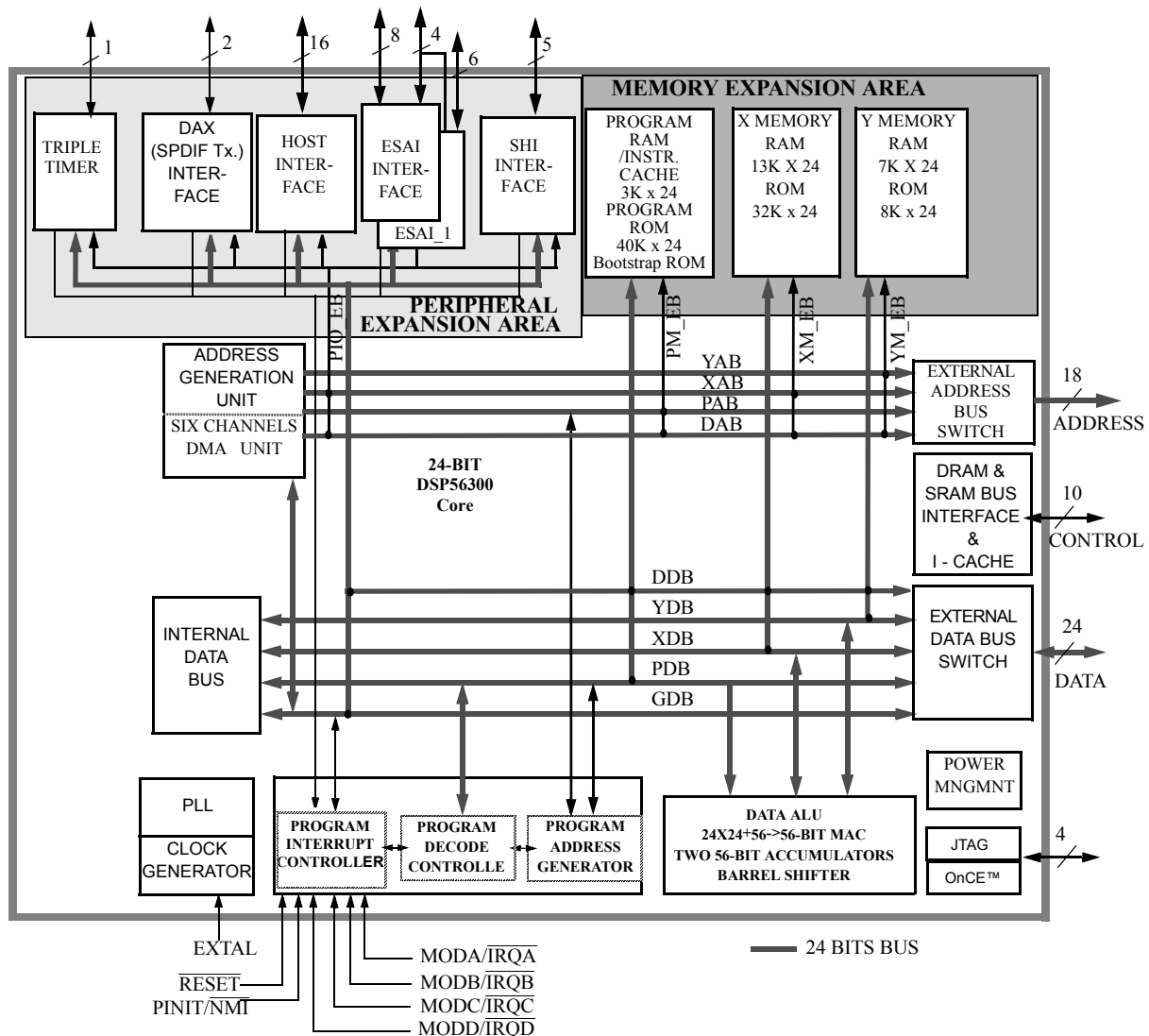


## 24-Bit Audio Digital Signal Processor

The DSP56366 supports digital audio applications requiring sound field processing, acoustic equalization, and other digital audio algorithms. The DSP56366 uses the high performance, single-clock-per-cycle DSP56300 core family of programmable CMOS digital signal processors (DSPs) combined with the audio signal processing capability of the Motorola Symphony™ DSP family, as shown in **Figure 1**. This design provides a two-fold performance increase over Motorola's popular Symphony family of DSPs while retaining code compatibility. Significant architectural enhancements include a barrel shifter, 24-bit addressing, instruction cache, and direct memory access (DMA). The DSP56366 offers 120 million instructions per second (MIPS) using an internal 120 MHz clock at 3.3 V.



**Figure 1** DSP56366 Block Diagram

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

---

## TABLE OF CONTENTS

|            |                                      |     |
|------------|--------------------------------------|-----|
| SECTION 1  | SIGNAL/CONNECTION DESCRIPTIONS ..... | 1-1 |
| SECTION 2  | SPECIFICATIONS.....                  | 2-1 |
| SECTION 3  | PACKAGING.....                       | 3-1 |
| SECTION 4  | DESIGN CONSIDERATIONS .....          | 4-1 |
| SECTION 5  | ORDERING INFORMATION.....            | 5-1 |
| APPENDIX A | POWER CONSUMPTION BENCHMARK .....    | A-1 |
| APPENDIX B | IBIS MODEL .....                     | B-1 |
| INDEX      | .....                                | I-1 |

### FOR TECHNICAL ASSISTANCE:

|                   |                                                                       |
|-------------------|-----------------------------------------------------------------------|
| <b>Telephone:</b> | 1-800-521-6274                                                        |
| <b>Email:</b>     | <a href="mailto:dsphelp@dsp.sps.mot.com">dsphelp@dsp.sps.mot.com</a>  |
| <b>Internet:</b>  | <a href="http://www.motorola-dsp.com">http://www.motorola-dsp.com</a> |

## Data Sheet Conventions

This data sheet uses the following conventions:

**OVERBAR**      Used to indicate a signal that is active when pulled low (For example, the  $\overline{\text{RESET}}$  pin is active when low.)

“asserted”      Means that a high true (active high) signal is high or that a low true (active low) signal is low

“deasserted”      Means that a high true (active high) signal is low or that a low true (active low) signal is high

| Examples: | Signal/Symbol           | Logic State | Signal State | Voltage                       |
|-----------|-------------------------|-------------|--------------|-------------------------------|
|           | $\overline{\text{PIN}}$ | True        | Asserted     | $V_{\text{IL}}/V_{\text{OL}}$ |
|           | $\overline{\text{PIN}}$ | False       | Deasserted   | $V_{\text{IH}}/V_{\text{OH}}$ |
|           | PIN                     | True        | Asserted     | $V_{\text{IH}}/V_{\text{OH}}$ |
|           | PIN                     | False       | Deasserted   | $V_{\text{IL}}/V_{\text{OL}}$ |

Note:      Values for  $V_{\text{IL}}$ ,  $V_{\text{OL}}$ ,  $V_{\text{IH}}$ , and  $V_{\text{OH}}$  are defined by individual product specifications.

## FEATURES

### DSP56300 Modular Chassis

- 120 Million Instructions Per Second (MIPS) with an 120 MHz clock at 3.3V.
- Object Code Compatible with the 56K core.
- Data ALU with a 24 x 24 bit multiplier-accumulator and a 56-bit barrel shifter. 16-bit arithmetic support.
- Program Control with position independent code support and instruction cache support.
- Six-channel DMA controller.
- PLL based clocking with a wide range of frequency multiplications (1 to 4096), predivider factors (1 to 16) and power saving clock divider ( $2^i$ :  $i=0$  to 7). Reduces clock noise.
- Internal address tracing support and OnCE™ for Hardware/Software debugging.
- JTAG port.
- Very low-power CMOS design, fully static design with operating frequencies down to DC.
- STOP and WAIT low-power standby modes.

### On-chip Memory Configuration

- 7Kx24 Bit Y-Data RAM and 8Kx24 Bit Y-Data ROM.
- 13Kx24 Bit X-Data RAM and 32Kx24 Bit X-Data ROM.
- 40Kx24 Bit Program ROM.
- 3Kx24 Bit Program RAM and 192x24 Bit Bootstrap ROM. 1K of Program RAM may be used as Instruction Cache or for Program ROM patching.
- 2Kx24 Bit from Y Data RAM and 5Kx24 Bit from X Data RAM can be switched to Program RAM resulting in up to 10Kx24 Bit of Program RAM.

### Off-chip Memory Expansion

- External Memory Expansion Port.
- Off-chip expansion up to two 16M x 24-bit word of Data memory.
- Off-chip expansion up to 16M x 24-bit word of Program memory.
- Simultaneous glueless interface to SRAM and DRAM.

### Advance Information

## Features

### Peripheral Modules

- Serial Audio Interface (ESAI): up to 4 receivers and up to 6 transmitters, master or slave. I<sup>2</sup>S, Sony, AC97, network and other programmable protocols.
- Serial Audio Interface I(ESAI\_1): up to 4 receivers and up to 6 transmitters, master or slave. I<sup>2</sup>S, Sony, AC97, network and other programmable protocols  
The ESAI\_1 shares four of the data pins with ESAI, and ESAI\_1 does NOT support HCKR and HCKT (high frequency clocks)
- Serial Host Interface (SHI): SPI and I<sup>2</sup>C protocols, multi master capability, 10-word receive FIFO, support for 8, 16 and 24-bit words.
- Byte-wide parallel Host Interface (HDI08) with DMA support.
- Triple Timer module (TEC).
- Digital Audio Transmitter (DAX): 1 serial transmitter capable of supporting the SPDIF, IEC958, CP-340 and AES/EBU digital audio formats.
- Pins of unused peripherals (except SHI) may be programmed as GPIO lines.

### 144-pin plastic TQFP package.

## Documentation

**Table 1** lists the documents that provide a complete description of the DSP56366 and are required to design properly with the part. Documentation is available from a local Motorola distributor, a Motorola semiconductor sales office, a Motorola Literature Distribution Center, or through the Motorola DSP home page on the Internet (the source for the latest information).

**Table 1 DSP56366 Documentation**

| Document Name                 | Description                                                                                             | Order Number  |
|-------------------------------|---------------------------------------------------------------------------------------------------------|---------------|
| DSP56300 Family Manual        | Detailed description of the 56000-family architecture and the 24-bit core processor and instruction set | DSP56300FM/AD |
| DSP56366 User's Manual        | Detailed description of memory, peripherals, and interfaces                                             | DSP56366UM/D  |
| DSP56366 Technical Data Sheet | Electrical and timing specifications; pin and package descriptions                                      | DSP56366/D    |
| DSP56366 Product Brief        | Brief description of the chip                                                                           | DSP56366P/D   |

## Advance Information

# SECTION 1

## SIGNAL/CONNECTION DESCRIPTIONS

### SIGNAL GROUPINGS

The input and output signals of the DSP56366 are organized into functional groups, which are listed in **Table 1-1** and illustrated in **Figure 1-1**.

The DSP56366 is operated from a 3.3 V supply; however, some of the inputs can tolerate 5 V. A special notice for this feature is added to the signal descriptions of those inputs.

**Table 1-1 DSP56366 Functional Signal Groupings**

| Functional Group                |                     | Number of Signals | Detailed Description |
|---------------------------------|---------------------|-------------------|----------------------|
| Power (V <sub>CC</sub> )        |                     | 20                | Table 1-2            |
| Ground (GND)                    |                     | 18                | Table 1-3            |
| Clock and PLL                   |                     | 3                 | Table 1-4            |
| Address bus                     | Port A <sup>1</sup> | 18                | Table 1-5            |
| Data bus                        |                     | 24                | Table 1-6            |
| Bus control                     |                     | 10                | Table 1-7            |
| Interrupt and mode control      |                     | 5                 | Table 1-8            |
| HDI08                           | Port B <sup>2</sup> | 16                | Table 1-9            |
| SHI                             |                     | 5                 | Table 1-10           |
| ESAI                            | Port C <sup>3</sup> | 12                | Table 1-11           |
| ESAI_1                          | Port E <sup>5</sup> | 6                 | Table 1-12           |
| Digital audio transmitter (DAX) | Port D <sup>4</sup> | 2                 | Table 1-13           |
| Timer                           |                     | 1                 | Table 1-14           |
| JTAG/OnCE Port                  |                     | 4                 | Table 1-15           |

Signal Groupings

Table 1-1 DSP56366 Functional Signal Groupings (Continued)

| Functional Group                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Number of Signals | Detailed Description |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------|
| Notes: 1. Port A is the external memory interface port, including the external address bus, data bus, and control signals.<br>2. Port B signals are the GPIO port signals which are multiplexed with the HDI08 signals.<br>3. Port C signals are the GPIO port signals which are multiplexed with the ESAI signals.<br>4. Port D signals are the GPIO port signals which are multiplexed with the DAX signals.<br>5. Port E signals are the GPIO port signals which are multiplexed with the ESAI_1 signals. |                   |                      |

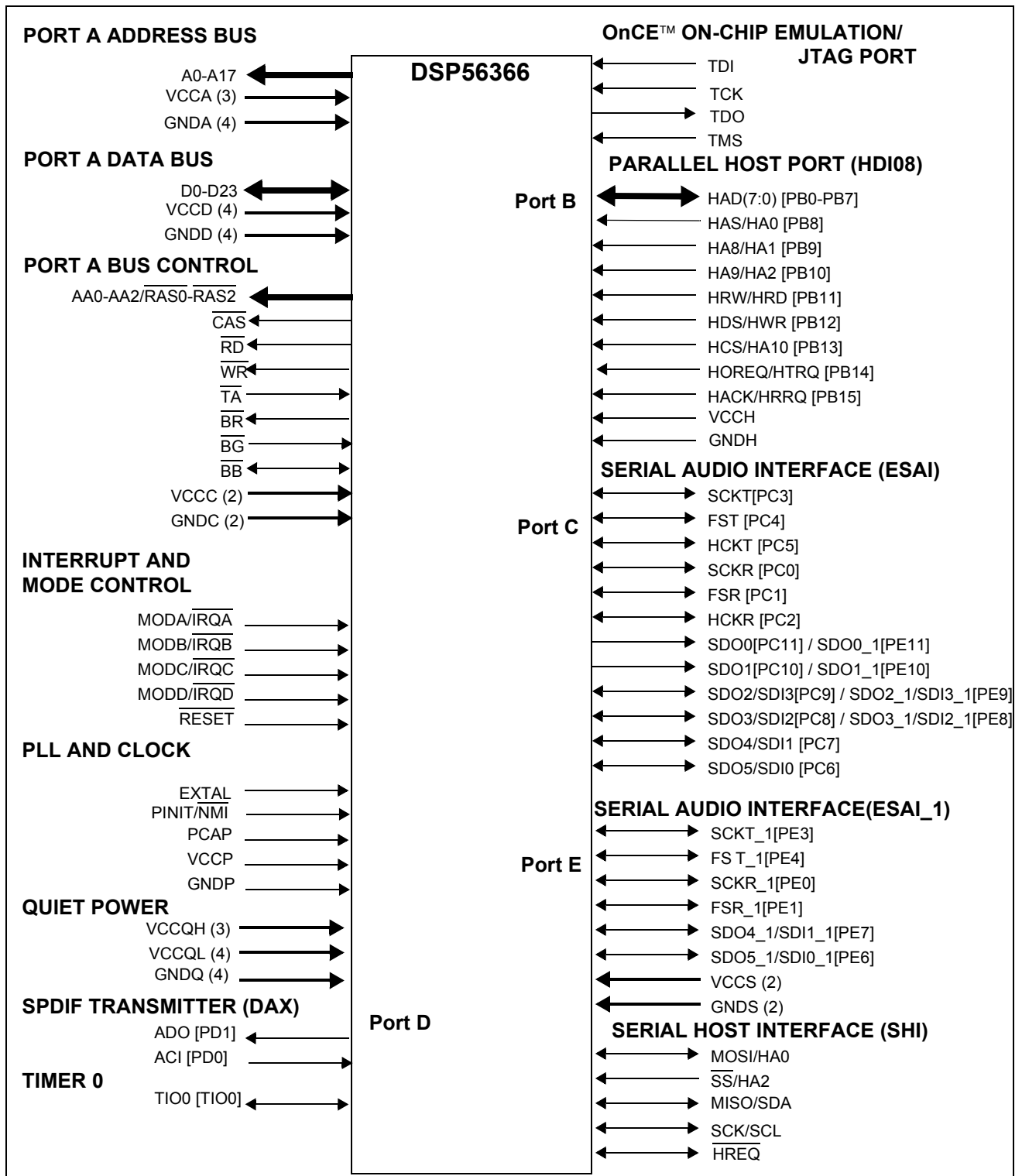


Figure 1-1 Signals Identified by Functional Group

## Power

## POWER

Table 1-2 Power Inputs

| Power Name     | Description                                                                                                                                                                                                                                                                                |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $V_{CCP}$      | <b>PLL Power</b> — $V_{CCP}$ is $V_{CC}$ dedicated for PLL use. The voltage should be well-regulated and the input should be provided with an extremely low impedance path to the $V_{CC}$ power rail. There is one $V_{CCP}$ input.                                                       |
| $V_{CCQL}$ (4) | <b>Quiet Core (Low) Power</b> — $V_{CCQL}$ is an isolated power for the internal processing logic. This input must be tied externally to all other chip power inputs. The user must provide adequate external decoupling capacitors. There are four $V_{CCQL}$ inputs.                     |
| $V_{CCQH}$ (3) | <b>Quiet External (High) Power</b> — $V_{CCQH}$ is a quiet power source for I/O lines. This input must be tied externally to all other chip power inputs. The user must provide adequate decoupling capacitors. There are three $V_{CCQH}$ inputs.                                         |
| $V_{CCA}$ (3)  | <b>Address Bus Power</b> — $V_{CCA}$ is an isolated power for sections of the address bus I/O drivers. This input must be tied externally to all other chip power inputs. The user must provide adequate external decoupling capacitors. There are three $V_{CCA}$ inputs.                 |
| $V_{CCD}$ (4)  | <b>Data Bus Power</b> — $V_{CCD}$ is an isolated power for sections of the data bus I/O drivers. This input must be tied externally to all other chip power inputs. The user must provide adequate external decoupling capacitors. There are four $V_{CCD}$ inputs.                        |
| $V_{CCC}$ (2)  | <b>Bus Control Power</b> — $V_{CCC}$ is an isolated power for the bus control I/O drivers. This input must be tied externally to all other chip power inputs. The user must provide adequate external decoupling capacitors. There are two $V_{CCC}$ inputs.                               |
| $V_{CCH}$      | <b>Host Power</b> — $V_{CCH}$ is an isolated power for the HDI08 I/O drivers. This input must be tied externally to all other chip power inputs. The user must provide adequate external decoupling capacitors. There is one $V_{CCH}$ input.                                              |
| $V_{CCS}$ (2)  | <b>SHI, ESAI, ESAI_1, DAX and Timer Power</b> — $V_{CCS}$ is an isolated power for the SHI, ESAI, ESAI_1, DAX and Timer. This input must be tied externally to all other chip power inputs. The user must provide adequate external decoupling capacitors. There are two $V_{CCS}$ inputs. |

