

Figure 81 depicts the SSI transmitter timing with external clock, and Table 58 lists the timing parameters.



**Figure 81. SSI Transmitter with External Clock Timing Diagram**

**Table 58. SSI Transmitter with External Clock Timing Parameters**

| ID                                   | Parameter                                      | Min   | Max  | Unit |
|--------------------------------------|------------------------------------------------|-------|------|------|
| External Clock Operation             |                                                |       |      |      |
| SS22                                 | (Tx/Rx) CK clock period                        | 81.4  | –    | ns   |
| SS23                                 | (Tx/Rx) CK clock high period                   | 36.0  | –    | ns   |
| SS24                                 | (Tx/Rx) CK clock rise time                     | –     | 6.0  | ns   |
| SS25                                 | (Tx/Rx) CK clock low period                    | 36.0  | –    | ns   |
| SS26                                 | (Tx/Rx) CK clock fall time                     | –     | 6.0  | ns   |
| SS27                                 | (Tx) CK high to FS (bl) high                   | –10.0 | 15.0 | ns   |
| SS29                                 | (Tx) CK high to FS (bl) low                    | 10.0  | –    | ns   |
| SS31                                 | (Tx) CK high to FS (wl) high                   | –10.0 | 15.0 | ns   |
| SS33                                 | (Tx) CK high to FS (wl) low                    | 10.0  | –    | ns   |
| SS37                                 | (Tx) CK high to STXD valid from high impedance | –     | 15.0 | ns   |
| SS38                                 | (Tx) CK high to STXD high/low                  | –     | 15.0 | ns   |
| SS39                                 | (Tx) CK high to STXD high impedance            | –     | 15.0 | ns   |
| Synchronous External Clock Operation |                                                |       |      |      |
| SS44                                 | SRXD setup before (Tx) CK falling              | 10.0  | –    | ns   |
| SS45                                 | SRXD hold after (Tx) CK falling                | 2.0   | –    | ns   |
| SS46                                 | SRXD rise/fall time                            | –     | 6.0  | ns   |

#### 4.3.22.4 SSI Receiver Timing with External Clock

Figure 82 depicts the SSI receiver timing with external clock, and Table 59 lists the timing parameters.