## GROUND

Table 1-3 Grounds

| Ground Name | Description                                                                                                                                                                                                                                                                                             |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $GND_P$     | <b>PLL Ground</b> — $GND_P$ is a ground dedicated for PLL use. The connection should be provided with an extremely low-impedance path to ground. $V_{CCP}$ should be bypassed to $GND_P$ by a 0.47 $\mu F$ capacitor located as close as possible to the chip package. There is one $GND_P$ connection. |

Table 1-3 Grounds

| Ground Name          | Description                                                                                                                                                                                                                                                                                                               |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GND <sub>Q</sub> (4) | <b>Quiet Ground</b> —GND <sub>Q</sub> is an isolated ground for the internal processing logic. This connection must be tied externally to all other chip ground connections. The user must provide adequate external decoupling capacitors. There are four GND <sub>Q</sub> connections.                                  |
| GND <sub>A</sub> (4) | <b>Address Bus Ground</b> —GND <sub>A</sub> is an isolated ground for sections of the address bus I/O drivers. This connection must be tied externally to all other chip ground connections. The user must provide adequate external decoupling capacitors. There are four GND <sub>A</sub> connections.                  |
| GND <sub>D</sub> (4) | <b>Data Bus Ground</b> —GND <sub>D</sub> is an isolated ground for sections of the data bus I/O drivers. This connection must be tied externally to all other chip ground connections. The user must provide adequate external decoupling capacitors. There are four GND <sub>D</sub> connections.                        |
| GND <sub>C</sub> (2) | <b>Bus Control Ground</b> —GND <sub>C</sub> is an isolated ground for the bus control I/O drivers. This connection must be tied externally to all other chip ground connections. The user must provide adequate external decoupling capacitors. There are two GND <sub>C</sub> connections.                               |
| GND <sub>H</sub>     | <b>Host Ground</b> —GND <sub>H</sub> is an isolated ground for the HD08 I/O drivers. This connection must be tied externally to all other chip ground connections. The user must provide adequate external decoupling capacitors. There is one GND <sub>H</sub> connection.                                               |
| GND <sub>S</sub> (2) | <b>SHI, ESAI, ESAI_1, DAX and Timer Ground</b> —GND <sub>S</sub> is an isolated ground for the SHI, ESAI, ESAI_1, DAX and Timer. This connection must be tied externally to all other chip ground connections. The user must provide adequate external decoupling capacitors. There are two GND <sub>S</sub> connections. |

## CLOCK AND PLL

Table 1-4 Clock and PLL Signals

| Signal Name                    | Type  | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------|-------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EXTAL                          | Input | Input              | <b>External Clock Input</b> —An external clock source must be connected to EXTAL in order to supply the clock to the internal clock generator and PLL.<br><i>This input cannot tolerate 5 V.</i>                                                                                                                                                                                                                                                                                                                                                                            |
| PCAP                           | Input | Input              | <b>PLL Capacitor</b> —PCAP is an input connecting an off-chip capacitor to the PLL filter. Connect one capacitor terminal to PCAP and the other terminal to V <sub>CCP</sub> . If the PLL is not used, PCAP may be tied to V <sub>CC</sub> , GND, or left floating.                                                                                                                                                                                                                                                                                                         |
| PINIT/ $\overline{\text{NMI}}$ | Input | Input              | <b>PLL Initial/Nonmaskable Interrupt</b> —During assertion of $\overline{\text{RESET}}$ , the value of PINIT/ $\overline{\text{NMI}}$ is written into the PLL Enable (PEN) bit of the PLL control register, determining whether the PLL is enabled or disabled. After $\overline{\text{RESET}}$ deassertion and during normal instruction processing, the PINIT/ $\overline{\text{NMI}}$ Schmitt-trigger input is a negative-edge-triggered nonmaskable interrupt (NMI) request internally synchronized to internal system clock.<br><i>This input cannot tolerate 5 V.</i> |

## External Memory Expansion Port (Port A)

**EXTERNAL MEMORY EXPANSION PORT (PORT A)**

When the DSP56366 enters a low-power standby mode (stop or wait), it releases bus mastership and tri-states the relevant port A signals: A0–A17, D0–D23, AA0/ $\overline{\text{RAS0}}$ –AA2/ $\overline{\text{RAS2}}$ ,  $\overline{\text{RD}}$ ,  $\overline{\text{WR}}$ ,  $\overline{\text{BB}}$ ,  $\overline{\text{CAS}}$ .

**External Address Bus****Table 1-5 External Address Bus Signals**

| Signal Name | Type   | State during Reset | Signal Description                                                                                                                                                                                                                                                                                              |
|-------------|--------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A0–A17      | Output | Tri-stated         | <b>Address Bus</b> —When the DSP is the bus master, A0–A17 are active-high outputs that specify the address for external program and data memory accesses. Otherwise, the signals are tri-stated. To minimize power dissipation, A0–A17 do not change state when external memory spaces are not being accessed. |

**External Data Bus****Table 1-6 External Data Bus Signals**

| Signal Name | Type         | State during Reset | Signal Description                                                                                                                                                                                                            |
|-------------|--------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D0–D23      | Input/Output | Tri-stated         | <b>Data Bus</b> —When the DSP is the bus master, D0–D23 are active-high, bidirectional input/outputs that provide the bidirectional data bus for external program and data memory accesses. Otherwise, D0–D23 are tri-stated. |

**External Bus Control****Table 1-7 External Bus Control Signals**

| Signal Name                                                        | Type   | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------------------------|--------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AA0–AA2/<br>$\overline{\text{RAS0}}$ –<br>$\overline{\text{RAS2}}$ | Output | Tri-stated         | <b>Address Attribute or Row Address Strobe</b> —When defined as AA, these signals can be used as chip selects or additional address lines. When defined as $\overline{\text{RAS}}$ , these signals can be used as $\overline{\text{RAS}}$ for DRAM interface. These signals are tri-statable outputs with programmable polarity. |

Table 1-7 External Bus Control Signals (Continued)

| Signal Name             | Type   | State during Reset  | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------|--------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\overline{\text{CAS}}$ | Output | Tri-stated          | <b>Column Address Strobe</b> —When the DSP is the bus master, $\overline{\text{CAS}}$ is an active-low output used by DRAM to strobe the column address. Otherwise, if the bus mastership enable (BME) bit in the DRAM control register is cleared, the signal is tri-stated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| $\overline{\text{RD}}$  | Output | Tri-stated          | <b>Read Enable</b> —When the DSP is the bus master, $\overline{\text{RD}}$ is an active-low output that is asserted to read external memory on the data bus (D0-D23). Otherwise, $\overline{\text{RD}}$ is tri-stated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| $\overline{\text{WR}}$  | Output | Tri-stated          | <b>Write Enable</b> —When the DSP is the bus master, $\overline{\text{WR}}$ is an active-low output that is asserted to write external memory on the data bus (D0-D23). Otherwise, $\overline{\text{WR}}$ is tri-stated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| $\overline{\text{TA}}$  | Input  | Ignored Input       | <p><b>Transfer Acknowledge</b>—If the DSP is the bus master and there is no external bus activity, or the DSP is not the bus master, the <math>\overline{\text{TA}}</math> input is ignored. The <math>\overline{\text{TA}}</math> input is a data transfer acknowledge (DTACK) function that can extend an external bus cycle indefinitely. Any number of wait states (1, 2, . . . infinity) may be added to the wait states inserted by the BCR by keeping <math>\overline{\text{TA}}</math> deasserted. In typical operation, <math>\overline{\text{TA}}</math> is deasserted at the start of a bus cycle, is asserted to enable completion of the bus cycle, and is deasserted before the next bus cycle. The current bus cycle completes one clock period after <math>\overline{\text{TA}}</math> is asserted synchronous to the internal system clock. The number of wait states is determined by the <math>\overline{\text{TA}}</math> input or by the bus control register (BCR), whichever is longer. The BCR can be used to set the minimum number of wait states in external bus cycles.</p> <p>In order to use the <math>\overline{\text{TA}}</math> functionality, the BCR must be programmed to at least one wait state. A zero wait state access cannot be extended by <math>\overline{\text{TA}}</math> deassertion, otherwise improper operation may result. <math>\overline{\text{TA}}</math> can operate synchronously or asynchronously, depending on the setting of the TAS bit in the operating mode register (OMR). <math>\overline{\text{TA}}</math> functionality may not be used while performing DRAM type accesses, otherwise improper operation may result.</p> |
| $\overline{\text{BR}}$  | Output | Output (deasserted) | <b>Bus Request</b> — $\overline{\text{BR}}$ is an active-low output, never tri-stated. $\overline{\text{BR}}$ is asserted when the DSP requests bus mastership. $\overline{\text{BR}}$ is deasserted when the DSP no longer needs the bus. $\overline{\text{BR}}$ may be asserted or deasserted independent of whether the DSP56366 is a bus master or a bus slave. Bus “parking” allows $\overline{\text{BR}}$ to be deasserted even though the DSP56366 is the bus master. (See the description of bus “parking” in the $\overline{\text{BB}}$ signal description.) The bus request hold (BRH) bit in the BCR allows $\overline{\text{BR}}$ to be asserted under software control even though the DSP does not need the bus. $\overline{\text{BR}}$ is typically sent to an external bus arbitrator that controls the priority, parking, and tenure of each master on the same external bus. $\overline{\text{BR}}$ is only affected by DSP requests for the external bus, never for the internal bus. During hardware reset, $\overline{\text{BR}}$ is deasserted and the arbitration is reset to the bus slave state.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

## Interrupt and Mode Control

Table 1-7 External Bus Control Signals (Continued)

| Signal Name     | Type         | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------|--------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\overline{BG}$ | Input        | Ignored Input      | <p><b>Bus Grant</b>—<math>\overline{BG}</math> is an active-low input. <math>\overline{BG}</math> is asserted by an external bus arbitration circuit when the DSP56366 becomes the next bus master. When <math>\overline{BG}</math> is asserted, the DSP56366 must wait until <math>\overline{BB}</math> is deasserted before taking bus mastership. When <math>\overline{BG}</math> is deasserted, bus mastership is typically given up at the end of the current bus cycle. This may occur in the middle of an instruction that requires more than one external bus cycle for execution.</p> <p>For proper <math>\overline{BG}</math> operation, the asynchronous bus arbitration enable bit (ABE) in the OMR register must be set.</p>                                                                                                                                                                                                                                                                                                       |
| $\overline{BB}$ | Input/Output | Input              | <p><b>Bus Busy</b>—<math>\overline{BB}</math> is a bidirectional active-low input/output. <math>\overline{BB}</math> indicates that the bus is active. Only after <math>\overline{BB}</math> is deasserted can the pending bus master become the bus master (and then assert the signal again). The bus master may keep <math>\overline{BB}</math> asserted after ceasing bus activity regardless of whether <math>\overline{BR}</math> is asserted or deasserted. This is called “bus parking” and allows the current bus master to reuse the bus without re-arbitration until another device requires the bus. The deassertion of <math>\overline{BB}</math> is done by an “active pull-up” method (i.e., <math>\overline{BB}</math> is driven high and then released and held high by an external pull-up resistor).</p> <p>For proper <math>\overline{BB}</math> operation, the asynchronous bus arbitration enable bit (ABE) in the OMR register must be set.</p> <p><math>\overline{BB}</math> requires an external pull-up resistor.</p> |

## INTERRUPT AND MODE CONTROL

The interrupt and mode control signals select the chip’s operating mode as it comes out of hardware reset. After  $\overline{RESET}$  is deasserted, these inputs are hardware interrupt request lines.

Table 1-8 Interrupt and Mode Control

| Signal Name                   | Type  | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------|-------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\overline{\text{MODA/IRQA}}$ | Input | Input              | <p><b>Mode Select A/External Interrupt Request A</b>—<math>\overline{\text{MODA/IRQA}}</math> is an active-low Schmitt-trigger input, internally synchronized to the DSP clock. <math>\overline{\text{MODA/IRQA}}</math> selects the initial chip operating mode during hardware reset and becomes a level-sensitive or negative-edge-triggered, maskable interrupt request input during normal instruction processing. <math>\overline{\text{MODA}}</math>, <math>\overline{\text{MODB}}</math>, <math>\overline{\text{MODC}}</math>, and <math>\overline{\text{MODD}}</math> select one of 16 initial chip operating modes, latched into the OMR when the <math>\overline{\text{RESET}}</math> signal is deasserted. If the processor is in the stop standby state and the <math>\overline{\text{MODA/IRQA}}</math> pin is pulled to GND, the processor will exit the stop state.</p> <p><i>This input is 5 V tolerant.</i></p> |
| $\overline{\text{MODB/IRQB}}$ | Input | Input              | <p><b>Mode Select B/External Interrupt Request B</b>—<math>\overline{\text{MODB/IRQB}}</math> is an active-low Schmitt-trigger input, internally synchronized to the DSP clock. <math>\overline{\text{MODB/IRQB}}</math> selects the initial chip operating mode during hardware reset and becomes a level-sensitive or negative-edge-triggered, maskable interrupt request input during normal instruction processing. <math>\overline{\text{MODA}}</math>, <math>\overline{\text{MODB}}</math>, <math>\overline{\text{MODC}}</math>, and <math>\overline{\text{MODD}}</math> select one of 16 initial chip operating modes, latched into OMR when the <math>\overline{\text{RESET}}</math> signal is deasserted.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                                                                                                  |
| $\overline{\text{MODC/IRQC}}$ | Input | Input              | <p><b>Mode Select C/External Interrupt Request C</b>—<math>\overline{\text{MODC/IRQC}}</math> is an active-low Schmitt-trigger input, internally synchronized to the DSP clock. <math>\overline{\text{MODC/IRQC}}</math> selects the initial chip operating mode during hardware reset and becomes a level-sensitive or negative-edge-triggered, maskable interrupt request input during normal instruction processing. <math>\overline{\text{MODA}}</math>, <math>\overline{\text{MODB}}</math>, <math>\overline{\text{MODC}}</math>, and <math>\overline{\text{MODD}}</math> select one of 16 initial chip operating modes, latched into OMR when the <math>\overline{\text{RESET}}</math> signal is deasserted.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                                                                                                  |
| $\overline{\text{MODD/IRQD}}$ | Input | Input              | <p><b>Mode Select D/External Interrupt Request D</b>—<math>\overline{\text{MODD/IRQD}}</math> is an active-low Schmitt-trigger input, internally synchronized to the DSP clock. <math>\overline{\text{MODD/IRQD}}</math> selects the initial chip operating mode during hardware reset and becomes a level-sensitive or negative-edge-triggered, maskable interrupt request input during normal instruction processing. <math>\overline{\text{MODA}}</math>, <math>\overline{\text{MODB}}</math>, <math>\overline{\text{MODC}}</math>, and <math>\overline{\text{MODD}}</math> select one of 16 initial chip operating modes, latched into OMR when the <math>\overline{\text{RESET}}</math> signal is deasserted.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                                                                                                  |
| $\overline{\text{RESET}}$     | Input | Input              | <p><b>Reset</b>—<math>\overline{\text{RESET}}</math> is an active-low, Schmitt-trigger input. When asserted, the chip is placed in the Reset state and the internal phase generator is reset. The Schmitt-trigger input allows a slowly rising input (such as a capacitor charging) to reset the chip reliably. When the <math>\overline{\text{RESET}}</math> signal is deasserted, the initial chip operating mode is latched from the <math>\overline{\text{MODA}}</math>, <math>\overline{\text{MODB}}</math>, <math>\overline{\text{MODC}}</math>, and <math>\overline{\text{MODD}}</math> inputs. The <math>\overline{\text{RESET}}</math> signal must be asserted during power up. A stable EXTAL signal must be supplied while <math>\overline{\text{RESET}}</math> is being asserted.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                       |

**PARALLEL HOST INTERFACE (HDI08)**

**PARALLEL HOST INTERFACE (HDI08)**

The HDI08 provides a fast, 8-bit, parallel data port that may be connected directly to the host bus. The HDI08 supports a variety of standard buses and can be directly connected to a number of industry standard microcomputers, microprocessors, DSPs, and DMA hardware.