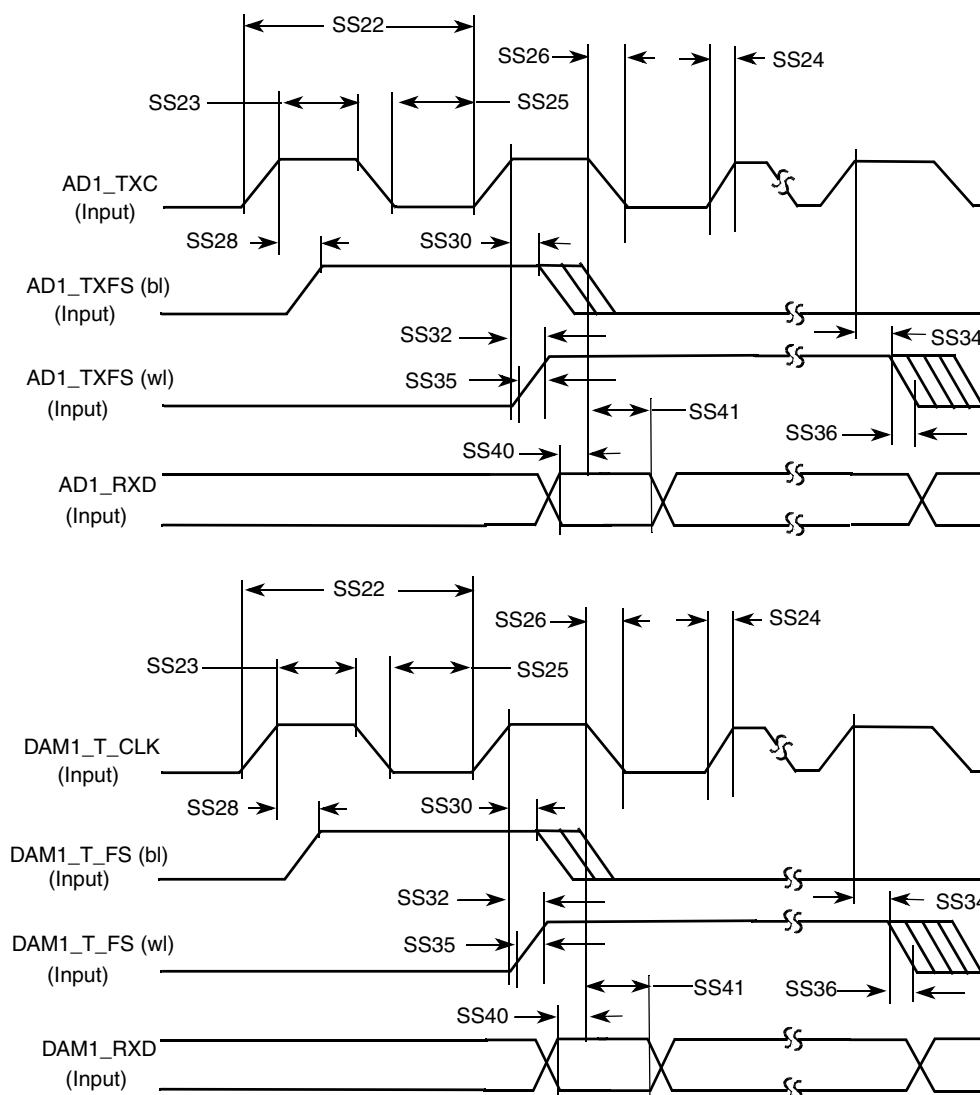


Figure 82. SSI Receiver with External Clock Timing Diagram

Table 59. SSI Receiver with External Clock Timing Parameters

| ID                       | Parameter                    | Min  | Max | Unit |
|--------------------------|------------------------------|------|-----|------|
| External Clock Operation |                              |      |     |      |
| SS22                     | (Tx/Rx) CK clock period      | 81.4 | —   | ns   |
| SS23                     | (Tx/Rx) CK clock high period | 36.0 | —   | ns   |
| SS24                     | (Tx/Rx) CK clock rise time   | —    | 6.0 | ns   |
| SS25                     | (Tx/Rx) CK clock low period  | 36.0 | —   | ns   |
| SS26                     | (Tx/Rx) CK clock fall time   | —    | 6.0 | ns   |

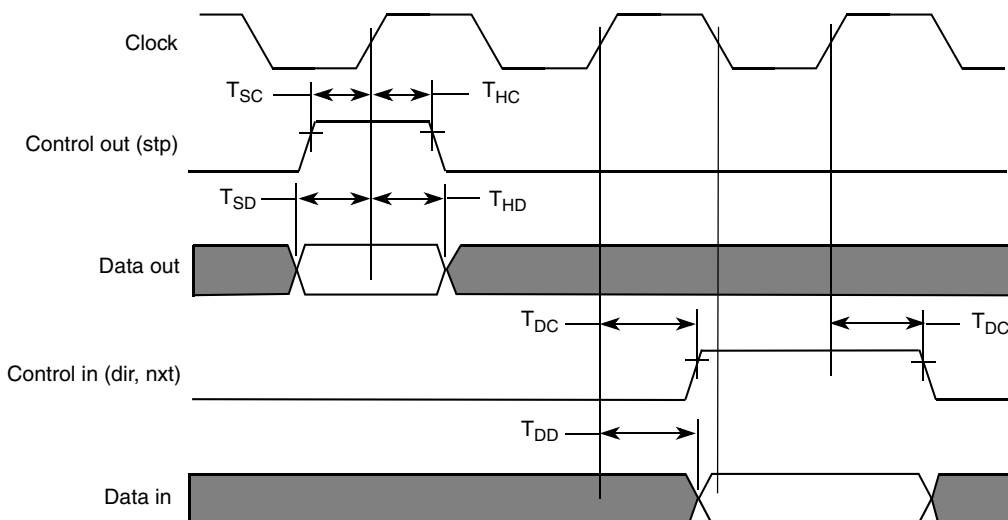
**Table 59. SSI Receiver with External Clock Timing Parameters (continued)**

| ID   | Parameter                          | Min   | Max  | Unit |
|------|------------------------------------|-------|------|------|
| SS28 | (Rx) CK high to FS (bl) high       | -10.0 | 15.0 | ns   |
| SS30 | (Rx) CK high to FS (bl) low        | 10.0  | –    | ns   |
| SS32 | (Rx) CK high to FS (wl) high       | -10.0 | 15.0 | ns   |
| SS34 | (Rx) CK high to FS (wl) low        | 10.0  | –    | ns   |
| SS35 | (Tx/Rx) External FS rise time      | –     | 6.0  | ns   |
| SS36 | (Tx/Rx) External FS fall time      | –     | 6.0  | ns   |
| SS40 | SRXD setup time before (Rx) CK low | 10.0  | –    | ns   |
| SS41 | SRXD hold time after (Rx) CK low   | 2.0   | –    | ns   |

### 4.3.23 USB Electrical Specifications

This section describes the electrical information of the USBOTG port. The OTG port supports both serial and parallel interfaces.

The high speed (HS) interface is supported via the ULPI (Ultra Low Pin Count Interface). [Figure 83](#) depicts the USB ULPI timing diagram, and [Table 60](#) lists the timing parameters.

**Figure 83. USB ULPI Interface Timing Diagram****Table 60. USB ULPI Interface Timing Specification<sup>1</sup>**

| Parameter                                  | Symbol                            | Min | Max | Units |
|--------------------------------------------|-----------------------------------|-----|-----|-------|
| Setup time (control in, 8-bit data in)     | T <sub>SC</sub> , T <sub>SD</sub> | 6   | –   | ns    |
| Hold time (control in, 8-bit data in)      | T <sub>HC</sub> , T <sub>HD</sub> | 0   | –   | ns    |
| Output delay (control out, 8-bit data out) | T <sub>DC</sub> , T <sub>DD</sub> | –   | 9   | ns    |

<sup>1</sup> Timing parameters are given as viewed by transceiver side.