## PARALLEL HOST INTERFACE (HDI08)

Table 1-9 Host Interface

| Signal Name                  | Type                           | State during Reset | Signal Description                                                                                                                                                                                                                                                                                    |
|------------------------------|--------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| H0–H7                        | Input/output                   | GPIO disconnected  | <b>Host Data</b> —When HDI08 is programmed to interface a nonmultiplexed host bus and the HI function is selected, these signals are lines 0–7 of the bidirectional, tri-state data bus.                                                                                                              |
| HAD0–HAD7                    | Input/output                   |                    | <b>Host Address/Data</b> —When HDI08 is programmed to interface a multiplexed host bus and the HI function is selected, these signals are lines 0–7 of the address/data bidirectional, multiplexed, tri-state bus.                                                                                    |
| PB0–PB7                      | Input, output, or disconnected |                    | <b>Port B 0–7</b> —When the HDI08 is configured as GPIO, these signals are individually programmable as input, output, or internally disconnected.<br><br>The default state after reset for these signals is GPIO disconnected.<br><br>These inputs are 5 V tolerant.                                 |
| HA0                          | Input                          | GPIO disconnected  | <b>Host Address Input 0</b> —When the HDI08 is programmed to interface a nonmultiplexed host bus and the HI function is selected, this signal is line 0 of the host address input bus.                                                                                                                |
| $\overline{\text{HAS}}$ /HAS | Input                          |                    | <b>Host Address Strobe</b> —When HDI08 is programmed to interface a multiplexed host bus and the HI function is selected, this signal is the host address strobe (HAS) Schmitt-trigger input. The polarity of the address strobe is programmable, but is configured active-low (HAS) following reset. |
| PB8                          | Input, output, or disconnected |                    | <b>Port B 8</b> —When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.<br><br>The default state after reset for this signal is GPIO disconnected.<br><br><i>This input is 5 V tolerant.</i>                                      |
| HA1                          | Input                          | GPIO disconnected  | <b>Host Address Input 1</b> —When the HDI08 is programmed to interface a nonmultiplexed host bus and the HI function is selected, this signal is line 1 of the host address (HA1) input bus.                                                                                                          |
| HA8                          | Input                          |                    | <b>Host Address 8</b> —When HDI08 is programmed to interface a multiplexed host bus and the HI function is selected, this signal is line 8 of the host address (HA8) input bus.                                                                                                                       |
| PB9                          | Input, output, or disconnected |                    | <b>Port B 9</b> —When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.<br><br>The default state after reset for this signal is GPIO disconnected.<br><br>This input is 5 V tolerant.                                             |

## PARALLEL HOST INTERFACE (HDI08)

Table 1-9 Host Interface (Continued)

| Signal Name                      | Type                           | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                |
|----------------------------------|--------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HA2                              | Input                          | GPIO disconnected  | <b>Host Address Input 2</b> —When the HDI08 is programmed to interface a non-multiplexed host bus and the HI function is selected, this signal is line 2 of the host address (HA2) input bus.                                                                                                                                     |
| HA9                              | Input                          |                    | <b>Host Address 9</b> —When HDI08 is programmed to interface a multiplexed host bus and the HI function is selected, this signal is line 9 of the host address (HA9) input bus.                                                                                                                                                   |
| PB10                             | Input, Output, or Disconnected |                    | <p><b>Port B 10</b>—When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.</p> <p>The default state after reset for this signal is GPIO disconnected.</p> <p><i>This input is 5 V tolerant.</i></p>                                                           |
| HRW                              | Input                          | GPIO disconnected  | <b>Host Read/Write</b> —When HDI08 is programmed to interface a single-data-strobe host bus and the HI function is selected, this signal is the Host Read/Write (HRW) input.                                                                                                                                                      |
| $\overline{\text{HRD}}$ /<br>HRD | Input                          |                    | <b>Host Read Data</b> —When HDI08 is programmed to interface a double-data-strobe host bus and the HI function is selected, this signal is the host read data strobe (HRD) Schmitt-trigger input. The polarity of the data strobe is programmable, but is configured as active-low ( $\overline{\text{HRD}}$ ) after reset.       |
| PB11                             | Input, Output, or Disconnected |                    | <p><b>Port B 11</b>—When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.</p> <p>The default state after reset for this signal is GPIO disconnected.</p> <p><i>This input is 5 V tolerant.</i></p>                                                           |
| $\overline{\text{HDS}}$ /<br>HDS | Input                          | GPIO disconnected  | <b>Host Data Strobe</b> —When HDI08 is programmed to interface a single-data-strobe host bus and the HI function is selected, this signal is the host data strobe (HDS) Schmitt-trigger input. The polarity of the data strobe is programmable, but is configured as active-low ( $\overline{\text{HDS}}$ ) following reset.      |
| $\overline{\text{HWR}}$ /<br>HWR | Input                          |                    | <b>Host Write Data</b> —When HDI08 is programmed to interface a double-data-strobe host bus and the HI function is selected, this signal is the host write data strobe (HWR) Schmitt-trigger input. The polarity of the data strobe is programmable, but is configured as active-low ( $\overline{\text{HWR}}$ ) following reset. |
| PB12                             | Input, output, or disconnected |                    | <p><b>Port B 12</b>—When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.</p> <p>The default state after reset for this signal is GPIO disconnected.</p> <p><i>This input is 5 V tolerant.</i></p>                                                           |

## PARALLEL HOST INTERFACE (HDI08)

Table 1-9 Host Interface (Continued)

| Signal Name                          | Type                           | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------|--------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HCS                                  | Input                          | GPIO disconnected  | <p><b>Host Chip Select</b>—When HDI08 is programmed to interface a nonmultiplexed host bus and the HI function is selected, this signal is the host chip select (HCS) input. The polarity of the chip select is programmable, but is configured active-low (<math>\overline{\text{HCS}}</math>) after reset.</p> <p><b>Host Address 10</b>—When HDI08 is programmed to interface a multiplexed host bus and the HI function is selected, this signal is line 10 of the host address (HA10) input bus.</p> <p><b>Port B 13</b>—When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.</p> <p>The default state after reset for this signal is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                                                                                       |
| HA10                                 | Input                          |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| PB13                                 | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| $\overline{\text{HOREQ}}$ /<br>HOREQ | Output                         | GPIO disconnected  | <p><b>Host Request</b>—When HDI08 is programmed to interface a single host request host bus and the HI function is selected, this signal is the host request (HOREQ) output. The polarity of the host request is programmable, but is configured as active-low (<math>\overline{\text{HOREQ}}</math>) following reset. The host request may be programmed as a driven or open-drain output.</p> <p><b>Transmit Host Request</b>—When HDI08 is programmed to interface a double host request host bus and the HI function is selected, this signal is the transmit host request (HTRQ) output. The polarity of the host request is programmable, but is configured as active-low (<math>\overline{\text{HTRQ}}</math>) following reset. The host request may be programmed as a driven or open-drain output.</p> <p><b>Port B 14</b>—When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.</p> <p>The default state after reset for this signal is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p> |
| $\overline{\text{HTRQ}}$ /<br>HTRQ   | Output                         |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| PB14                                 | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

## PARALLEL HOST INTERFACE (HDI08)

Table 1-9 Host Interface (Continued)

| Signal Name                        | Type                              | State during Reset   | Signal Description                                                                                                                                                                                                                                                                                                                                                                         |
|------------------------------------|-----------------------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\overline{\text{HACK}}$ /<br>HACK | Input                             | GPIO<br>disconnected | <b>Host Acknowledge</b> —When HDI08 is programmed to interface a single host request host bus and the HI function is selected, this signal is the host acknowledge (HACK) Schmitt-trigger input. The polarity of the host acknowledge is programmable, but is configured as active-low ( $\overline{\text{HACK}}$ ) after reset.                                                           |
| $\overline{\text{HRRQ}}$ /<br>HRRQ | Output                            |                      | <b>Receive Host Request</b> —When HDI08 is programmed to interface a double host request host bus and the HI function is selected, this signal is the receive host request (HRRQ) output. The polarity of the host request is programmable, but is configured as active-low ( $\overline{\text{HRRQ}}$ ) after reset. The host request may be programmed as a driven or open-drain output. |
| PB15                               | Input, output, or<br>disconnected |                      | <p><b>Port B 15</b>—When the HDI08 is configured as GPIO, this signal is individually programmed as input, output, or internally disconnected.</p> <p>The default state after reset for this signal is GPIO disconnected.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                                                    |

## SERIAL HOST INTERFACE

The SHI has five I/O signals that can be configured to allow the SHI to operate in either SPI or I<sup>2</sup>C mode.

**Table 1-10 Serial Host Interface Signals**

| Signal Name | Signal Type                | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------|----------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SCK         | Input or output            | Tri-stated         | <p><b>SPI Serial Clock</b>—The SCK signal is an output when the SPI is configured as a master and a Schmitt-trigger input when the SPI is configured as a slave. When the SPI is configured as a master, the SCK signal is derived from the internal SHI clock generator. When the SPI is configured as a slave, the SCK signal is an input, and the clock signal from the external master synchronizes the data transfer. The SCK signal is ignored by the SPI if it is defined as a slave and the slave select (<math>\overline{SS}</math>) signal is not asserted. In both the master and slave SPI devices, data is shifted on one edge of the SCK signal and is sampled on the opposite edge where data is stable. Edge polarity is determined by the SPI transfer protocol.</p> <p><b>I<sup>2</sup>C Serial Clock</b>—SCL carries the clock for I<sup>2</sup>C bus transactions in the I<sup>2</sup>C mode. SCL is a Schmitt-trigger input when configured as a slave and an open-drain output when configured as a master. SCL should be connected to V<sub>CC</sub> through a pull-up resistor.</p> <p>This signal is tri-stated during hardware, software, and individual reset. Thus, there is no need for an external pull-up in this state.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                 |
| SCL         | Input or output            |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| MISO        | Input or output            | Tri-stated         | <p><b>SPI Master-In-Slave-Out</b>—When the SPI is configured as a master, MISO is the master data input line. The MISO signal is used in conjunction with the MOSI signal for transmitting and receiving serial data. This signal is a Schmitt-trigger input when configured for the SPI Master mode, an output when configured for the SPI Slave mode, and tri-stated if configured for the SPI Slave mode when <math>\overline{SS}</math> is deasserted. An external pull-up resistor is not required for SPI operation.</p> <p><b>I<sup>2</sup>C Data and Acknowledge</b>—In I<sup>2</sup>C mode, SDA is a Schmitt-trigger input when receiving and an open-drain output when transmitting. SDA should be connected to V<sub>CC</sub> through a pull-up resistor. SDA carries the data for I<sup>2</sup>C transactions. The data in SDA must be stable during the high period of SCL. The data in SDA is only allowed to change when SCL is low. When the bus is free, SDA is high. The SDA line is only allowed to change during the time SCL is high in the case of start and stop events. A high-to-low transition of the SDA line while SCL is high is a unique situation, and is defined as the start event. A low-to-high transition of SDA while SCL is high is a unique situation defined as the stop event.</p> <p>This signal is tri-stated during hardware, software, and individual reset. Thus, there is no need for an external pull-up in this state.</p> <p>This input is 5 V tolerant.</p> |
| SDA         | Input or open-drain output |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

## Serial Host Interface

Table 1-10 Serial Host Interface Signals (Continued)

| Signal Name       | Signal Type     | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------|-----------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MOSI              | Input or output |                    | <b>SPI Master-Out-Slave-In</b> —When the SPI is configured as a master, MOSI is the master data output line. The MOSI signal is used in conjunction with the MISO signal for transmitting and receiving serial data. MOSI is the slave data input line when the SPI is configured as a slave. This signal is a Schmitt-trigger input when configured for the SPI Slave mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| HA0               | Input           | Tri-stated         | <p><b>I<sup>2</sup>C Slave Address 0</b>—This signal uses a Schmitt-trigger input when configured for the I<sup>2</sup>C mode. When configured for I<sup>2</sup>C slave mode, the HA0 signal is used to form the slave device address. HA0 is ignored when configured for the I<sup>2</sup>C master mode.</p> <p>This signal is tri-stated during hardware, software, and individual reset. Thus, there is no need for an external pull-up in this state.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| $\overline{SS}$   | Input           |                    | <b>SPI Slave Select</b> —This signal is an active low Schmitt-trigger input when configured for the SPI mode. When configured for the SPI Slave mode, this signal is used to enable the SPI slave for transfer. When configured for the SPI master mode, this signal should be kept deasserted (pulled high). If it is asserted while configured as SPI master, a bus error condition is flagged. If $\overline{SS}$ is deasserted, the SHI ignores SCK clocks and keeps the MISO output signal in the high-impedance state.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| HA2               | Input           | Tri-stated         | <p><b>I<sup>2</sup>C Slave Address 2</b>—This signal uses a Schmitt-trigger input when configured for the I<sup>2</sup>C mode. When configured for the I<sup>2</sup>C Slave mode, the HA2 signal is used to form the slave device address. HA2 is ignored in the I<sup>2</sup>C master mode.</p> <p>This signal is tri-stated during hardware, software, and individual reset. Thus, there is no need for an external pull-up in this state.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| $\overline{HREQ}$ | Input or Output | Tri-stated         | <p><b>Host Request</b>—This signal is an active low Schmitt-trigger input when configured for the master mode but an active low output when configured for the slave mode.</p> <p>When configured for the slave mode, <math>\overline{HREQ}</math> is asserted to indicate that the SHI is ready for the next data word transfer and deasserted at the first clock pulse of the new data word transfer. When configured for the master mode, <math>\overline{HREQ}</math> is an input. When asserted by the external slave device, it will trigger the start of the data word transfer by the master. After finishing the data word transfer, the master will await the next assertion of <math>\overline{HREQ}</math> to proceed to the next transfer.</p> <p>This signal is tri-stated during hardware, software, personal reset, or when the HREQ1–HREQ0 bits in the HCSR are cleared. There is no need for external pull-up in this state.</p> <p><i>This input is 5 V tolerant.</i></p> |

## ENHANCED SERIAL AUDIO INTERFACE

**Table 1-11 Enhanced Serial Audio Interface Signals**

| Signal Name     | Signal Type                                           | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------|-------------------------------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HCKR<br><br>PC2 | Input or output<br><br>Input, output, or disconnected | GPIO disconnected  | <p><b>High Frequency Clock for Receiver</b>—When programmed as an input, this signal provides a high frequency clock source for the ESAI receiver as an alternate to the DSP core clock. When programmed as an output, this signal can serve as a high-frequency sample clock (e.g., for external digital to analog converters [DACs]) or as an additional system clock.</p> <p><b>Port C 2</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| HCKT<br><br>PC5 | Input or output<br><br>Input, output, or disconnected | GPIO disconnected  | <p><b>High Frequency Clock for Transmitter</b>—When programmed as an input, this signal provides a high frequency clock source for the ESAI transmitter as an alternate to the DSP core clock. When programmed as an output, this signal can serve as a high frequency sample clock (e.g., for external DACs) or as an additional system clock.</p> <p><b>Port C 5</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p><i>This input is 5 V tolerant.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| FSR<br><br>PC1  | Input or output<br><br>Input, output, or disconnected | GPIO disconnected  | <p><b>Frame Sync for Receiver</b>—This is the receiver frame sync input/output signal. In the asynchronous mode (SYN=0), the FSR pin operates as the frame sync input or output used by all the enabled receivers. In the synchronous mode (SYN=1), it operates as either the serial flag 1 pin (TEBE=0), or as the transmitter external buffer enable control (TEBE=1, RFSD=1).</p> <p>When this pin is configured as serial flag pin, its direction is determined by the RFSD bit in the RCCR register. When configured as the output flag OF1, this pin will reflect the value of the OF1 bit in the SAICR register, and the data in the OF1 bit will show up at the pin synchronized to the frame sync in normal mode or the slot in network mode. When configured as the input flag IF1, the data value at the pin will be stored in the IF1 bit in the SAISR register, synchronized by the frame sync in normal mode or the slot in network mode.</p> <p><b>Port C 1</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p><i>This input is 5 V tolerant.</i></p> |

## Enhanced Serial Audio Interface

Table 1-11 Enhanced Serial Audio Interface Signals (Continued)

| Signal Name | Signal Type                    | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------|--------------------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FST         | Input or output                | GPIO disconnected  | <p><b>Frame Sync for Transmitter</b>—This is the transmitter frame sync input/output signal. For synchronous mode, this signal is the frame sync for both transmitters and receivers. For asynchronous mode, FST is the frame sync for the transmitters only. The direction is determined by the transmitter frame sync direction (TFSD) bit in the ESAI transmit clock control register (TCCR).</p> <p><b>Port C 4</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected. The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| PC4         | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| SCKR        | Input or output                | GPIO disconnected  | <p><b>Receiver Serial Clock</b>—SCKR provides the receiver serial bit clock for the ESAI. The SCKR operates as a clock input or output used by all the enabled receivers in the asynchronous mode (SYN=0), or as serial flag 0 pin in the synchronous mode (SYN=1).</p> <p>When this pin is configured as serial flag pin, its direction is determined by the RCKD bit in the RCCR register. When configured as the output flag OF0, this pin will reflect the value of the OF0 bit in the SAICR register, and the data in the OF0 bit will show up at the pin synchronized to the frame sync in normal mode or the slot in network mode. When configured as the input flag IF0, the data value at the pin will be stored in the IF0 bit in the SAISR register, synchronized by the frame sync in normal mode or the slot in network mode.</p> <p><b>Port C 0</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected. The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p> |
| PC0         | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| SCKT        | Input or output                | GPIO disconnected  | <p><b>Transmitter Serial Clock</b>—This signal provides the serial bit rate clock for the ESAI. SCKT is a clock input or output used by all enabled transmitters and receivers in synchronous mode, or by all enabled transmitters in asynchronous mode.</p> <p><b>Port C 3</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected. The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| PC3         | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

Table 1-11 Enhanced Serial Audio Interface Signals (Continued)

| Signal Name     | Signal Type                    | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------|--------------------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SDO5            | Output                         | GPIO disconnected  | <p><b>Serial Data Output 5</b>—When programmed as a transmitter, SDO5 is used to transmit data from the TX5 serial transmit shift register.</p> <p><b>Serial Data Input 0</b>—When programmed as a receiver, SDI0 is used to receive serial data into the RX0 serial receive shift register.</p> <p><b>Port C 6</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                        |
| SDI0            | Input                          |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| PC6             | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| SDO4            | Output                         | GPIO disconnected  | <p><b>Serial Data Output 4</b>—When programmed as a transmitter, SDO4 is used to transmit data from the TX4 serial transmit shift register.</p> <p><b>Serial Data Input 1</b>—When programmed as a receiver, SDI1 is used to receive serial data into the RX1 serial receive shift register.</p> <p><b>Port C 7</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                        |
| SDI1            | Input                          |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| PC7             | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| SDO3/<br>SDO3_1 | Output                         | GPIO disconnected  | <p><b>Serial Data Output 3</b>—When programmed as a transmitter, SDO3 is used to transmit data from the TX3 serial transmit shift register.</p> <p>When enabled for ESAI_1 operation, this is the ESAI_1 Serial Data Output 3.</p> <p><b>Serial Data Input 2</b>—When programmed as a receiver, SDI2 is used to receive serial data into the RX2 serial receive shift register.</p> <p>When enabled for ESAI_1 operation, this is the ESAI_1 Serial Data Input 2.</p> <p><b>Port C 8</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>When enabled for ESAI_1 GPIO, this is the Port E 8 signal.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p> |
| SDI2/<br>SDI2_1 | Input                          |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| PC8/PE8         | Input, output, or disconnected |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## Enhanced Serial Audio Interface

Table 1-11 Enhanced Serial Audio Interface Signals (Continued)

| Signal Name     | Signal Type                    | State during Reset   | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------|--------------------------------|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SDO2/<br>SDO2_1 | Output                         | GPIO<br>disconnected | <p><b>Serial Data Output 2</b>—When programmed as a transmitter, SDO2 is used to transmit data from the TX2 serial transmit shift register. When enabled for ESAI_1 operation, this is the ESAI_1 Serial Data Output 2.</p> <p><b>Serial Data Input 3</b>—When programmed as a receiver, SDI3 is used to receive serial data into the RX3 serial receive shift register. When enabled for ESAI_1 operation, this is the ESAI_1 Serial Data Input 3.</p> <p><b>Port C 9</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected. When enabled for ESAI_1 GPIO, this is the Port E 9 signal.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p> |
| SDI3/<br>SDI3_1 | Input                          |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| PC9/PE9         | Input, output, or disconnected |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| SDO1/<br>SDO1_1 | Output                         | GPIO<br>disconnected | <p><b>Serial Data Output 1</b>—SDO1 is used to transmit data from the TX1 serial transmit shift register. When enabled for ESAI_1 operation, this is the ESAI_1 Serial Data Output 1.</p> <p><b>Port C 10</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected. When enabled for ESAI_1 GPIO, this is the Port E 10 signal.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                                             |
| PC10/<br>PE10   | Input, output, or disconnected |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| SDO0/<br>SDO0_1 | Output                         | GPIO<br>disconnected | <p><b>Serial Data Output 0</b>—SDO0 is used to transmit data from the TX0 serial transmit shift register. When enabled for ESAI_1 operation, this is the ESAI_1 Serial Data Output 0.</p> <p><b>Port C 11</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected. When enabled for ESAI_1 GPIO, this is the Port E 11 signal.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                                                                                                                                                                                                                             |
| PC11/<br>PE11   | Input, output, or disconnected |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

**ENHANCED SERIAL AUDIO INTERFACE\_1****Table 1-12 Enhanced Serial Audio Interface\_1 Signals**

| Signal Name | Signal Type                    | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------|--------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FSR_1       | Input or output                | GPIO disconnected  | <p><b>Frame Sync for Receiver_1</b>—This is the receiver frame sync input/output signal. In the asynchronous mode (SYN=0), the FSR pin operates as the frame sync input or output used by all the enabled receivers. In the synchronous mode (SYN=1), it operates as either the serial flag 1 pin (TEBE=0), or as the transmitter external buffer enable control (TEBE=1, RFSD=1).</p> <p>When this pin is configured as serial flag pin, its direction is determined by the RFSD bit in the RCCR register. When configured as the output flag OF1, this pin will reflect the value of the OF1 bit in the SAICR register, and the data in the OF1 bit will show up at the pin synchronized to the frame sync in normal mode or the slot in network mode. When configured as the input flag IF1, the data value at the pin will be stored in the IF1 bit in the SAISR register, synchronized by the frame sync in normal mode or the slot in network mode.</p> |
| PE1         | Input, output, or disconnected |                    | <p><b>Port E 1</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input cannot tolerate 5 V.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| FST_1       | Input or output                | GPIO disconnected  | <p><b>Frame Sync for Transmitter_1</b>—This is the transmitter frame sync input/output signal. For synchronous mode, this signal is the frame sync for both transmitters and receivers. For asynchronous mode, FST is the frame sync for the transmitters only. The direction is determined by the transmitter frame sync direction (TFSD) bit in the ESAI transmit clock control register (TCCR).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| PE4         | Input, output, or disconnected |                    | <p><b>Port E 4</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input cannot tolerate 5 V.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## Enhanced Serial Audio Interface\_1

Table 1-12 Enhanced Serial Audio Interface\_1 Signals

| Signal Name | Signal Type                    | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------|--------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SCKR_1      | Input or output                | GPIO disconnected  | <p><b>Receiver Serial Clock_1</b>—SCKR provides the receiver serial bit clock for the ESAI. The SCKR operates as a clock input or output used by all the enabled receivers in the asynchronous mode (SYN=0), or as serial flag 0 pin in the synchronous mode (SYN=1).</p> <p>When this pin is configured as serial flag pin, its direction is determined by the RCKD bit in the RCCR register. When configured as the output flag OF0, this pin will reflect the value of the OF0 bit in the SAICR register, and the data in the OF0 bit will show up at the pin synchronized to the frame sync in normal mode or the slot in network mode. When configured as the input flag IF0, the data value at the pin will be stored in the IF0 bit in the SAISR register, synchronized by the frame sync in normal mode or the slot in network mode.</p> |
| PE0         | Input, output, or disconnected |                    | <p><b>Port E 0</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input cannot tolerate 5 V.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| SCKT_1      | Input or output                | GPIO disconnected  | <p><b>Transmitter Serial Clock_1</b>—This signal provides the serial bit rate clock for the ESAI. SCKT is a clock input or output used by all enabled transmitters and receivers in synchronous mode, or by all enabled transmitters in asynchronous mode.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| PE3         | Input, output, or disconnected |                    | <p><b>Port E 3</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input cannot tolerate 5 V.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| SDO5_1      | Output                         | GPIO disconnected  | <p><b>Serial Data Output 5_1</b>—When programmed as a transmitter, SDO5 is used to transmit data from the TX5 serial transmit shift register.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| SDI0_1      | Input                          |                    | <p><b>Serial Data Input 0_1</b>—When programmed as a receiver, SDI0 is used to receive serial data into the RX0 serial receive shift register.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| PE6         | Input, output, or disconnected |                    | <p><b>Port E 6</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input cannot tolerate 5 V.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

Table 1-12 Enhanced Serial Audio Interface\_1 Signals

| Signal Name | Signal Type                    | State during Reset | Signal Description                                                                                                                                                                                                                               |
|-------------|--------------------------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SDO4_1      | Output                         | GPIO disconnected  | <b>Serial Data Output 4_1</b> —When programmed as a transmitter, SDO4 is used to transmit data from the TX4 serial transmit shift register.                                                                                                      |
| SDI1_1      | Input                          |                    | <b>Serial Data Input 1_1</b> —When programmed as a receiver, SDI1 is used to receive serial data into the RX1 serial receive shift register.                                                                                                     |
| PE7         | Input, output, or disconnected |                    | <p><b>Port E 7</b>—When the ESAI is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p> |

## SPDIF TRANSMITTER DIGITAL AUDIO INTERFACE

Table 1-13 Digital Audio Interface (DAX) Signals

| Signal Name | Type                           | State During Reset | Signal Description                                                                                                                                                                                                                                                                                      |
|-------------|--------------------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACI         | Input                          | GPIO Disconnected  | <b>Audio Clock Input</b> —This is the DAX clock input. When programmed to use an external clock, this input supplies the DAX clock. The external clock frequency must be 256, 384, or 512 times the audio sampling frequency ( $256 \times F_s$ , $384 \times F_s$ or $512 \times F_s$ , respectively). |
| PD0         | Input, output, or disconnected |                    | <p><b>Port D 0</b>—When the DAX is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                         |
| ADO         | Output                         | GPIO Disconnected  | <b>Digital Audio Data Output</b> —This signal is an audio and non-audio output in the form of AES/EBU, CP340 and IEC958 data in a biphase mark format.                                                                                                                                                  |
| PD1         | Input, output, or disconnected |                    | <p><b>Port D 1</b>—When the DAX is configured as GPIO, this signal is individually programmable as input, output, or internally disconnected.</p> <p>The default state after reset is GPIO disconnected.</p> <p>This input is 5 V tolerant.</p>                                                         |

## Timer

**TIMER****Table 1-14 Timer Signal**

| Signal Name | Type            | State during Reset | Signal Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------|-----------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TIO0        | Input or Output | Input              | <p><b>Timer 0 Schmitt-Trigger Input/Output</b>—When timer 0 functions as an external event counter or in measurement mode, TIO0 is used as input. When timer 0 functions in watchdog, timer, or pulse modulation mode, TIO0 is used as output.</p> <p>The default mode after reset is GPIO input. This can be changed to output or configured as a timer input/output through the timer 0 control/status register (TCSR0). If TIO0 is not being used, it is recommended to either define it as GPIO output immediately at the beginning of operation or leave it defined as GPIO input but connected to Vcc through a pull-up resistor in order to ensure a stable logic level at this input.</p> <p><i>This input is 5 V tolerant.</i></p> |

**JTAG/OnCE INTERFACE****Table 1-15 JTAG/OnCE Interface**

| Signal Name | Signal Type | State during Reset | Signal Description                                                                                                                                                                                                                             |
|-------------|-------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TCK         | Input       | Input              | <p><b>Test Clock</b>—TCK is a test clock input signal used to synchronize the JTAG test logic. It has an internal pull-up resistor.</p> <p><i>This input is 5 V tolerant.</i></p>                                                              |
| TDI         | Input       | Input              | <p><b>Test Data Input</b>—TDI is a test data serial input signal used for test instructions and data. TDI is sampled on the rising edge of TCK and has an internal pull-up resistor.</p> <p>This input is 5 V tolerant.</p>                    |
| TDO         | Output      | Tri-stated         | <p><b>Test Data Output</b>—TDO is a test data serial output signal used for test instructions and data. TDO is tri-statable and is actively driven in the shift-IR and shift-DR controller states. TDO changes on the falling edge of TCK.</p> |
| TMS         | Input       | Input              | <p><b>Test Mode Select</b>—TMS is an input signal used to sequence the test controller's state machine. TMS is sampled on the rising edge of TCK and has an internal pull-up resistor.</p> <p>This input is 5 V tolerant.</p>                  |





# SECTION 2

## SPECIFICATIONS

---

### INTRODUCTION

The DSP56366 is a high density CMOS device with Transistor-Transistor Logic (TTL) compatible inputs and outputs. The DSP56366 specifications are preliminary and are from design simulations, and may not be fully tested or guaranteed. Finalized specifications will be published after full characterization and device qualifications are complete.

### MAXIMUM RATINGS

#### CAUTION

**This device contains circuitry protecting against damage due to high static voltage or electrical fields. However, normal precautions should be taken to avoid exceeding maximum voltage ratings. Reliability of operation is enhanced if unused inputs are pulled to an appropriate logic voltage level (e.g., either GND or  $V_{CC}$ ). The suggested value for a pullup or pulldown resistor is 10 k $\Omega$ .**

**Note:** In the calculation of timing requirements, adding a maximum value of one specification to a minimum value of another specification does not yield a reasonable sum. A maximum specification is calculated using a worst case variation of process parameter values in one direction. The minimum specification is calculated using the worst case for the same parameters in the opposite direction. Therefore, a “maximum” value for a specification will never occur in the same device that has a “minimum” value for another specification; adding a maximum to a minimum represents a condition that can never exist.

## Specifications

### Thermal Characteristics

**Table 2-1 Maximum Ratings**

| Rating <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Symbol                           | Value <sup>1, 2</sup>               | Unit |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-------------------------------------|------|
| Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | V <sub>CC</sub>                  | −0.3 to +4.0                        | V    |
| All input voltages excluding “5 V tolerant” inputs <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | V <sub>IN</sub>                  | GND -0.3 to V <sub>CC</sub> + 0.3   | V    |
| All “5 V tolerant” input voltages <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | V <sub>IN5</sub>                 | GND − 0.3 to V <sub>CC</sub> + 3.95 | V    |
| Current drain per pin excluding V <sub>CC</sub> and GND                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | I                                | 10                                  | mA   |
| Operating temperature range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | T <sub>J</sub><br>T <sub>a</sub> | −40 to +105<br>−40 to +85           | °C   |
| Storage temperature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | T <sub>STG</sub>                 | −55 to +125                         | °C   |
| Notes: 1. GND = 0 V, V <sub>CC</sub> = 3.3 V ± 0.16 V, T <sub>J</sub> = −40°C to +105°C, CL = 50 pF<br>2. Absolute maximum ratings are stress ratings only, and functional operation at the maximum is not guaranteed. Stress beyond the maximum rating may affect device reliability or cause permanent damage to the device.<br>3. <b>CAUTION:</b> All “5 V Tolerant” input voltages must not be more than 3.95 V greater than the supply voltage; this restriction applies to “power on”, as well as during normal operation. In any case, the input voltages cannot be more than 5.75 V. “5 V Tolerant” inputs are inputs that tolerate 5 V. |                                  |                                     |      |

## THERMAL CHARACTERISTICS

**Table 2-2 Thermal Characteristics**

| Characteristic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Symbol                              | TQFP Value | Unit |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------|------|
| Junction-to-ambient thermal resistance <sup>1, 2</sup> Natural Convection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | R <sub>θJA</sub> or θ <sub>JA</sub> | 37         | °C/W |
| Junction-to-case thermal resistance <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | R <sub>θJC</sub> or θ <sub>JC</sub> | 7          | °C/W |
| Thermal characterization parameter <sup>4</sup> Natural Convection                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Ψ <sub>JT</sub>                     | 2.0        | °C/W |
| 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.<br>2. Per SEMI G38-87 and JEDEC JESD51-2 with the single layer board horizontal.<br>3. Thermal resistance between the die and the case top surface as measured by the cold plate method (MIL SPEC-883 Method 1012.1).<br>4. 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. |                                     |            |      |

## DC ELECTRICAL CHARACTERISTICS

Table 2-3 DC Electrical Characteristics<sup>6</sup>

| Characteristics                                                                                                                                                                            | Symbol           | Min                    | Typ | Max                    | Unit |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------------|-----|------------------------|------|
| Supply voltage                                                                                                                                                                             | V <sub>CC</sub>  | 3.14                   | 3.3 | 3.46                   | V    |
| Input high voltage                                                                                                                                                                         |                  |                        |     |                        |      |
| • D(0:23), $\overline{\text{BG}}$ , $\overline{\text{BB}}$ , $\overline{\text{TA}}$ , ESAI_1(except SDO4_1)                                                                                | V <sub>IH</sub>  | 2.0                    | —   | V <sub>CC</sub>        | V    |
| • MOD <sup>1</sup> / $\overline{\text{IRQ}}$ <sup>1</sup> , $\overline{\text{RESET}}$ , PINIT/ $\overline{\text{NMI}}$ and all JTAG/ESAI/Timer/HDI08/DAX/ESAI_1(only SDO4_1)/SHI(SPI mode) | V <sub>IHP</sub> | 2.0                    | —   | V <sub>CC</sub> + 3.95 |      |
| • SHI(I2C mode)                                                                                                                                                                            | V <sub>IHP</sub> | 1.5                    | —   | V <sub>CC</sub> + 3.95 |      |
| • EXTAL <sup>8</sup>                                                                                                                                                                       | V <sub>IHX</sub> | 0.8 × V <sub>CC</sub>  | —   | V <sub>CC</sub>        |      |
| Input low voltage                                                                                                                                                                          |                  |                        |     |                        |      |
| • D(0:23), $\overline{\text{BG}}$ , $\overline{\text{BB}}$ , $\overline{\text{TA}}$ , ESAI_1(except SDO4_1)                                                                                | V <sub>IL</sub>  | −0.3                   | —   | 0.8                    | V    |
| • MOD <sup>1</sup> / $\overline{\text{IRQ}}$ <sup>1</sup> , $\overline{\text{RESET}}$ , PINIT/ $\overline{\text{NMI}}$ and all JTAG/ESAI/Timer/HDI08/DAX/ESAI_1(only SDO4_1)/SHI(SPI mode) | V <sub>ILP</sub> | −0.3                   | —   | 0.8                    |      |
| • SHI(I2C mode)                                                                                                                                                                            | V <sub>ILP</sub> | −0.3                   | —   | 0.3 × V <sub>CC</sub>  |      |
| • EXTAL <sup>8</sup>                                                                                                                                                                       | V <sub>ILX</sub> | −0.3                   | —   | 0.2 × V <sub>CC</sub>  |      |
| Input leakage current                                                                                                                                                                      | I <sub>IN</sub>  | −10                    | —   | 10                     | μA   |
| High impedance (off-state) input current (@ 2.4 V / 0.4 V)                                                                                                                                 | I <sub>TSI</sub> | −10                    | —   | 10                     | μA   |
| Output high voltage                                                                                                                                                                        |                  |                        |     |                        |      |
| • TTL (I <sub>OH</sub> = −0.4 mA) <sup>5,7</sup>                                                                                                                                           | V <sub>OH</sub>  | 2.4                    | —   | —                      | V    |
| • CMOS (I <sub>OH</sub> = −10 μA) <sup>5</sup>                                                                                                                                             |                  | V <sub>CC</sub> − 0.01 | —   | —                      | V    |
| Output low voltage                                                                                                                                                                         |                  |                        |     |                        |      |
| • TTL (I <sub>OL</sub> = 3.0 mA, open-drain pins I <sub>OL</sub> = 6.7 mA) <sup>5,7</sup>                                                                                                  | V <sub>OL</sub>  | —                      | —   | 0.4                    | V    |
| • CMOS (I <sub>OL</sub> = 10 μA) <sup>5</sup>                                                                                                                                              |                  | —                      | —   | 0.01                   |      |
| Internal supply current <sup>2</sup> at internal clock of 120MHz                                                                                                                           |                  |                        |     |                        |      |
| • In Normal mode                                                                                                                                                                           | I <sub>CCI</sub> | —                      | 116 | 200                    | mA   |
| • In Wait mode                                                                                                                                                                             | I <sub>CCW</sub> | —                      | 7.3 | 25                     | mA   |
| • In Stop mode <sup>4</sup>                                                                                                                                                                | I <sub>CCS</sub> | —                      | 1   | 10                     | mA   |
| PLL supply current                                                                                                                                                                         |                  | —                      | 1   | 2.5                    | mA   |
| Input capacitance <sup>5</sup>                                                                                                                                                             | C <sub>IN</sub>  | —                      | —   | 10                     | pF   |

## DC Electrical Characteristics

Table 2-3 DC Electrical Characteristics<sup>6</sup> (Continued)

| Characteristics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Symbol | Min | Typ | Max | Unit |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|-----|-----|------|
| <p>Notes:</p> <ol style="list-style-type: none"> <li>Refers to MODA/<math>\overline{\text{IRQA}}</math>, MODB/<math>\overline{\text{IRQB}}</math>, MODC/<math>\overline{\text{IRQC}}</math>, and MODD/<math>\overline{\text{IRQD}}</math> pins</li> <li><b>Power Consumption Considerations</b> on page 4-4 provides a formula to compute the estimated current requirements in Normal mode. In order to obtain these results, all inputs must be terminated (i.e., not allowed to float). Measurements are based on synthetic intensive DSP benchmarks. The power consumption numbers in this specification are 90% of the measured results of this benchmark. This reflects typical DSP applications. Typical internal supply current is measured with <math>V_{CC} = 3.3 \text{ V}</math> at <math>T_J = 105^\circ\text{C}</math>. Maximum internal supply current is measured with <math>V_{CC} = 3.46 \text{ V}</math> at <math>T_J = 105^\circ\text{C}</math>.</li> <li>Deleted.</li> <li>In order to obtain these results, all inputs, which are not disconnected at Stop mode, must be terminated (i.e., not allowed to float).</li> <li>Periodically sampled and not 100% tested</li> <li><math>V_{CC} = 3.3 \text{ V} \pm .16 \text{ V}</math>; <math>T_J = -40^\circ\text{C}</math> to <math>+105^\circ\text{C}</math>, <math>C_L = 50 \text{ pF}</math></li> <li>This characteristic does not apply to PCAP.</li> <li>Driving EXTAL to the low <math>V_{\text{IH}X}</math> or the high <math>V_{\text{IL}X}</math> value may cause additional power consumption (DC current). To minimize power consumption, the minimum <math>V_{\text{IH}X}</math> should be no lower than <math>0.9 \times V_{CC}</math> and the maximum <math>V_{\text{IL}X}</math> should be no higher than <math>0.1 \times V_{CC}</math>.</li> </ol> |        |     |     |     |      |

## AC ELECTRICAL CHARACTERISTICS

The timing waveforms shown in the AC electrical characteristics section are tested with a  $V_{IL}$  maximum of 0.3 V and a  $V_{IH}$  minimum of 2.4 V for all pins except EXTAL, which is tested using the input levels shown in **Note 8** of the previous table. AC timing specifications, which are referenced to a device input signal, are measured in production with respect to the 50% point of the respective input signal's transition. DSP56366 output levels are measured with the production test machine  $V_{OL}$  and  $V_{OH}$  reference levels set at 0.4 V and 2.4 V, respectively.