## 5 Package Information and Pinout

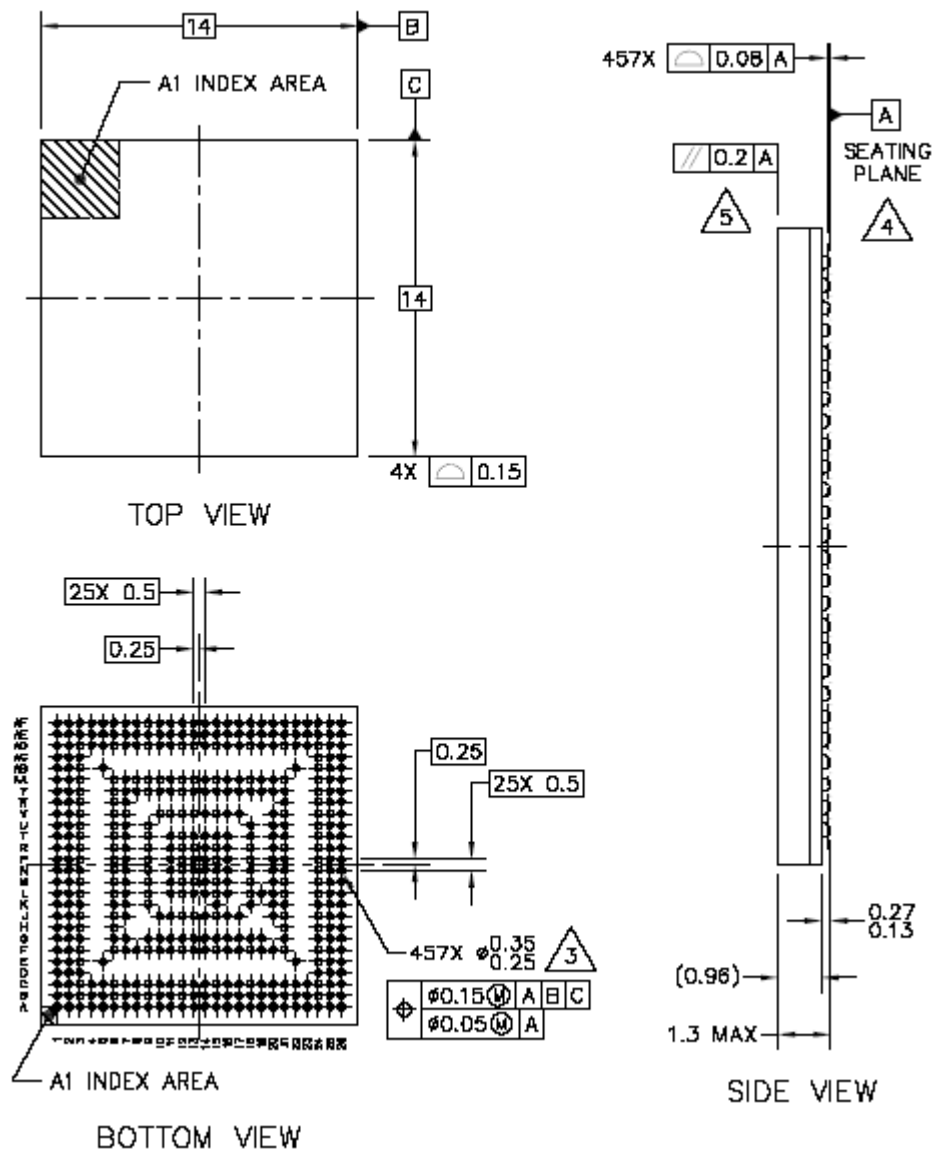
This section includes the following:

- Pin/contact assignment information
- Mechanical package drawing

### 5.1 MAPBGA Production Package 457 14 x 14 mm, 0.5 mm Pitch

See [Figure 84](#) for package drawings and dimensions of the production package.

### 5.1.1 Production Package Outline Drawing



**NOTES:**

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM A.
4. DATUM A, THE SEATING PLANE, IS DETERMINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
5. PARALLELISM MEASUREMENT SHALL EXCLUDE ANY EFFECT OF MARK ON TOP SURFACE OF PACKAGE.