**Note:** Although the minimum value for the frequency of EXTAL is 0 MHz, the device AC test conditions are 15 MHz and rated speed.

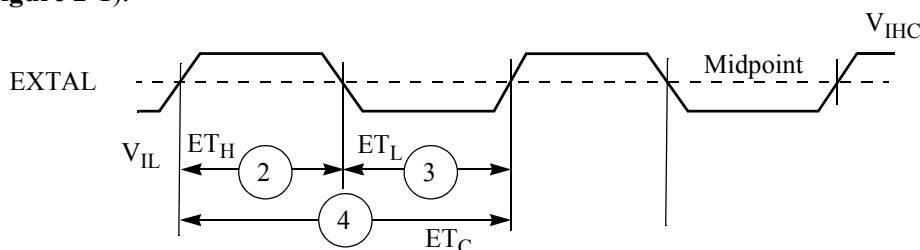
## INTERNAL CLOCKS

Table 2-4 Internal Clocks

| Characteristics                                                                                                                                                                                                                                                                                                       | Symbol    | Expression <sup>1, 2</sup>                   |                                    |                                              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------|------------------------------------|----------------------------------------------|
|                                                                                                                                                                                                                                                                                                                       |           | Min                                          | Typ                                | Max                                          |
| Internal operation frequency with PLL enabled                                                                                                                                                                                                                                                                         | f         | —                                            | $(Ef \times MF) / (PDF \times DF)$ | —                                            |
| Internal operation frequency with PLL disabled                                                                                                                                                                                                                                                                        | f         | —                                            | $Ef/2$                             | —                                            |
| Internal clock high period                                                                                                                                                                                                                                                                                            | $T_H$     | —                                            | $ET_C$                             | —                                            |
| • With PLL disabled                                                                                                                                                                                                                                                                                                   |           | —                                            | —                                  | —                                            |
| • With PLL enabled and $MF \leq 4$                                                                                                                                                                                                                                                                                    |           | $0.49 \times ET_C \times PDF \times DF / MF$ | —                                  | $0.51 \times ET_C \times PDF \times DF / MF$ |
| • With PLL enabled and $MF > 4$                                                                                                                                                                                                                                                                                       |           | $0.47 \times ET_C \times PDF \times DF / MF$ | —                                  | $0.53 \times ET_C \times PDF \times DF / MF$ |
| Internal clock low period                                                                                                                                                                                                                                                                                             | $T_L$     | —                                            | $ET_C$                             | —                                            |
| • With PLL disabled                                                                                                                                                                                                                                                                                                   |           | —                                            | —                                  | —                                            |
| • With PLL enabled and $MF \leq 4$                                                                                                                                                                                                                                                                                    |           | $0.49 \times ET_C \times PDF \times DF / MF$ | —                                  | $0.51 \times ET_C \times PDF \times DF / MF$ |
| • With PLL enabled and $MF > 4$                                                                                                                                                                                                                                                                                       |           | $0.47 \times ET_C \times PDF \times DF / MF$ | —                                  | $0.53 \times ET_C \times PDF \times DF / MF$ |
| Internal clock cycle time with PLL enabled                                                                                                                                                                                                                                                                            | $T_C$     | —                                            | $ET_C \times PDF \times DF / MF$   | —                                            |
| Internal clock cycle time with PLL disabled                                                                                                                                                                                                                                                                           | $T_C$     | —                                            | $2 \times ET_C$                    | —                                            |
| Instruction cycle time                                                                                                                                                                                                                                                                                                | $I_{CYC}$ | —                                            | $T_C$                              | —                                            |
| Notes: 1. DF = Division Factor<br>Ef = External frequency<br>$ET_C$ = External clock cycle<br>MF = Multiplication Factor<br>PDF = Predivision Factor<br>$T_C$ = internal clock cycle<br>2. See the <b>PLL and Clock Generation</b> section in the <i>DSP56300 Family Manual</i> for a detailed discussion of the PLL. |           |                                              |                                    |                                              |

## EXTERNAL CLOCK OPERATION

The DSP56366 system clock is an externally supplied square wave voltage source connected to EXTAL(Figure 2-1).



Note: The midpoint is  $0.5 (V_{IHC} + V_{ILC})$ .

**Figure 2-1 External Clock Timing**

**Table 2-5 Clock Operation**

| No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Characteristics                                                                                                                                             | Symbol           | Min                 | Max           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|---------------------|---------------|
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Frequency of EXTAL (EXTAL Pin Frequency)<br>The rise and fall time of this external clock should be 3 ns maximum.                                           | Ef               | 0                   | 120.0         |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | EXTAL input high <sup>1, 2</sup><br>• With PLL disabled (46.7%–53.3% duty cycle <sup>6</sup> )<br>• With PLL enabled (42.5%–57.5% duty cycle <sup>6</sup> ) | ET <sub>H</sub>  | 3.89 ns<br>3.54 ns  | ∞<br>157.0 μs |
| 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | EXTAL input low <sup>1, 2</sup><br>• With PLL disabled (46.7%–53.3% duty cycle <sup>6</sup> )<br>• With PLL enabled (42.5%–57.5% duty cycle <sup>6</sup> )  | ET <sub>L</sub>  | 3.89 ns<br>3.54 ns  | ∞<br>157.0 μs |
| 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | EXTAL cycle time <sup>2</sup><br>• With PLL disabled<br>• With PLL enabled                                                                                  | ET <sub>C</sub>  | 8.33 ns<br>8.33 ns  | ∞<br>273.1 μs |
| 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Instruction cycle time = I <sub>CYC</sub> = T <sub>C</sub> <sup>4</sup><br>• With PLL disabled<br>• With PLL enabled                                        | I <sub>CYC</sub> | 16.66 ns<br>8.33 ns | ∞<br>8.53 μs  |
| Notes: 1. Measured at 50% of the input transition<br>2. The maximum value for PLL enabled is given for minimum V <sub>CO</sub> and maximum MF.<br>3.<br>4. The maximum value for PLL enabled is given for minimum VCO and maximum DF.<br>5.<br>6. The indicated duty cycle is for the specified maximum frequency for which a part is rated. The minimum clock high or low time required for correct operation, however, remains the same at lower operating frequencies; therefore, when a lower clock frequency is used, the signal symmetry may vary from the specified duty cycle as long as the minimum high time and low time requirements are met. |                                                                                                                                                             |                  |                     |               |

**PHASE LOCK LOOP (PLL) CHARACTERISTICS****Table 2-6 PLL Characteristics**

| Characteristics                                                                                                                                                                                                                                                                          | Min                                  | Max                                   | Unit |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------|------|
| V <sub>CO</sub> frequency when PLL enabled<br>(MF × E <sub>f</sub> × 2/PDF)                                                                                                                                                                                                              | 30                                   | 240                                   | MHz  |
| PLL external capacitor (PCAP pin to V <sub>CCP</sub> ) (C <sub>PCAP</sub> <sup>1)</sup><br><ul style="list-style-type: none"> <li>• @ MF ≤ 4</li> <li>• @ MF &gt; 4</li> </ul>                                                                                                           | <br>(MF × 580) – 100<br><br>MF × 830 | <br>(MF × 780) – 140<br><br>MF × 1470 | pF   |
| Notes: 1. C <sub>PCAP</sub> is the value of the PLL capacitor (connected between the PCAP pin and V <sub>CCP</sub> ). The recommended value in pF for C <sub>PCAP</sub> can be computed from one of the following equations:<br>(MF × 680)–120, for MF ≤ 4, or<br>MF × 1100, for MF > 4. |                                      |                                       |      |

**RESET, STOP, MODE SELECT, AND INTERRUPT TIMING****Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing<sup>6</sup>**

| No. | Characteristics                                                                                                                                                                                                                                   | Expression                                       | Min   | Max    | Unit          |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------|--------|---------------|
| 8   | Delay from $\overline{\text{RESET}}$ assertion to all pins at reset value <sup>3</sup>                                                                                                                                                            | —                                                | —     | 26.0   | ns            |
| 9   | Required $\overline{\text{RESET}}$ duration <sup>4</sup>                                                                                                                                                                                          |                                                  |       |        |               |
|     | • Power on, external clock generator, PLL disabled                                                                                                                                                                                                | $50 \times \text{ET}_C$                          | 416.7 | —      | ns            |
|     | • Power on, external clock generator, PLL enabled                                                                                                                                                                                                 | $1000 \times \text{ET}_C$                        | 8.3   | —      | $\mu\text{s}$ |
|     | • During normal operation                                                                                                                                                                                                                         | $2.5 \times T_C$                                 | 20.8  | —      | ns            |
| 10  | Delay from asynchronous $\overline{\text{RESET}}$ deassertion to first external address output (internal reset deassertion) <sup>5</sup>                                                                                                          |                                                  |       |        |               |
|     | • Minimum                                                                                                                                                                                                                                         | $3.25 \times T_C + 2.0$                          | 29.1  | —      | ns            |
|     | • Maximum                                                                                                                                                                                                                                         | $20.25 T_C + 7.50$                               | —     | 176.2  | ns            |
| 13  | Mode select setup time                                                                                                                                                                                                                            |                                                  | 30.0  | —      | ns            |
| 14  | Mode select hold time                                                                                                                                                                                                                             |                                                  | 0.0   | —      | ns            |
| 15  | Minimum edge-triggered interrupt request assertion width                                                                                                                                                                                          |                                                  | 5.5   | —      | ns            |
| 16  | Minimum edge-triggered interrupt request deassertion width                                                                                                                                                                                        |                                                  | 5.5   | —      | ns            |
| 17  | Delay from $\overline{\text{IRQA}}$ , $\overline{\text{IRQB}}$ , $\overline{\text{IRQC}}$ , $\overline{\text{IRQD}}$ , $\overline{\text{NMI}}$ assertion to external memory access address out valid                                              |                                                  |       |        |               |
|     | • Caused by first interrupt instruction fetch                                                                                                                                                                                                     | $4.25 \times T_C + 2.0$                          | 37.4  | —      | ns            |
|     | • Caused by first interrupt instruction execution                                                                                                                                                                                                 | $7.25 \times T_C + 2.0$                          | 62.4  | —      | ns            |
| 18  | Delay from $\overline{\text{IRQA}}$ , $\overline{\text{IRQB}}$ , $\overline{\text{IRQC}}$ , $\overline{\text{IRQD}}$ , $\overline{\text{NMI}}$ assertion to general-purpose transfer output valid caused by first interrupt instruction execution | $10 \times T_C + 5.0$                            | 88.3  | —      | ns            |
| 19  | Delay from address output valid caused by first interrupt instruction execute to interrupt request deassertion for level sensitive fast interrupts <sup>1</sup>                                                                                   | $3.75 \times T_C + \text{WS} \times T_C - 10.94$ | —     | Note 7 | ns            |
| 20  | Delay from $\overline{\text{RD}}$ assertion to interrupt request deassertion for level sensitive fast interrupts <sup>1</sup>                                                                                                                     | $3.25 \times T_C + \text{WS} \times T_C - 10.94$ | —     | Note 7 | ns            |
| 21  | Delay from $\overline{\text{WR}}$ assertion to interrupt request deassertion for level sensitive fast interrupts <sup>1</sup>                                                                                                                     |                                                  |       |        |               |
|     | • DRAM for all WS                                                                                                                                                                                                                                 | $(\text{WS} + 3.5) \times T_C - 10.94$           | —     | Note 7 | ns            |
|     | • SRAM WS = 1                                                                                                                                                                                                                                     | $(\text{WS} + 3.5) \times T_C - 10.94$           | —     | Note 7 |               |
|     | • SRAM WS = 2, 3                                                                                                                                                                                                                                  | $(\text{WS} + 3) \times T_C - 10.94$             | —     | Note 7 |               |
|     | • SRAM WS $\geq 4$                                                                                                                                                                                                                                | $(\text{WS} + 2.5) \times T_C - 10.94$           | —     | Note 7 |               |
| 24  | Duration for $\overline{\text{IRQA}}$ assertion to recover from Stop state                                                                                                                                                                        |                                                  | 4.9   | —      |               |

## Reset, Stop, Mode Select, and Interrupt Timing

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing<sup>6</sup> (Continued)

| No. | Characteristics                                                                                                                | Expression                                                                                           | Min  | Max   | Unit |
|-----|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------|-------|------|
| 25  | Delay from $\overline{\text{IRQA}}$ assertion to fetch of first instruction (when exiting Stop) <sup>2, 3</sup>                |                                                                                                      |      |       |      |
|     | • PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is enabled (OMR Bit 6 = 0)                                    | $\text{PLC} \times \text{ET}_C \times \text{PDF} + (128 \text{ K} - \text{PLC}/2) \times \text{T}_C$ | —    | —     | ms   |
|     | • PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is not enabled (OMR Bit 6 = 1)                                | $\text{PLC} \times \text{ET}_C \times \text{PDF} + (23.75 \pm 0.5) \times \text{T}_C$                | —    | —     | ms   |
|     | • PLL is active during Stop (PCTL Bit 17 = 1) (Implies No Stop Delay)                                                          | $(8.25 \pm 0.5) \times \text{T}_C$                                                                   | 64.6 | 72.9  | ns   |
| 26  | Duration of level sensitive $\overline{\text{IRQA}}$ assertion to ensure interrupt service (when exiting Stop) <sup>2, 3</sup> |                                                                                                      |      |       |      |
|     | • PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is enabled (OMR Bit 6 = 0)                                    | $\text{PLC} \times \text{ET}_C \times \text{PDF} + (128\text{K} - \text{PLC}/2) \times \text{T}_C$   | —    | —     | ms   |
|     | • PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is not enabled (OMR Bit 6 = 1)                                | $\text{PLC} \times \text{ET}_C \times \text{PDF} + (20.5 \pm 0.5) \times \text{T}_C$                 | —    | —     | ms   |
|     | • PLL is active during Stop (PCTL Bit 17 = 1) (implies no Stop delay)                                                          | $5.5 \times \text{T}_C$                                                                              | 45.8 | —     | ns   |
| 27  | Interrupt Requests Rate                                                                                                        |                                                                                                      |      |       |      |
|     | • HDI08, ESAI, ESAI_1, SHI, DAX, Timer                                                                                         | $12\text{T}_C$                                                                                       | —    | 100.0 | ns   |
|     | • DMA                                                                                                                          | $8\text{T}_C$                                                                                        | —    | 66.7  | ns   |
|     | • $\overline{\text{IRQ}}$ , $\overline{\text{NMI}}$ (edge trigger)                                                             | $8\text{T}_C$                                                                                        | —    | 66.7  | ns   |
|     | • $\overline{\text{IRQ}}$ (level trigger)                                                                                      | $12\text{T}_C$                                                                                       | —    | 100.0 | ns   |
| 28  | DMA Requests Rate                                                                                                              |                                                                                                      |      |       |      |
|     | • Data read from HDI08, ESAI, ESAI_1, SHI, DAX                                                                                 | $6\text{T}_C$                                                                                        | —    | 50.0  | ns   |
|     | • Data write to HDI08, ESAI, ESAI_1, SHI, DAX                                                                                  | $7\text{T}_C$                                                                                        | —    | 58.0  | ns   |
|     | • Timer                                                                                                                        | $2\text{T}_C$                                                                                        | —    | 16.7  | ns   |
|     | • $\overline{\text{IRQ}}$ , $\overline{\text{NMI}}$ (edge trigger)                                                             | $3\text{T}_C$                                                                                        | —    | 25.0  | ns   |

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing<sup>6</sup> (Continued)

| No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Characteristics                                                                                                                                                                               | Expression              | Min  | Max | Unit |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------|-----|------|
| 29                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Delay from $\overline{\text{IRQA}}$ , $\overline{\text{IRQB}}$ , $\overline{\text{IRQC}}$ , $\overline{\text{IRQD}}$ , NMI assertion to external memory (DMA source) access address out valid | $4.25 \times T_C + 2.0$ | 37.4 | —   | ns   |
| <p>Notes:</p> <ol style="list-style-type: none"> <li>When using fast interrupts and <math>\overline{\text{IRQA}}</math>, <math>\overline{\text{IRQB}}</math>, <math>\overline{\text{IRQC}}</math>, and <math>\overline{\text{IRQD}}</math> are defined as level-sensitive, timings 19 through 21 apply to prevent multiple interrupt service. To avoid these timing restrictions, the deasserted Edge-triggered mode is recommended when using fast interrupts. Long interrupts are recommended when using Level-sensitive mode.</li> <li>This timing depends on several settings:</li> </ol> <p>For PLL disable, using external clock (PCTL Bit 16 = 1), no stabilization delay is required and recovery time will be defined by the PCTL Bit 17 and OMR Bit 6 settings.</p> <p>For PLL enable, if PCTL Bit 17 is 0, the PLL is shutdown during Stop. Recovering from Stop requires the PLL to get locked. The PLL lock procedure duration, PLL Lock Cycles (PLC), may be in the range of 0 to 1000 cycles. This procedure occurs in parallel with the stop delay counter, and stop recovery will end when the last of these two events occurs: the stop delay counter completes count or PLL lock procedure completion.</p> <p>PLC value for PLL disable is 0.</p> <p>The maximum value for <math>ET_C</math> is 4096 (maximum MF) divided by the desired internal frequency (i.e., for 120 MHz it is <math>4096/120 \text{ MHz} = 34.1 \mu\text{s}</math>). During the stabilization period, <math>T_C</math>, <math>T_H</math>, and <math>T_L</math> will not be constant, and their width may vary, so timing may vary as well.</p> <ol style="list-style-type: none"> <li>Periodically sampled and not 100% tested</li> <li><math>\overline{\text{RESET}}</math> duration is measured during the time in which <math>\overline{\text{RESET}}</math> is asserted, <math>V_{CC}</math> is valid, and the EXTAL input is active and valid. When the <math>V_{CC}</math> is valid, but the other “required RESET duration” conditions (as specified above) have not been yet met, the device circuitry will be in an uninitialized state that can result in significant power consumption and heat-up. Designs should minimize this state to the shortest possible duration.</li> <li>If PLL does not lose lock</li> <li><math>V_{CC} = 3.3 \text{ V} \pm 0.16 \text{ V}</math>; <math>T_J = -40^\circ\text{C}</math> to <math>+105^\circ\text{C}</math>, <math>C_L = 50 \text{ pF}</math></li> <li>WS = number of wait states (measured in clock cycles, number of <math>T_C</math>). Use expression to compute maximum value.</li> </ol> |                                                                                                                                                                                               |                         |      |     |      |

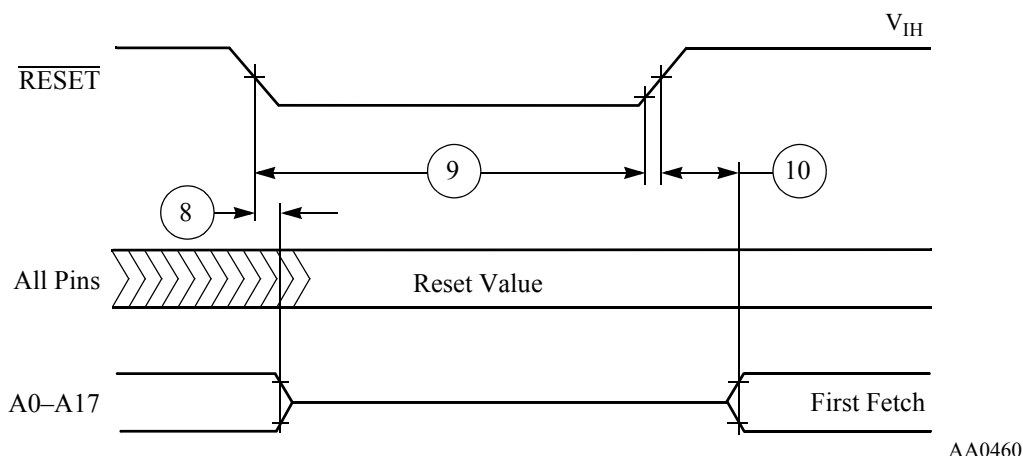
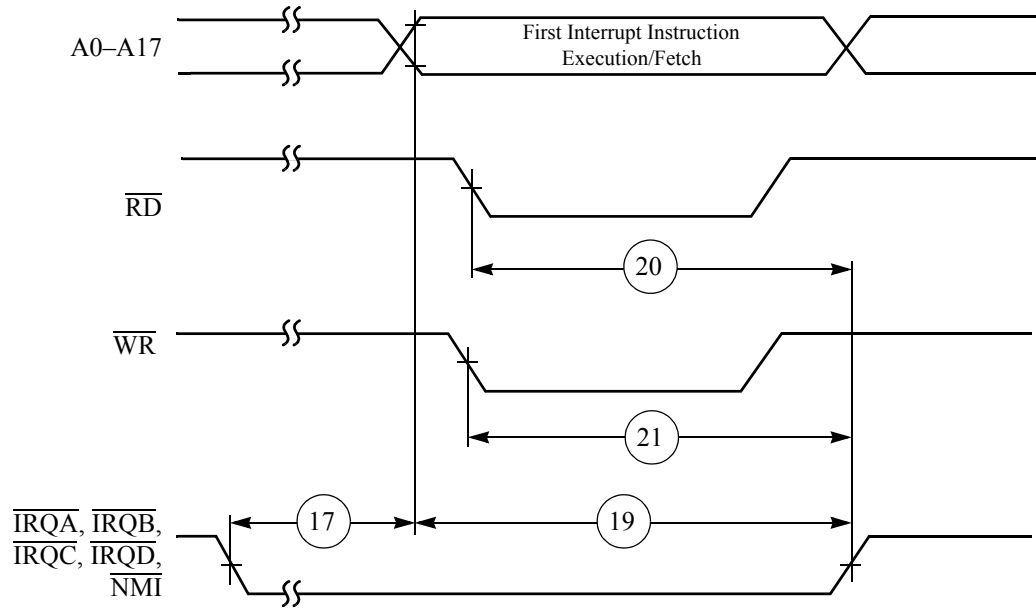
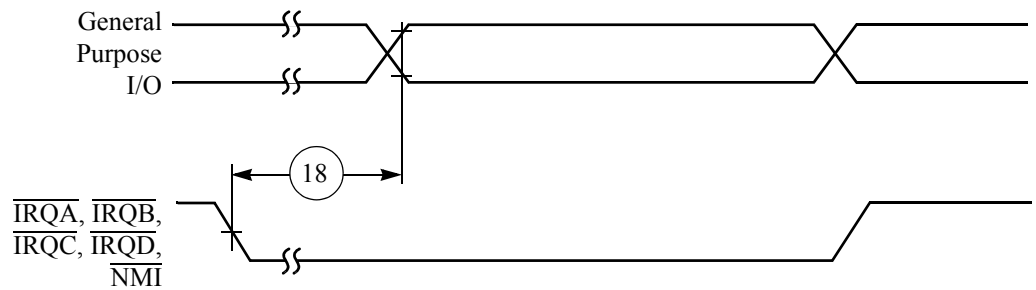


Figure 2-2 Reset Timing

Reset, Stop, Mode Select, and Interrupt Timing

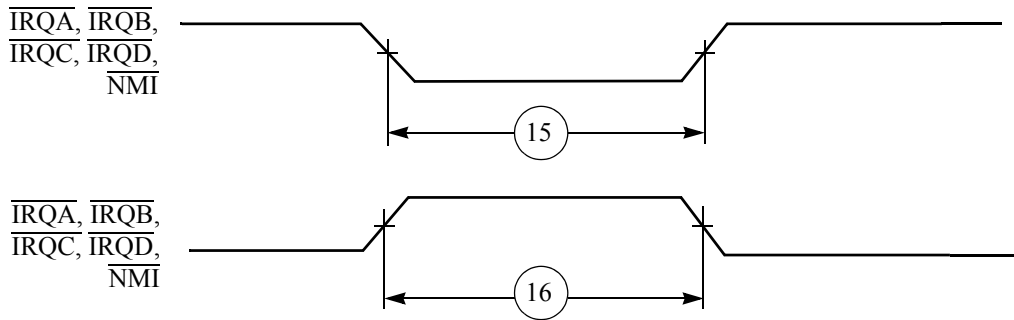


a) First Interrupt Instruction Execution



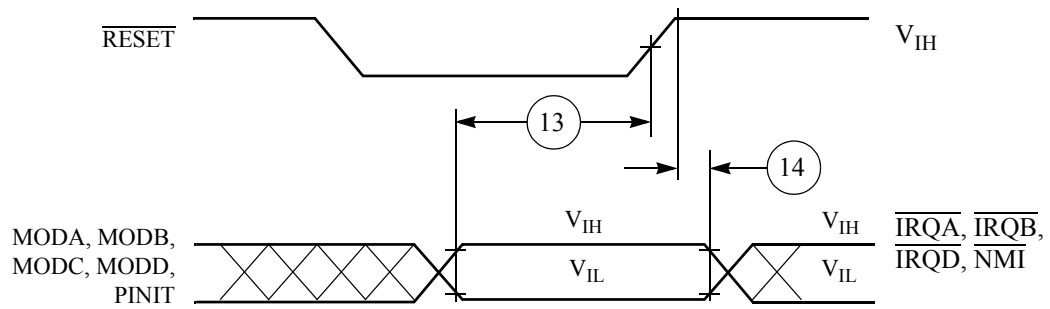
b) General Purpose I/O

Figure 2-3 External Fast Interrupt Timing



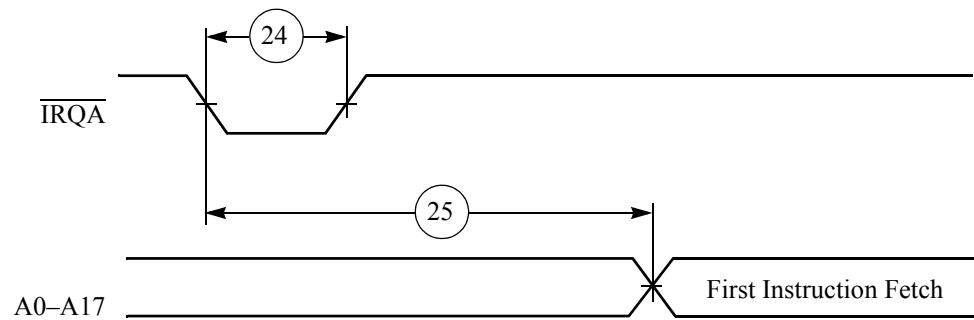
AA0463

Figure 2-4 External Interrupt Timing (Negative Edge-Triggered)

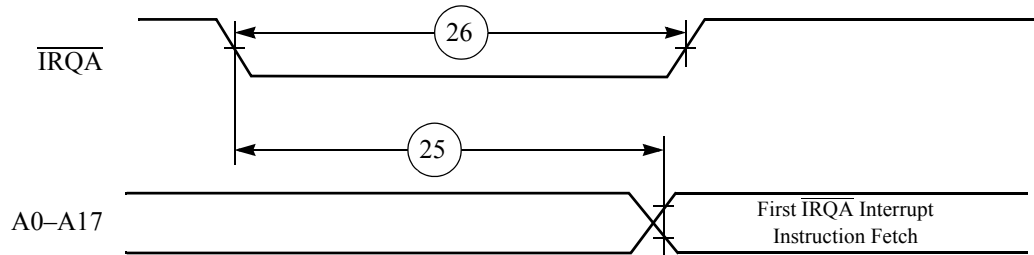


AA0465

Figure 2-5 Operating Mode Select Timing



AA0466

Figure 2-6 Recovery from Stop State Using  $\overline{IRQA}$ 

AA0467

Figure 2-7 Recovery from Stop State Using  $\overline{IRQA}$  Interrupt Service

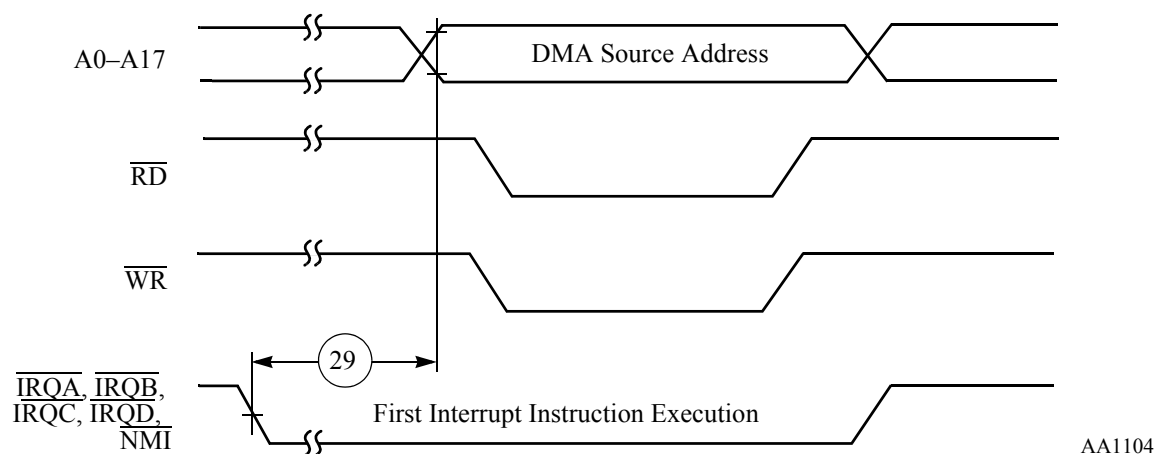


Figure 2-8 External Memory Access (DMA Source) Timing

## EXTERNAL MEMORY EXPANSION PORT (PORT A)

## SRAM Timing

Table 2-8 SRAM Read and Write Accesses<sup>3</sup>

| No. | Characteristics                                                | Symbol            | Expression <sup>1</sup>                                     | Min  | Max | Unit |
|-----|----------------------------------------------------------------|-------------------|-------------------------------------------------------------|------|-----|------|
| 100 | Address valid and AA assertion pulse width                     | $t_{RC}, t_{WC}$  | $(WS + 1) \times T_C - 4.0$<br>[1 ≤ WS ≤ 3]                 | 12.0 | —   | ns   |
|     |                                                                |                   | $(WS + 2) \times T_C - 4.0$<br>[4 ≤ WS ≤ 7]                 | 46.0 | —   | ns   |
|     |                                                                |                   | $(WS + 3) \times T_C - 4.0$<br>[WS ≥ 8]                     | 87.0 | —   | ns   |
| 101 | Address and AA valid to $\overline{WR}$ assertion              | $t_{AS}$          | $0.25 \times T_C - 2.0$<br>[WS = 1]                         | 0.1  | —   | ns   |
|     |                                                                |                   | $1.25 \times T_C - 2.0$<br>[WS ≥ 4]                         | 8.4  | —   | ns   |
| 102 | $\overline{WR}$ assertion pulse width                          | $t_{WP}$          | $1.5 \times T_C - 4.0$ [WS = 1]                             | 8.5  | —   | ns   |
|     |                                                                |                   | All frequencies:<br>$WS \times T_C - 4.0$<br>[2 ≤ WS ≤ 3]   | 12.7 | —   | ns   |
|     |                                                                |                   | $(WS - 0.5) \times T_C - 4.0$<br>[WS ≥ 4]                   | 25.2 | —   | ns   |
| 103 | $\overline{WR}$ deassertion to address not valid               | $t_{WR}$          | $0.25 \times T_C - 2.0$<br>[1 ≤ WS ≤ 3]                     | 0.1  | —   | ns   |
|     |                                                                |                   | $1.25 \times T_C - 2.0$<br>[4 ≤ WS ≤ 7]                     | 8.4  | —   | ns   |
|     |                                                                |                   | $2.25 \times T_C - 2.0$<br>[WS ≥ 8]                         | 16.7 | —   | ns   |
|     |                                                                |                   | All frequencies:<br>$1.25 \times T_C - 4.0$<br>[4 ≤ WS ≤ 7] | 6.4  | —   | ns   |
|     |                                                                |                   | $2.25 \times T_C - 4.0$<br>[WS ≥ 8]                         | 14.7 | —   | ns   |
| 104 | Address and AA valid to input data valid                       | $t_{AA}, t_{AC}$  | $(WS + 0.75) \times T_C - 7.0$<br>[WS ≥ 1]                  | —    | 7.6 | ns   |
| 105 | $\overline{RD}$ assertion to input data valid                  | $t_{OE}$          | $(WS + 0.25) \times T_C - 7.0$<br>[WS ≥ 1]                  | —    | 3.4 | ns   |
| 106 | $\overline{RD}$ deassertion to data not valid (data hold time) | $t_{OHZ}$         |                                                             | 0.0  | —   | ns   |
| 107 | Address valid to $\overline{WR}$ deassertion <sup>2</sup>      | $t_{AW}$          | $(WS + 0.75) \times T_C - 4.0$<br>[WS ≥ 1]                  | 10.6 | —   | ns   |
| 108 | Data valid to $\overline{WR}$ deassertion (data setup time)    | $t_{DS} (t_{DW})$ | $(WS - 0.25) \times T_C - 3.0$<br>[WS ≥ 1]                  | 3.2  | —   | ns   |