**Figure 84. Production Package: Case 1581—0.5 mm Pitch**

# 5.1.2 MAPBGA Signal Assignment

|    | 1           | 2          | 3              | 4          | 5         | 6              | 7              | 8              | 9              | 10          | 11        | 12        | 13        | 14          | 15        | 16        | 17        | 18        | 19       | 20          | 21          | 22          | 23       | 24             | 25         | 26          |     |    |
|----|-------------|------------|----------------|------------|-----------|----------------|----------------|----------------|----------------|-------------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|-----------|----------|-------------|-------------|-------------|----------|----------------|------------|-------------|-----|----|
| A  | GND         | GND        | SFS5           | CSPI2_MISO | CSPI2_SS2 | USBOT_G_DAT A7 | USBOT_G_DAT A3 | USBOT_G_NXT    | USB_BYP        | RXD1        | DSR_D CE1 | DSR_D TE1 | RXD2      | CE_CO NTR0L | KEY_R OW3 | KEY_R OW7 | KEY_C OL3 | KEY_C OL7 | TDO      | SJC_M OD    | SVEN0       | CAPTU RE    | GPI01_ 6 | WATCH DOG_R ST | GND        | GND         | A   |    |
| B  | GND         | GND        | STXD4          | SRXD 5     | CSPI2_SS0 | CSPI2_SPI_R DY | USBOT_G_DAT A5 | USBOT_G_DAT A1 | USBOT_G_DIR    | USB_P WR    | CTS1      | DCD_D CE1 | DCD_D TE1 | RTS2        | KEY_R OW1 | KEY_R OW5 | KEY_C OL1 | KEY_C OL5 | TCK      | TRSTB       | SRX0        | SCLK0       | GPI01_ 1 | GPI01_ 5       | GND        | GND         | B   |    |
| C  | GND         | GND        | SRXD4          | SCK4       | STXD5     | CSPI2_SS1      | CSPI2_SCLK     | USBOT_G_DAT A4 | USBOT_G_STP    | USB_O C     | DTR_D CE1 | DTR_D TE1 | TXD2      | KEY_R OW2   | KEY_C OL0 | KEY_C OL4 | RTCK      | DE        | SRST0    | GPI01_ 2    | BOOT_ MODE1 | BOOT_ MODE3 | CLKO     | GND            | GND        | GND         | C   |    |
| D  | GND         | CSPI3_MOSI | SCK5           |            |           |                |                |                |                |             |           |           |           |             |           |           |           |           |          |             |             |             |          | BOOT_ MODE2    | GND        | BOOT_ MODE4 | D   |    |
| E  | CSPI3_SCLK  | ATA_DI OR  | CSPI2_MOSI     |            | NVCC5     |                |                |                |                |             |           |           |           |             |           |           |           |           |          |             |             | GND         |          | GND            | DVFS0      | POWER FAIL  | E   |    |
| F  | ATA_D MACK  | ATA_C S1   | SFS4           |            |           | NVCC5          | BATT_ LINE     | USBOT_G_DAT A6 | USBOT_G_DAT A0 | TXD1        | RI_DC E1  | DTR_D CE2 | KEY_R OW0 | KEY_R OW6   | KEY_C OL6 | TDI       | STX0      | GPI01_ 0  | GPI01_ 4 | BOOT_ MODE0 | GND         |             |          | CKIH           | GPI01_ 3   | VSTBY       | F   |    |
| G  | PWMO        | PC_R W     | CSPI3_MISO     |            |           | CSPI3_SPI_R DY | NVCC5          |                | USBOT_G_DAT A2 | USBOT_G_CLK | RTS1      | RI_DT E1  | CTS2      | KEY_R OW4   | KEY_C OL2 | TMS       | SIMPD 0   | COMP ARE  | NVCC1    |             | NVCC1       |             |          | DVFS1          | VPG0       | CLKSS       | G   |    |
| H  | PC_RST      | PC_BV D1   | ATA_R ESET     |            |           | ATA_DI OW      |                |                |                |             |           |           |           |             |           |           |           |           |          |             | CKIL        |             |          | POR            | I2C_DA T   | GPI03_ 1    | H   |    |
| J  | PC_VS 1     | PC_RE ADY  | IOIS16         |            |           | ATA_C S0       | PC_PO E        |                |                | QVCC1       | QVCC1     | NVCC8     | NVCC8     | QVCC        | NVCC6     | NVCC6     | NVCC9     |           |          | VPG1        | RESET_ IN   |             |          | I2C_CL K       | CSI_VS YNC | CSI_PIX CLK | J   |    |
| K  | PC_CD 2     | SD1_D ATA3 | PC_P WRON      |            |           | PC_BV D2       | PC_VS 2        |                | QVCC1          |             |           |           |           |             | NVCC6     |           |           | NVCC1     |          | CSI_H SYNC  | GPI03_ 0    |             |          | CSI_MC LK      | CSI_D5     | CSI_D7      | K   |    |
| L  | SD1_D ATA1  | SD1_C MD   | SD1_D ATA2     |            |           | PC_WA IT       | PC_CD 1        |                | NVCC3          |             | QVCC1     | GND       | QVCC      | QVCC        | QVCC      | QVCC      |           | NVCC4     | NVCC4    | CSI_D8      | CSI_D4      |             |          | CSI_D6         | CSI_D9     | CSI_D1 1    | L   |    |
| M  | USBH2_DATA0 | USBH2_STP  | USBH2_DATA1    |            |           | SD1_D ATA0     | SD1_C LK       |                | NVCC3          |             | GND       | GND       | GND       | GND         | GND       | GND       |           | QVCC      |          | CSI_D1 4    | CSI_D1 2    |             |          | CSI_D1 0       | CSI_D1 3   | CSI_D1 5    | M   |    |
| N  | USBH2_CLK   | CSPI1_SCLK | CSPI1_SPI_R DY |            |           | USBH2_DATA0    | USBH2_DIR      |                | QVCC4          |             | NVCC3     | GND       | GND       | GND         | GND       | GND       |           | NVCC7     |          | SD_D_I      | FPSHIF T    |             |          | VSYNC 0        | HSYNC      | DRDY0       | N   |    |
| P  | CSPI1_SS1   | CSPI1_MOSI | CSPI1_SS0      |            |           | CSPI1_SS2      | CSPI1_MISO     |                | NVCC1 0        |             | NVCC1 0   | GND       | GND       | GND         | GND       | GND       |           | NVCC7     |          | READ        | LCS1        |             |          | SD_D_ CLK      | SD_D_I O   | LCS0        | P   |    |
| R  | STXD3       | SCK3       | SRXD3          |            |           | SFS3           | SRXD6          |                | QVCC4          |             | NVCC1 0   | GND       | GND       | GND         | GND       | GND       |           | NVCC7     |          | D3_CL S     | PAR_RS      |             |          | CONTR AST      | WRITE 3    | VSYNC       | R   |    |
| T  | STXD6       | SCK6       | SFS6           |            |           | NFCE           | NFWE           |                | QVCC4          |             | NVCC1 0   | GND       | GND       | SGND        | MGND      | UGND      |           | NVCC7     |          | LD4         | LD2         |             |          | LD0            | SER_R S    | D3_REV      | T   |    |
| U  | NFRB        | NFWP       | NFCLE          |            |           | D15            | D11            |                | QVCC4          |             |           |           |           |             |           |           |           | QVCC      |          | TTM_P AD    | LD8         |             |          | LD6            | D3_SPL     | LD1         | U   |    |
| V  | NFALE       | NFRE       | D13            |            |           | D9             | D5             |                | QVCC           | QVCC        | QVCC      | QVCC      | SVCC      | MVCC        | UVCC      | GND       |           |           |          | LD17        | LD13        |             |          | LD10           | LD3        | LD5         | V   |    |
| W  | D14         | D12        | D7             |            |           | D3             | NVCC2 2        |                |                |             |           |           |           |             |           |           |           |           |          |             | EB0         |             |          | LD15           | LD7        | LD9         | W   |    |
| Y  | D10         | D8         | D1             |            |           | IOQVD D        | NVCC2 2        | NVCC2 2        | NVCC2 2        | NVCC2 2     | NVCC2 2   | NVCC2 2   | NVCC2 1   | NVCC2 1     | NVCC2 1   | NVCC2 1   | NVCC2 1   | NVCC2 1   | NVCC2 1  | NVCC2 1     | M_GRA NT    |             |          | EB1            | LD11       | LD12        | Y   |    |
| AA | D6          | D4         | A4             |            |           | NVCC2 2        | SD31           | SD28           | SD27           | SD23        | SD21      | SD18      | SD16      | SD13        | SD9       | SD7       | SD5       | SD3       | SD2      | DQM2        | SDCLK       |             |          | FVCC           | LD14       | LD16        | AA  |    |
| AB | D2          | D0         | A6             |            | A2        |                |                |                |                |             |           |           |           |             |           |           |           |           |          |             |             |             |          | FGND           | OE         | BCLK        | AB  |    |
| AC | MA10        | GND        | A11            |            |           |                |                |                |                |             |           |           |           |             |           |           |           |           |          |             |             |             |          | FUSE_V DD      | M_REQ UEST | GND         | AC  |    |
| AD | GND         | GND        | A12            | A13        | A8        | A0             | SDBA0          | SDQS3          | SD29           | SD25        | SDQS2     | SD17      | SD15      | SD12        | SD8       | SDQS0     | SD4       | SD0       | DQM1     | CAS         | SDCKE 0     | CS3         | ECB      | GND            | GND        | GND         | AD  |    |
| AE | GND         | GND        | A7             | A3         | SDBA1     | SD30           | SD26           | SD24           | SD22           | SD20        | SD19      | SDQS1     | SD14      | SD11        | SD10      | SD6       | SD1       | DQM3      | DQM0     | SDCLK       | CS2         | LBA         | CS0      | GND            | GND        | GND         | AE  |    |
| AF | GND         | GND        | A9             | A5         | A1        | A25            | A24            | A23            | A22            | A21         | A20       | A19       | A18       | A17         | A16       | A15       | A14       | A10       | RAS      | SDWE 1      | SDCKE 1     | CS5         | CS1      | CS4            | GND        | GND         | GND | AF |
|    | 1           | 2          | 3              | 4          | 5         | 6              | 7              | 8              | 9              | 10          | 11        | 12        | 13        | 14          | 15        | 16        | 17        | 18        | 19       | 20          | 21          | 22          | 23       | 24             | 25         | 26          |     |    |

Figure 85. Ball Map—0.5 mm Pitch

Table 61 shows the device connection list for power and ground, alpha-sorted.

**Table 61. 14 x 14 BGA Ground/Power ID by Ball Grid Location**

| <b>GND/PWR ID</b> | <b>Ball Location</b>                                                                                                                                                                                                                                                                                    |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FGND              | AB24                                                                                                                                                                                                                                                                                                    |
| FUSE_VDD          | AC24                                                                                                                                                                                                                                                                                                    |
| FVCC              | AA24                                                                                                                                                                                                                                                                                                    |
| GND               | A1, A2, A25, A26, B1, B2, B25, B26, C1, C2, C24, C25, C26, D1, D25, E22, E24, F21, L12, M11, M12, M13, M14, M15, M16, N12, N13, N14, N15, N16, P12, P13, P14, P15, P16, R12, R13, R14, R15, R16, T12, T13, V17, AC2, AC26, AD1, AD2, AD24, AD25, AD26, AE1, AE2, AE24, AE25, AE26, AF1, AF2, AF25, AF26 |
| IOQVDD            | Y6                                                                                                                                                                                                                                                                                                      |
| MGND              | T15                                                                                                                                                                                                                                                                                                     |
| MVCC              | V15                                                                                                                                                                                                                                                                                                     |
| NVCC1             | G19, G21, K18                                                                                                                                                                                                                                                                                           |
| NVCC2             | Y17, Y18, Y19, Y20                                                                                                                                                                                                                                                                                      |
| NVCC3             | L9, M9, N11                                                                                                                                                                                                                                                                                             |
| NVCC4             | L18, L19                                                                                                                                                                                                                                                                                                |
| NVCC5             | E5, F6, G7                                                                                                                                                                                                                                                                                              |
| NVCC6             | J15, J16, K15                                                                                                                                                                                                                                                                                           |
| NVCC7             | N18, P18, R18, T18                                                                                                                                                                                                                                                                                      |
| NVCC8             | J12, J13                                                                                                                                                                                                                                                                                                |
| NVCC9             | J17                                                                                                                                                                                                                                                                                                     |
| NVCC10            | P9, P11, R11, T11                                                                                                                                                                                                                                                                                       |
| NVCC21            | Y14, Y15, Y16                                                                                                                                                                                                                                                                                           |
| NVCC22            | W7, Y7, Y8, Y9, Y10, Y11, Y12, Y13, AA6                                                                                                                                                                                                                                                                 |
| QVCC              | J14, L13, L14, L15, L16, M18, U18, V10, V11, V12, V13                                                                                                                                                                                                                                                   |
| QVCC1             | J10, J11, K9, L11                                                                                                                                                                                                                                                                                       |
| QVCC4             | N9, R9, T9, U9                                                                                                                                                                                                                                                                                          |
| SGND              | T14                                                                                                                                                                                                                                                                                                     |
| SVCC              | V14                                                                                                                                                                                                                                                                                                     |
| UVCC              | V16                                                                                                                                                                                                                                                                                                     |
| UGND              | T16                                                                                                                                                                                                                                                                                                     |