Table 2-8 SRAM Read and Write Accesses<sup>3</sup> (Continued)

| No. | Characteristics                                             | Symbol   | Expression <sup>1</sup>                 | Min  | Max  | Unit |
|-----|-------------------------------------------------------------|----------|-----------------------------------------|------|------|------|
| 109 | Data hold time from $\overline{WR}$ deassertion             | $t_{DH}$ | $0.25 \times T_C - 2.0$<br>[1 ≤ WS ≤ 3] | 0.1  | —    | ns   |
|     |                                                             |          | $1.25 \times T_C - 2.0$<br>[4 ≤ WS ≤ 7] | 8.4  | —    | ns   |
|     |                                                             |          | $2.25 \times T_C - 2.0$<br>[WS ≥ 8]     | 16.7 | —    | ns   |
| 110 | $\overline{WR}$ assertion to data active                    | —        | $0.75 \times T_C - 3.7$<br>[WS = 1]     | 2.5  | —    | ns   |
|     |                                                             |          | $0.25 \times T_C - 3.7$<br>[2 ≤ WS ≤ 3] | 0.0  | —    |      |
|     |                                                             |          | $-0.25 \times T_C - 3.7$<br>[WS ≥ 4]    | 0.0  | —    |      |
| 111 | $\overline{WR}$ deassertion to data high impedance          | —        | $0.25 \times T_C + 0.2$<br>[1 ≤ WS ≤ 3] | —    | 2.3  | ns   |
|     |                                                             |          | $1.25 \times T_C + 0.2$<br>[4 ≤ WS ≤ 7] | —    | 10.6 |      |
|     |                                                             |          | $2.25 \times T_C + 0.2$<br>[WS ≥ 8]     | —    | 18.9 |      |
| 112 | Previous $\overline{RD}$ deassertion to data active (write) | —        | $1.25 \times T_C - 4.0$<br>[1 ≤ WS ≤ 3] | 6.4  | —    | ns   |
|     |                                                             |          | $2.25 \times T_C - 4.0$<br>[4 ≤ WS ≤ 7] | 14.7 | —    |      |
|     |                                                             |          | $3.25 \times T_C - 4.0$<br>[WS ≥ 8]     | 23.1 | —    |      |
| 113 | $\overline{RD}$ deassertion time                            |          | $0.75 \times T_C - 4.0$<br>[1 ≤ WS ≤ 3] | 2.2  | —    | ns   |
|     |                                                             |          | $1.75 \times T_C - 4.0$<br>[4 ≤ WS ≤ 7] | 10.6 | —    | ns   |
|     |                                                             |          | $2.75 \times T_C - 4.0$<br>[WS ≥ 8]     | 18.9 | —    | ns   |
| 114 | $\overline{WR}$ deassertion time                            |          | $0.5 \times T_C - 4.0$<br>[WS = 1]      | 0.2  | —    | ns   |
|     |                                                             |          | $T_C - 2.0$<br>[2 ≤ WS ≤ 3]             | 6.3  | —    | ns   |
|     |                                                             |          | $2.5 \times T_C - 4.0$<br>[4 ≤ WS ≤ 7]  | 16.8 | —    | ns   |
|     |                                                             |          | $3.5 \times T_C - 4.0$<br>[WS ≥ 8]      | 25.2 | —    | ns   |
| 115 | Address valid to $\overline{RD}$ assertion                  |          | $0.5 \times T_C - 4.0$                  | 0.2  | —    | ns   |
| 116 | $\overline{RD}$ assertion pulse width                       |          | $(WS + 0.25) \times T_C - 4.0$          | 6.4  | —    | ns   |
| 117 | $\overline{RD}$ deassertion to address not valid            |          | $0.25 \times T_C - 2.0$<br>[1 ≤ WS ≤ 3] | 0.1  | —    | ns   |
|     |                                                             |          | $1.25 \times T_C - 2.0$<br>[4 ≤ WS ≤ 7] | 8.4  | —    | ns   |
|     |                                                             |          | $2.25 \times T_C - 2.0$<br>[WS ≥ 8]     | 16.7 | —    | ns   |

Table 2-8 SRAM Read and Write Accesses<sup>3</sup> (Continued)

| No. | Characteristics                                                                                               | Symbol | Expression <sup>1</sup> | Min | Max | Unit |
|-----|---------------------------------------------------------------------------------------------------------------|--------|-------------------------|-----|-----|------|
| 118 | $\overline{\text{TA}}$ setup before $\overline{\text{RD}}$ or $\overline{\text{WR}}$ deassertion <sup>4</sup> |        | $0.25 \times T_C + 2.0$ | 4.1 | —   | ns   |
| 119 | $\overline{\text{TA}}$ hold after $\overline{\text{RD}}$ or $\overline{\text{WR}}$ deassertion                |        |                         | 0.0 | —   | ns   |

Notes:

1. WS is the number of wait states specified in the BCR.
2. Timings 100, 107 are guaranteed by design, not tested.
3. All timings for 100 MHz are measured from  $0.5 \cdot V_{CC}$  to  $.05 \cdot V_{CC}$
4. In the case of  $\overline{\text{TA}}$  negation: timing 118 is relative to the deassertion edge of  $\overline{\text{RD}}$  or  $\overline{\text{WR}}$  were  $\overline{\text{TA}}$  to remain active

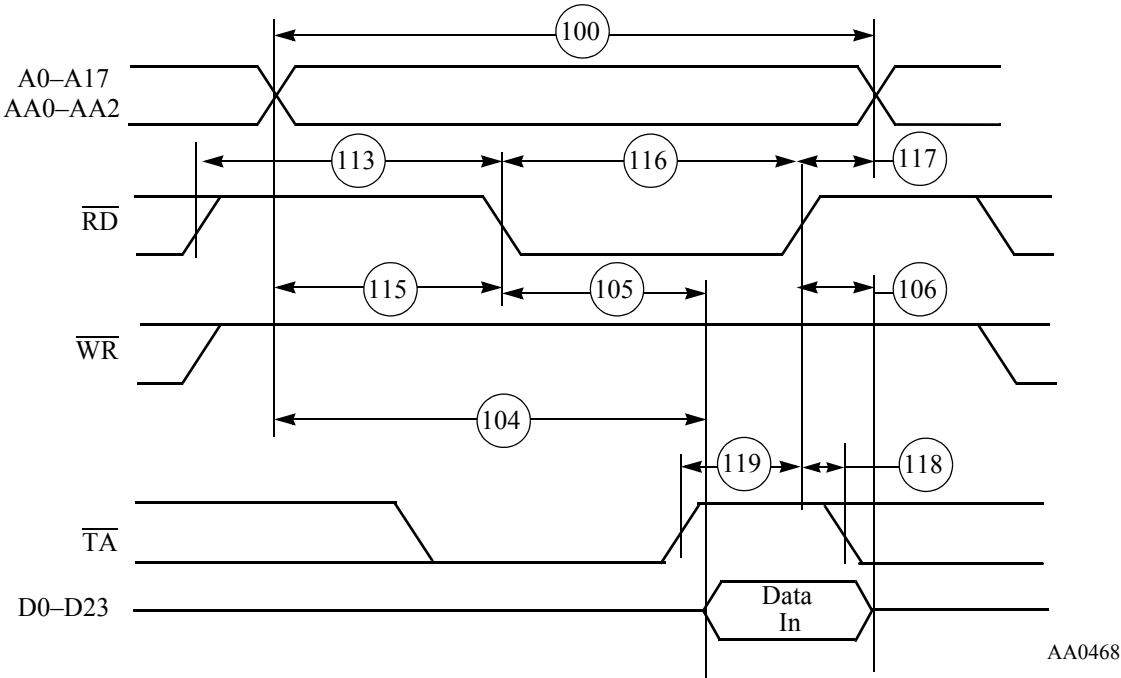


Figure 2-9 SRAM Read Access

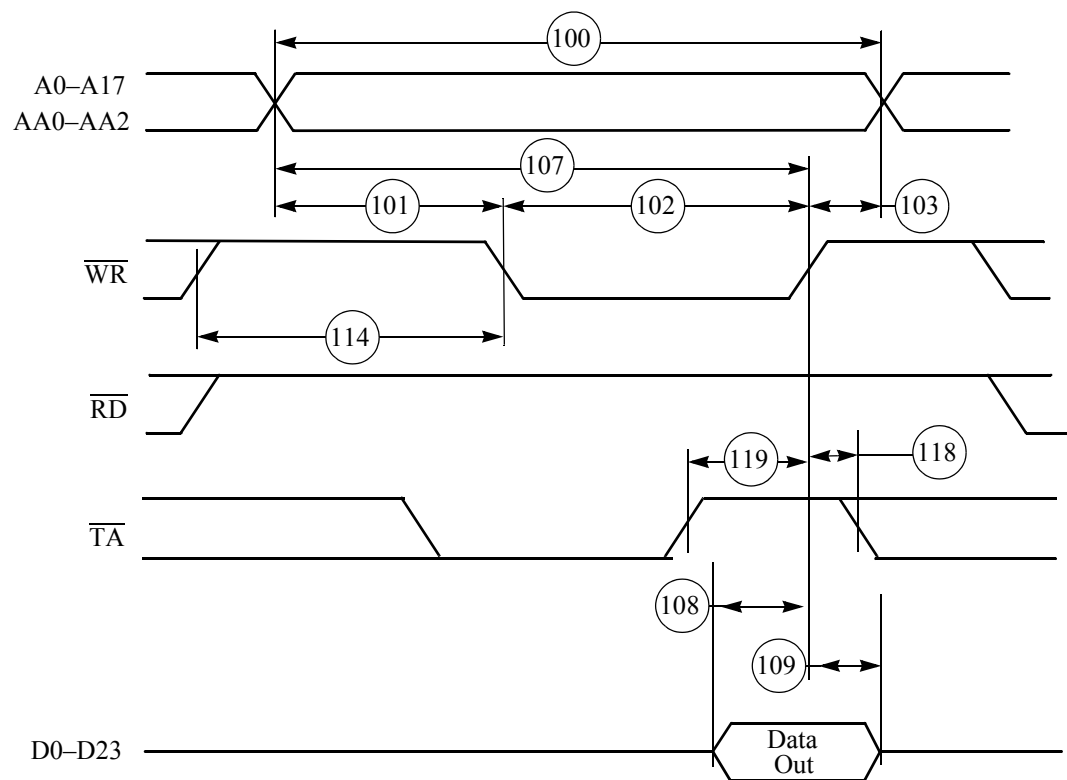
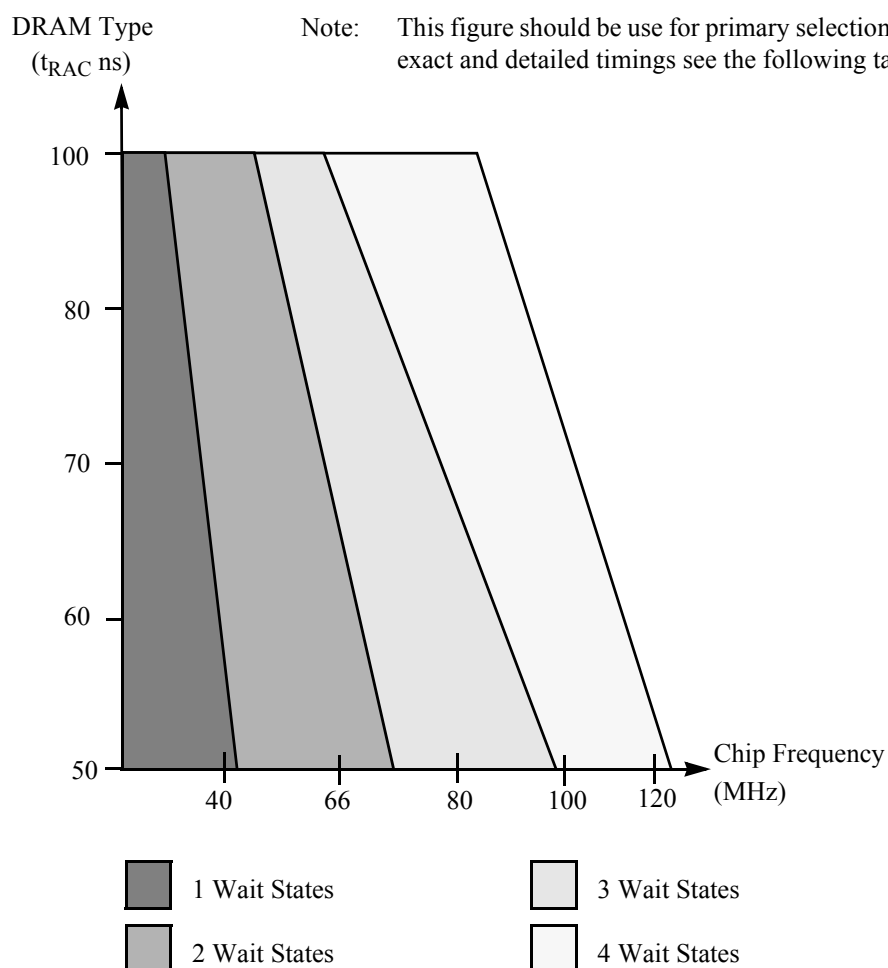


Figure 2-10 SRAM Write Access

## DRAM Timing

The selection guides provided in **Figure 2-11** and **Figure 2-14** should be used for primary selection only. Final selection should be based on the timing provided in the following tables. As an example, the selection guide suggests that 4 wait states must be used for 100 MHz operation when using Page Mode DRAM. However, by using the information in the appropriate table, a designer may choose to evaluate whether fewer wait states might be used by determining which timing prevents operation at 100 MHz, running the chip at a slightly lower frequency (e.g., 95 MHz), using faster DRAM (if it becomes available), and control factors such as capacitive and resistive load to improve overall system performance.



**Figure 2-11 DRAM Page Mode Wait States Selection Guide**

Table 2-9 DRAM Page Mode Timings, One Wait State (Low-Power Applications)<sup>1, 2, 3</sup>

| No. | Characteristics                                                                                                                                                    | Symbol     | Expression              | 20 MHz <sup>6</sup> |      | 30 MHz <sup>6</sup> |      | Unit |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------|---------------------|------|---------------------|------|------|
|     |                                                                                                                                                                    |            |                         | Min                 | Max  | Min                 | Max  |      |
| 131 | Page mode cycle time for two consecutive accesses of the same direction                                                                                            | $t_{PC}$   | $2 \times T_C$          | 100.0               | —    | 66.7                | —    | ns   |
|     | Page mode cycle time for mixed (read and write) accesses                                                                                                           |            | $1.25 \times T_C$       | 62.5                | —    | 41.7                | —    |      |
| 132 | $\overline{CAS}$ assertion to data valid (read)                                                                                                                    | $t_{CAC}$  | $T_C - 7.5$             | —                   | 42.5 | —                   | 25.8 | ns   |
| 133 | Column address valid to data valid (read)                                                                                                                          | $t_{AA}$   | $1.5 \times T_C - 7.5$  | —                   | 67.5 | —                   | 42.5 | ns   |
| 134 | $\overline{CAS}$ deassertion to data not valid (read hold time)                                                                                                    | $t_{OFF}$  |                         | 0.0                 | —    | 0.0                 | —    | ns   |
| 135 | Last $\overline{CAS}$ assertion to $\overline{RAS}$ deassertion                                                                                                    | $t_{RSH}$  | $0.75 \times T_C - 4.0$ | 33.5                | —    | 21.0                | —    | ns   |
| 136 | Previous $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion                                                                                              | $t_{RHCP}$ | $2 \times T_C - 4.0$    | 96.0                | —    | 62.7                | —    | ns   |
| 137 | $\overline{CAS}$ assertion pulse width                                                                                                                             | $t_{CAS}$  | $0.75 \times T_C - 4.0$ | 33.5                | —    | 21.0                | —    | ns   |
| 138 | Last $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion <sup>4</sup><br>• $BRW[1:0] = 00$<br>• $BRW[1:0] = 01$<br>• $BRW[1:0] = 10$<br>• $BRW[1:0] = 11$ | $t_{CRP}$  | $1.75 \times T_C - 6.0$ | 81.5                | —    | 52.3                | —    | ns   |
|     |                                                                                                                                                                    |            | $3.25 \times T_C - 6.0$ | 156.5               | —    | 102.2               | —    | ns   |
|     |                                                                                                                                                                    |            | $4.25 \times T_C - 6.0$ | 206.5               | —    | 135.5               | —    | ns   |
|     |                                                                                                                                                                    |            | $6.25 \times T_C - 6.0$ | 306.5               | —    | 202.1               | —    | ns   |
| 139 | $\overline{CAS}$ deassertion pulse width                                                                                                                           | $t_{CP}$   | $0.5 \times T_C - 4.0$  | 21.0                | —    | 12.7                | —    | ns   |
| 140 | Column address valid to $\overline{CAS}$ assertion                                                                                                                 | $t_{ASC}$  | $0.5 \times T_C - 4.0$  | 21.0                | —    | 12.7                | —    | ns   |
| 141 | $\overline{CAS}$ assertion to column address not valid                                                                                                             | $t_{CAH}$  | $0.75 \times T_C - 4.0$ | 33.5                | —    | 21.0                | —    | ns   |
| 142 | Last column address valid to $\overline{RAS}$ deassertion                                                                                                          | $t_{RAL}$  | $2 \times T_C - 4.0$    | 96.0                | —    | 62.7                | —    | ns   |
| 143 | $\overline{WR}$ deassertion to $\overline{CAS}$ assertion                                                                                                          | $t_{RCS}$  | $0.75 \times T_C - 3.8$ | 33.7                | —    | 21.2                | —    | ns   |
| 144 | $\overline{CAS}$ deassertion to $\overline{WR}$ assertion                                                                                                          | $t_{RCH}$  | $0.25 \times T_C - 3.7$ | 8.8                 | —    | 4.6                 | —    | ns   |
| 145 | $\overline{CAS}$ assertion to $\overline{WR}$ deassertion                                                                                                          | $t_{WCH}$  | $0.5 \times T_C - 4.2$  | 20.8                | —    | 12.5                | —    | ns   |
| 146 | $\overline{WR}$ assertion pulse width                                                                                                                              | $t_{WP}$   | $1.5 \times T_C - 4.5$  | 70.5                | —    | 45.5                | —    | ns   |
| 147 | Last $\overline{WR}$ assertion to $\overline{RAS}$ deassertion                                                                                                     | $t_{RWL}$  | $1.75 \times T_C - 4.3$ | 83.2                | —    | 54.0                | —    | ns   |
| 148 | $\overline{WR}$ assertion to $\overline{CAS}$ deassertion                                                                                                          | $t_{CWL}$  | $1.75 \times T_C - 4.3$ | 83.2                | —    | 54.0                | —    | ns   |
| 149 | Data valid to $\overline{CAS}$ assertion (Write)                                                                                                                   | $t_{DS}$   | $0.25 \times T_C - 4.0$ | 8.5                 | —    | 4.3                 | —    | ns   |
| 150 | $\overline{CAS}$ assertion to data not valid (write)                                                                                                               | $t_{DH}$   | $0.75 \times T_C - 4.0$ | 33.5                | —    | 21.0                | —    | ns   |