Table 62 shows the device connection list for signals only, alpha-sorted by signal identification.

**Table 62. 14 x 14 BGA Signal ID by Ball Grid Location**

| Signal ID  | Ball Location | Signal ID     | Ball Location |
|------------|---------------|---------------|---------------|
| A0         | AD6           | CKIL          | H21           |
| A1         | AF5           | CLKO          | C23           |
| A10        | AF18          | CLKSS         | G26           |
| A11        | AC3           | COMPARE       | G18           |
| A12        | AD3           | CONTRAST      | R24           |
| A13        | AD4           | CS0           | AE23          |
| A14        | AF17          | CS1           | AF23          |
| A15        | AF16          | CS2           | AE21          |
| A16        | AF15          | CS3           | AD22          |
| A17        | AF14          | CS4           | AF24          |
| A18        | AF13          | CS5           | AF22          |
| A19        | AF12          | CSI_D10       | M24           |
| A2         | AB5           | CSI_D11       | L26           |
| A20        | AF11          | CSI_D12       | M21           |
| A21        | AF10          | CSI_D13       | M25           |
| A22        | AF9           | CSI_D14       | M20           |
| A23        | AF8           | CSI_D15       | M26           |
| A24        | AF7           | CSI_D4        | L21           |
| A25        | AF6           | CSI_D5        | K25           |
| A3         | AE4           | CSI_D6        | L24           |
| A4         | AA3           | CSI_D7        | K26           |
| A5         | AF4           | CSI_D8        | L20           |
| A6         | AB3           | CSI_D9        | L25           |
| A7         | AE3           | CSI_HSYNC     | K20           |
| A8         | AD5           | CSI_MCLK      | K24           |
| A9         | AF3           | CSI_PIXCLK    | J26           |
| ATA_CS0    | J6            | CSI_VSYNC     | J25           |
| ATA_CS1    | F2            | CSPI1_MISO    | P7            |
| ATA_DIOR   | E2            | CSPI1_MOSI    | P2            |
| ATA_DIOW   | H6            | CSPI1_SCLK    | N2            |
| ATA_DMACK  | F1            | CSPI1_SPI_RDY | N3            |
| ATA_RESET  | H3            | CSPI1_SS0     | P3            |
| BATT_LINE  | F7            | CSPI1_SS1     | P1            |
| BCLK       | AB26          | CSPI1_SS2     | P6            |
| BOOT_MODE0 | F20           | CSPI2_MISO    | A4            |
| BOOT_MODE1 | C21           | CSPI2_MOSI    | E3            |
| BOOT_MODE2 | D24           | CSPI2_SCLK    | C7            |
| BOOT_MODE3 | C22           | CSPI2_SPI_RDY | B6            |
| BOOT_MODE4 | D26           | CSPI2_SS0     | B5            |
| CAPTURE    | A22           | CSPI2_SS1     | C6            |
| CAS        | AD20          | CSPI2_SS2     | A5            |
| CE_CONTROL | A14           | CSPI3_MISO    | G3            |
| CKIH       | F24           | CSPI3_MOSI    | D2            |

Table 62. 14 x 14 BGA Signal ID by Ball Grid Location (continued)

| Signal ID     | Ball Location | Signal ID         | Ball Location |
|---------------|---------------|-------------------|---------------|
| CSPI3_SCLK    | E1            | GPIO1_3           | F25           |
| CSPI3_SPI_RDY | G6            | GPIO1_4           | F19           |
| CTS1          | B11           | GPIO1_5 (PWR RDY) | B24           |
| CTS2          | G13           | GPIO1_6           | A23           |
| D0            | AB2           | GPIO3_0           | K21           |
| D1            | Y3            | GPIO3_1           | H26           |
| D10           | Y1            | HSYNC             | N25           |
| D11           | U7            | I2C_CLK           | J24           |
| D12           | W2            | I2C_DAT           | H25           |
| D13           | V3            | IOIS16            | J3            |
| D14           | W1            | KEY_COL0          | C15           |
| D15           | U6            | KEY_COL1          | B17           |
| D2            | AB1           | KEY_COL2          | G15           |
| D3            | W6            | KEY_COL3          | A17           |
| D3_CLS        | R20           | KEY_COL4          | C16           |
| D3_REV        | T26           | KEY_COL5          | B18           |
| D3_SPL        | U25           | KEY_COL6          | F15           |
| D4            | AA2           | KEY_COL7          | A18           |
| D5            | V7            | KEY_ROW0          | F13           |
| D6            | AA1           | KEY_ROW1          | B15           |
| D7            | W3            | KEY_ROW2          | C14           |
| D8            | Y2            | KEY_ROW3          | A15           |
| D9            | V6            | KEY_ROW4          | G14           |
| DCD_DCE1      | B12           | KEY_ROW5          | B16           |
| DCD_DTE1      | B13           | KEY_ROW6          | F14           |
| DE            | C18           | KEY_ROW7          | A16           |
| DQM0          | AE19          | L2PG              | See VPG1      |
| DQM1          | AD19          | LBA               | AE22          |
| DQM2          | AA20          | LCS0              | P26           |
| DQM3          | AE18          | LCS1              | P21           |
| DRDY0         | N26           | LD0               | T24           |
| DSR_DCE1      | A11           | LD1               | U26           |
| DSR_DTE1      | A12           | LD10              | V24           |
| DTR_DCE1      | C11           | LD11              | Y25           |
| DTR_DCE2      | F12           | LD12              | Y26           |
| DTR_DTE1      | C12           | LD13              | V21           |
| DVFS0         | E25           | LD14              | AA25          |
| DVFS1         | G24           | LD15              | W24           |
| EB0           | W21           | LD16              | AA26          |
| EB1           | Y24           | LD17              | V20           |
| ECB           | AD23          | LD2               | T21           |
| FPSHIFT       | N21           | LD3               | V25           |
| GPIO1_0       | F18           | LD4               | T20           |
| GPIO1_1       | B23           | LD5               | V26           |
| GPIO1_2       | C20           | LD6               | U24           |

Table 62. 14 x 14 BGA Signal ID by Ball Grid Location (continued)

| Signal ID  | Ball Location | Signal ID | Ball Location |
|------------|---------------|-----------|---------------|
| LD7        | W25           | SCK6      | T2            |
| LD8        | U21           | SCLK0     | B22           |
| LD9        | W26           | SD_D_CLK  | P24           |
| M_GRANT    | Y21           | SD_D_I    | N20           |
| M_REQUEST  | AC25          | SD_D_IO   | P25           |
| MA10       | AC1           | SD0       | AD18          |
| MCUPG      | See VPG0      | SD1       | AE17          |
| NFALE      | V1            | SD1_CLK   | M7            |
| NFCE       | T6            | SD1_CMD   | L2            |
| NFCLE      | U3            | SD1_DATA0 | M6            |
| NFRB       | U1            | SD1_DATA1 | L1            |
| NFRE       | V2            | SD1_DATA2 | L3            |
| NFWE       | T7            | SD1_DATA3 | K2            |
| NFWP       | U2            | SD10      | AE15          |
| OE         | AB25          | SD11      | AE14          |
| PAR_RS     | R21           | SD12      | AD14          |
| PC_BVD1    | H2            | SD13      | AA14          |
| PC_BVD2    | K6            | SD14      | AE13          |
| PC_CD1     | L7            | SD15      | AD13          |
| PC_CD2     | K1            | SD16      | AA13          |
| PC_POE     | J7            | SD17      | AD12          |
| PC_PWRON   | K3            | SD18      | AA12          |
| PC_READY   | J2            | SD19      | AE11          |
| PC_RST     | H1            | SD2       | AA19          |
| PC_RW      | G2            | SD20      | AE10          |
| PC_VS1     | J1            | SD21      | AA11          |
| PC_VS2     | K7            | SD22      | AE9           |
| PC_WAIT    | L6            | SD23      | AA10          |
| POR        | H24           | SD24      | AE8           |
| POWER_FAIL | E26           | SD25      | AD10          |
| PWMO       | G1            | SD26      | AE7           |
| RAS        | AF19          | SD27      | AA9           |
| READ       | P20           | SD28      | AA8           |
| RESET_IN   | J21           | SD29      | AD9           |
| RI_DCE1    | F11           | SD3       | AA18          |
| RI_DTE1    | G12           | SD30      | AE6           |
| RTCK       | C17           | SD31      | AA7           |
| RTS1       | G11           | SD4       | AD17          |
| RTS2       | B14           | SD5       | AA17          |
| RW         | AB22          | SD6       | AE16          |
| RXD1       | A10           | SD7       | AA16          |
| RXD2       | A13           | SD8       | AD15          |
| SCK3       | R2            | SD9       | AA15          |
| SCK4       | C4            | SDBA0     | AD7           |
| SCK5       | D3            | SDBA1     | AE5           |

Table 62. 14 x 14 BGA Signal ID by Ball Grid Location (continued)

| Signal ID | Ball Location | Signal ID    | Ball Location |
|-----------|---------------|--------------|---------------|
| SDCKE0    | AD21          | TRSTB        | B20           |
| SDCKE1    | AF21          | TTM_PAD      | U20           |
| SDCLK     | AA21          | TXD1         | F10           |
| SDCLK     | AE20          | TXD2         | C13           |
| SDQS0     | AD16          | USB_BYP      | A9            |
| SDQS1     | AE12          | USB_OC       | C10           |
| SDQS2     | AD11          | USB_PWR      | B10           |
| SDQS3     | AD8           | USBH2_CLK    | N1            |
| SDWE      | AF20          | USBH2_DATA0  | M1            |
| SER_RS    | T25           | USBH2_DATA1  | M3            |
| SFS3      | R6            | USBH2_DIR    | N7            |
| SFS4      | F3            | USBH2_NXT    | N6            |
| SFS5      | A3            | USBH2_STP    | M2            |
| SFS6      | T3            | USBOTG_CLK   | G10           |
| SIMPD0    | G17           | USBOTG_DATA0 | F9            |
| SJC_MOD   | A20           | USBOTG_DATA1 | B8            |
| SRST0     | C19           | USBOTG_DATA2 | G9            |
| SRX0      | B21           | USBOTG_DATA3 | A7            |
| SRXD3     | R3            | USBOTG_DATA4 | C8            |
| SRXD4     | C3            | USBOTG_DATA5 | B7            |
| SRXD5     | B4            | USBOTG_DATA6 | F8            |
| SRXD6     | R7            | USBOTG_DATA7 | A6            |
| STX0      | F17           | USBOTG_DIR   | B9            |
| STXD3     | R1            | USBOTG_NXT   | A8            |
| STXD4     | B3            | USBOTG_STP   | C9            |
| STXD5     | C5            | VPG0         | G25           |
| STXD6     | T1            | VPG1         | J20           |
| SVEN0     | A21           | VSTBY        | F26           |
| TCK       | B19           | VSYNC0       | N24           |
| TDI       | F16           | VSYNC3       | R26           |
| TDO       | A19           | WATCHDOG_RST | A24           |
| TMS       | G16           | WRITE        | R25           |

## 6 Product Documentation

This Data Sheet is labeled as a particular type: Product Preview, Advance Information, or Technical Data. Definitions of these types are available at: <http://www.freescale.com>.

All related product documentation for the i.MX31 and i.MX31L is located at <http://www.freescale.com/imx>.

## 6.1 Revision History

Table 63 summarizes revisions to this document since the release of Rev. 2.1.

**Table 63. Revision History**

| Rev | Location                                                                                                                                                                                                                                 | Revision                                                                                                                                                                                                                                                                                                                                                                         |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2.2 | Was Figure 3, "Power-Up Sequence Option 2," on page 16                                                                                                                                                                                   | Deleted Figure 3, Power-Up Sequence, Option 2<br>Removed "Option 1" from Figure 2.                                                                                                                                                                                                                                                                                               |
| 2.2 | Table 29, "WEIM Bus Timing Parameters," on page 35                                                                                                                                                                                       | Changed WEIM13/14 min/max parameter values.                                                                                                                                                                                                                                                                                                                                      |
| 2.2 | Table 27, "DPLL Specifications," on page 31                                                                                                                                                                                              | Added PLL output frequency range parameters.                                                                                                                                                                                                                                                                                                                                     |
| 2.2 | Table 52, "SDHC Interface Timing Parameters," on page 83                                                                                                                                                                                 | Revised maximum parameter values for SD7/8.                                                                                                                                                                                                                                                                                                                                      |
| 2.2 | Table 7, "Operating Ranges," on page 12                                                                                                                                                                                                  | Changed the following parameter values: <ul style="list-style-type: none"> <li>Core operating voltage</li> <li>PLL/FPM operating voltage</li> <li>Modified footnotes 2 and 6.</li> </ul>                                                                                                                                                                                         |
| 2.3 | Fig 67 Write Access Timing and Figure 68 Read Access Timing Diagrams                                                                                                                                                                     | Changed RD/WR signal name to RW and inverted the RW waveforms.                                                                                                                                                                                                                                                                                                                   |
| 2.3 | <ul style="list-style-type: none"> <li>Figure 19, "CSPI Master Mode Timing Diagram," on page 30 and Figure 20, "CSPI Slave Mode Timing Diagram," on page 30</li> <li>Table 26, "CSPI Interface Timing Parameters," on page 30</li> </ul> | <ul style="list-style-type: none"> <li>CSPI Timing Diagrams redrawn to reference the proper clock edge for data.</li> <li>CSPI Interface Timing Parameters table's signal name descriptions changed to match timing diagrams.</li> <li>CSPI parameter CS9 changed from 5 to 6 ns.</li> <li>CS11 minimum value removed and footnote added.</li> </ul>                             |
| 2.3 | Table 7, "Operating Ranges," on page 12                                                                                                                                                                                                  | Added statement to Table 7 Operation Conditions footnote 3 concerning Real-Time Clock functionality in State-Retention Mode.                                                                                                                                                                                                                                                     |
| 2.3 | Table 30, "DDR/SDR SDRAM Read Cycle Timing Parameters," on page 40                                                                                                                                                                       | DDR/SDR Read cycle Timing: SD9 changed from 1.2 to 1.8 ns.                                                                                                                                                                                                                                                                                                                       |
| 2.3 | Table 6, "Thermal Resistance Data—14 × 14 mm Package," on page 11                                                                                                                                                                        | Added table to data sheet.                                                                                                                                                                                                                                                                                                                                                       |
| 2.3 | Throughout Document                                                                                                                                                                                                                      | Minor changes throughout document, including: <ul style="list-style-type: none"> <li>Change heading name from Power Specifications to Supply Current Specifications.</li> <li>Changed reference to Chapter 4 of the reference manual from Signal Description Pin Assignment table, to Multiplexing table.</li> <li>Relocated Fusebox Supply Current Parameters table.</li> </ul> |



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