## External Memory Expansion Port (Port A)

Table 2-9 DRAM Page Mode Timings, One Wait State (Low-Power Applications)<sup>1, 2, 3</sup> (Continued)

| No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Characteristics                                                | Symbol    | Expression              | 20 MHz <sup>6</sup> |      | 30 MHz <sup>6</sup> |      | Unit |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------|-------------------------|---------------------|------|---------------------|------|------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |           |                         | Min                 | Max  | Min                 | Max  |      |
| 151                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $\overline{WR}$ assertion to $\overline{CAS}$ assertion        | $t_{WCS}$ | $T_C - 4.3$             | 45.7                | —    | 29.0                | —    | ns   |
| 152                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Last $\overline{RD}$ assertion to $\overline{RAS}$ deassertion | $t_{ROH}$ | $1.5 \times T_C - 4.0$  | 71.0                | —    | 46.0                | —    | ns   |
| 153                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $\overline{RD}$ assertion to data valid                        | $t_{GA}$  | $T_C - 7.5$             | —                   | 42.5 | —                   | 25.8 | ns   |
| 154                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $\overline{RD}$ deassertion to data not valid <sup>5</sup>     | $t_{GZ}$  |                         | 0.0                 | —    | 0.0                 | —    | ns   |
| 155                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $\overline{WR}$ assertion to data active                       |           | $0.75 \times T_C - 0.3$ | 37.2                | —    | 24.7                | —    | ns   |
| 156                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $\overline{WR}$ deassertion to data high impedance             |           | $0.25 \times T_C$       | —                   | 12.5 | —                   | 8.3  | ns   |
| Notes: 1. The number of wait states for Page mode access is specified in the DCR.<br>2. The refresh period is specified in the DCR.<br>3. All the timings are calculated for the worst case. Some of the timings are better for specific cases (e.g., $t_{PC}$ equals $2 \times T_C$ for read-after-read or write-after-write sequences).<br>4. BRW[1:0] (DRAM control register bits) defines the number of wait states that should be inserted in each DRAM out-of-page access.<br>5. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is $t_{OFF}$ and not $t_{GZ}$ .<br>6. Reduced DSP clock speed allows use of Page Mode DRAM with one Wait state (See <b>Figure 2-14</b> ). |                                                                |           |                         |                     |      |                     |      |      |

Table 2-10 DRAM Page Mode Timings, Two Wait States<sup>1, 2, 3, 7</sup>

| No. | Characteristics                                                         | Symbol     | Expression              | 66 MHz |      | 80 MHz |      | Unit |
|-----|-------------------------------------------------------------------------|------------|-------------------------|--------|------|--------|------|------|
|     |                                                                         |            |                         | Min    | Max  | Min    | Max  |      |
| 131 | Page mode cycle time for two consecutive accesses of the same direction | $t_{PC}$   | $2 \times T_C$          | 45.4   | —    | 37.5   | —    | ns   |
|     | Page mode cycle time for mixed (read and write) accesses                |            | $1.25 \times T_C$       | 41.1   | —    | 34.4   | —    |      |
| 132 | $\overline{CAS}$ assertion to data valid (read)                         | $t_{CAC}$  | $1.5 \times T_C - 7.5$  | —      | 15.2 | —      | —    | ns   |
|     |                                                                         |            | $1.5 \times T_C - 6.5$  | —      | —    | —      | 12.3 | ns   |
| 133 | Column address valid to data valid (read)                               | $t_{AA}$   | $2.5 \times T_C - 7.5$  | —      | 30.4 | —      | —    | ns   |
|     |                                                                         |            | $2.5 \times T_C - 6.5$  | —      | —    | —      | 24.8 | ns   |
| 134 | $\overline{CAS}$ deassertion to data not valid (read hold time)         | $t_{OFF}$  |                         | 0.0    | —    | 0.0    | —    | ns   |
| 135 | Last $\overline{CAS}$ assertion to $\overline{RAS}$ deassertion         | $t_{RSH}$  | $1.75 \times T_C - 4.0$ | 22.5   | —    | 17.9   | —    | ns   |
| 136 | Previous $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion   | $t_{RHCP}$ | $3.25 \times T_C - 4.0$ | 45.2   | —    | 36.6   | —    | ns   |
| 137 | $\overline{CAS}$ assertion pulse width                                  | $t_{CAS}$  | $1.5 \times T_C - 4.0$  | 18.7   | —    | 14.8   | —    | ns   |

## External Memory Expansion Port (Port A)

Table 2-10 DRAM Page Mode Timings, Two Wait States<sup>1, 2, 3, 7</sup> (Continued)

| No. | Characteristics                                                                                                                                                                                              | Symbol           | Expression              | 66 MHz |      | 80 MHz |      | Unit |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------|--------|------|--------|------|------|
|     |                                                                                                                                                                                                              |                  |                         | Min    | Max  | Min    | Max  |      |
| 138 | Last $\overline{\text{CAS}}$ deassertion to $\overline{\text{RAS}}$ deassertion <sup>5</sup><br>• $\text{BRW}[1:0] = 00$<br>• $\text{BRW}[1:0] = 01$<br>• $\text{BRW}[1:0] = 10$<br>• $\text{BRW}[1:0] = 11$ | $t_{\text{CRP}}$ | $2.0 \times T_C - 6.0$  | 24.4   | —    | 19.0   | —    | ns   |
|     |                                                                                                                                                                                                              |                  | $3.5 \times T_C - 6.0$  | 47.2   | —    | 37.8   | —    | ns   |
|     |                                                                                                                                                                                                              |                  | $4.5 \times T_C - 6.0$  | 62.4   | —    | 50.3   | —    | ns   |
|     |                                                                                                                                                                                                              |                  | $6.5 \times T_C - 6.0$  | 92.8   | —    | 75.3   | —    | ns   |
| 139 | $\overline{\text{CAS}}$ deassertion pulse width                                                                                                                                                              | $t_{\text{CP}}$  | $1.25 \times T_C - 4.0$ | 14.9   | —    | 11.6   | —    | ns   |
| 140 | Column address valid to $\overline{\text{CAS}}$ assertion                                                                                                                                                    | $t_{\text{ASC}}$ | $T_C - 4.0$             | 11.2   | —    | 8.5    | —    | ns   |
| 141 | $\overline{\text{CAS}}$ assertion to column address not valid                                                                                                                                                | $t_{\text{CAH}}$ | $1.75 \times T_C - 4.0$ | 22.5   | —    | 17.9   | —    | ns   |
| 142 | Last column address valid to $\overline{\text{RAS}}$ deassertion                                                                                                                                             | $t_{\text{RAL}}$ | $3 \times T_C - 4.0$    | 41.5   | —    | 33.5   | —    | ns   |
| 143 | $\overline{\text{WR}}$ deassertion to $\overline{\text{CAS}}$ assertion                                                                                                                                      | $t_{\text{RCS}}$ | $1.25 \times T_C - 3.8$ | 15.1   | —    | 11.8   | —    | ns   |
| 144 | $\overline{\text{CAS}}$ deassertion to $\overline{\text{WR}}$ assertion                                                                                                                                      | $t_{\text{RCH}}$ | $0.5 \times T_C - 3.7$  | 3.9    | —    | 2.6    | —    | ns   |
| 145 | $\overline{\text{CAS}}$ assertion to $\overline{\text{WR}}$ deassertion                                                                                                                                      | $t_{\text{WCH}}$ | $1.5 \times T_C - 4.2$  | 18.5   | —    | 14.6   | —    | ns   |
| 146 | $\overline{\text{WR}}$ assertion pulse width                                                                                                                                                                 | $t_{\text{WP}}$  | $2.5 \times T_C - 4.5$  | 33.5   | —    | 26.8   | —    | ns   |
| 147 | Last $\overline{\text{WR}}$ assertion to $\overline{\text{RAS}}$ deassertion                                                                                                                                 | $t_{\text{RWL}}$ | $2.75 \times T_C - 4.3$ | 33.4   | —    | 26.8   | —    | ns   |
| 148 | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ deassertion                                                                                                                                      | $t_{\text{CWL}}$ | $2.5 \times T_C - 4.3$  | 33.6   | —    | 27.0   | —    | ns   |
| 149 | Data valid to $\overline{\text{CAS}}$ assertion (write)                                                                                                                                                      | $t_{\text{DS}}$  | $0.25 \times T_C - 3.7$ | 0.1    | —    | —      | —    | ns   |
|     |                                                                                                                                                                                                              |                  | $0.25 \times T_C - 3.0$ | —      | —    | 0.1    | —    | ns   |
| 150 | $\overline{\text{CAS}}$ assertion to data not valid (write)                                                                                                                                                  | $t_{\text{DH}}$  | $1.75 \times T_C - 4.0$ | 22.5   | —    | 17.9   | —    | ns   |
| 151 | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ assertion                                                                                                                                        | $t_{\text{WCS}}$ | $T_C - 4.3$             | 10.9   | —    | 8.2    | —    | ns   |
| 152 | Last $\overline{\text{RD}}$ assertion to $\overline{\text{RAS}}$ deassertion                                                                                                                                 | $t_{\text{ROH}}$ | $2.5 \times T_C - 4.0$  | 33.9   | —    | 27.3   | —    | ns   |
| 153 | $\overline{\text{RD}}$ assertion to data valid                                                                                                                                                               | $t_{\text{GA}}$  | $1.75 \times T_C - 7.5$ | —      | 19.0 | —      | —    | ns   |
|     |                                                                                                                                                                                                              |                  | $1.75 \times T_C - 6.5$ | —      | —    | —      | 15.4 | ns   |
| 154 | $\overline{\text{RD}}$ deassertion to data not valid <sup>6</sup>                                                                                                                                            | $t_{\text{GZ}}$  |                         | 0.0    | —    | 0.0    | —    | ns   |
| 155 | $\overline{\text{WR}}$ assertion to data active                                                                                                                                                              |                  | $0.75 \times T_C - 0.3$ | 11.1   | —    | 9.1    | —    | ns   |
| 156 | $\overline{\text{WR}}$ deassertion to data high impedance                                                                                                                                                    |                  | $0.25 \times T_C$       | —      | 3.8  | —      | 3.1  | ns   |

Table 2-10 DRAM Page Mode Timings, Two Wait States<sup>1, 2, 3, 7</sup> (Continued)

| No.    | Characteristics | Symbol                                                                                                                                                                                          | Expression | 66 MHz |     | 80 MHz |     | Unit |
|--------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------|-----|--------|-----|------|
|        |                 |                                                                                                                                                                                                 |            | Min    | Max | Min    | Max |      |
| Notes: | 1.              | The number of wait states for Page mode access is specified in the DCR.                                                                                                                         |            |        |     |        |     |      |
|        | 2.              | The refresh period is specified in the DCR.                                                                                                                                                     |            |        |     |        |     |      |
|        | 3.              | The asynchronous delays specified in the expressions are valid for DSP56366.                                                                                                                    |            |        |     |        |     |      |
|        | 4.              | All the timings are calculated for the worst case. Some of the timings are better for specific cases (e.g., $t_{PC}$ equals $3 \times T_C$ for read-after-read or write-after-write sequences). |            |        |     |        |     |      |
|        | 5.              | BRW[1:0] (DRAM Control Register bits) defines the number of wait states that should be inserted in each DRAM out-of-page access.                                                                |            |        |     |        |     |      |
|        | 6.              | $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is $t_{OFF}$ and not $t_{GZ}$ .                                              |            |        |     |        |     |      |
|        | 7.              | There are no DRAMs fast enough to fit to two wait states Page mode @ 100MHz (See <b>Figure 2-11</b> )                                                                                           |            |        |     |        |     |      |

Table 2-11 DRAM Page Mode Timings, Three Wait States<sup>1, 2, 3</sup>

| No. | Characteristics                                                                                                                                                  | Symbol     | Expression              | Min  | Max  | Unit |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------|------|------|------|
| 131 | Page mode cycle time for two consecutive accesses of the same direction                                                                                          | $t_{PC}$   | $2 \times T_C$          | 40.0 | —    | ns   |
|     | Page mode cycle time for mixed (read and write) accesses                                                                                                         |            | $1.25 \times T_C$       | 35.0 | —    |      |
| 132 | $\overline{CAS}$ assertion to data valid (read)                                                                                                                  | $t_{CAC}$  | $2 \times T_C - 7.0$    | —    | 13.0 | ns   |
| 133 | Column address valid to data valid (read)                                                                                                                        | $t_{AA}$   | $3 \times T_C - 7.0$    | —    | 23.0 | ns   |
| 134 | $\overline{CAS}$ deassertion to data not valid (read hold time)                                                                                                  | $t_{OFF}$  |                         | 0.0  | —    | ns   |
| 135 | Last $\overline{CAS}$ assertion to $\overline{RAS}$ deassertion                                                                                                  | $t_{RSH}$  | $2.5 \times T_C - 4.0$  | 21.0 | —    | ns   |
| 136 | Previous $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion                                                                                            | $t_{RHCP}$ | $4.5 \times T_C - 4.0$  | 41.0 | —    | ns   |
| 137 | $\overline{CAS}$ assertion pulse width                                                                                                                           | $t_{CAS}$  | $2 \times T_C - 4.0$    | 16.0 | —    | ns   |
| 138 | Last $\overline{CAS}$ deassertion to $\overline{RAS}$ assertion <sup>5</sup><br>• $BRW[1:0] = 00$<br>• $BRW[1:0] = 01$<br>• $BRW[1:0] = 10$<br>• $BRW[1:0] = 11$ | $t_{CRP}$  | $2.25 \times T_C - 6.0$ | —    | —    | ns   |
|     |                                                                                                                                                                  |            | $3.75 \times T_C - 6.0$ | —    | —    | ns   |
|     |                                                                                                                                                                  |            | $4.75 \times T_C - 6.0$ | 41.5 | —    | ns   |
|     |                                                                                                                                                                  |            | $6.75 \times T_C - 6.0$ | 61.5 | —    | ns   |
| 139 | $\overline{CAS}$ deassertion pulse width                                                                                                                         | $t_{CP}$   | $1.5 \times T_C - 4.0$  | 11.0 | —    | ns   |
| 140 | Column address valid to $\overline{CAS}$ assertion                                                                                                               | $t_{ASC}$  | $T_C - 4.0$             | 6.0  | —    | ns   |
| 141 | $\overline{CAS}$ assertion to column address not valid                                                                                                           | $t_{CAH}$  | $2.5 \times T_C - 4.0$  | 21.0 | —    | ns   |
| 142 | Last column address valid to $\overline{RAS}$ deassertion                                                                                                        | $t_{RAL}$  | $4 \times T_C - 4.0$    | 36.0 | —    | ns   |
| 143 | $\overline{WR}$ deassertion to $\overline{CAS}$ assertion                                                                                                        | $t_{RCS}$  | $1.25 \times T_C - 4.0$ | 8.5  | —    | ns   |
| 144 | $\overline{CAS}$ deassertion to $\overline{WR}$ assertion                                                                                                        | $t_{RCH}$  | $0.75 \times T_C - 4.0$ | 3.5  | —    | ns   |
| 145 | $\overline{CAS}$ assertion to $\overline{WR}$ deassertion                                                                                                        | $t_{WCH}$  | $2.25 \times T_C - 4.2$ | 18.3 | —    | ns   |
| 146 | $\overline{WR}$ assertion pulse width                                                                                                                            | $t_{WP}$   | $3.5 \times T_C - 4.5$  | 30.5 | —    | ns   |
| 147 | Last $\overline{WR}$ assertion to $\overline{RAS}$ deassertion                                                                                                   | $t_{RWL}$  | $3.75 \times T_C - 4.3$ | 33.2 | —    | ns   |
| 148 | $\overline{WR}$ assertion to $\overline{CAS}$ deassertion                                                                                                        | $t_{CWL}$  | $3.25 \times T_C - 4.3$ | 28.2 | —    | ns   |
| 149 | Data valid to $\overline{CAS}$ assertion (write)                                                                                                                 | $t_{DS}$   | $0.5 \times T_C - 4.0$  | 1.0  | —    | ns   |

Table 2-11 DRAM Page Mode Timings, Three Wait States<sup>1, 2, 3</sup> (Continued)

| No. | Characteristics                                                              | Symbol           | Expression              | Min  | Max  | Unit |
|-----|------------------------------------------------------------------------------|------------------|-------------------------|------|------|------|
| 150 | $\overline{\text{CAS}}$ assertion to data not valid (write)                  | $t_{\text{DH}}$  | $2.5 \times T_C - 4.0$  | 21.0 | —    | ns   |
| 151 | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ assertion        | $t_{\text{WCS}}$ | $1.25 \times T_C - 4.3$ | 8.2  | —    | ns   |
| 152 | Last $\overline{\text{RD}}$ assertion to $\overline{\text{RAS}}$ deassertion | $t_{\text{ROH}}$ | $3.5 \times T_C - 4.0$  | 31.0 | —    | ns   |
| 153 | $\overline{\text{RD}}$ assertion to data valid                               | $t_{\text{GA}}$  | $2.5 \times T_C - 7.0$  | —    | 18.0 | ns   |
| 154 | $\overline{\text{RD}}$ deassertion to data not valid <sup>6</sup>            | $t_{\text{GZ}}$  |                         | 0.0  | —    | ns   |
| 155 | $\overline{\text{WR}}$ assertion to data active                              |                  | $0.75 \times T_C - 0.3$ | 7.2  | —    | ns   |
| 156 | $\overline{\text{WR}}$ deassertion to data high impedance                    |                  | $0.25 \times T_C$       | —    | 2.5  | ns   |

- Notes:
1. The number of wait states for Page mode access is specified in the DCR.
  2. The refresh period is specified in the DCR.
  3. The asynchronous delays specified in the expressions are valid for DSP56366.
  4. All the timings are calculated for the worst case. Some of the timings are better for specific cases (e.g.,  $t_{\text{PC}}$  equals  $4 \times T_C$  for read-after-read or write-after-write sequences).
  5. BRW[1:0] (DRAM control register bits) defines the number of wait states that should be inserted in each DRAM out-of-page-access.
  6.  $\overline{\text{RD}}$  deassertion will always occur after  $\overline{\text{CAS}}$  deassertion; therefore, the restricted timing is  $t_{\text{OFF}}$  and not  $t_{\text{GZ}}$ .

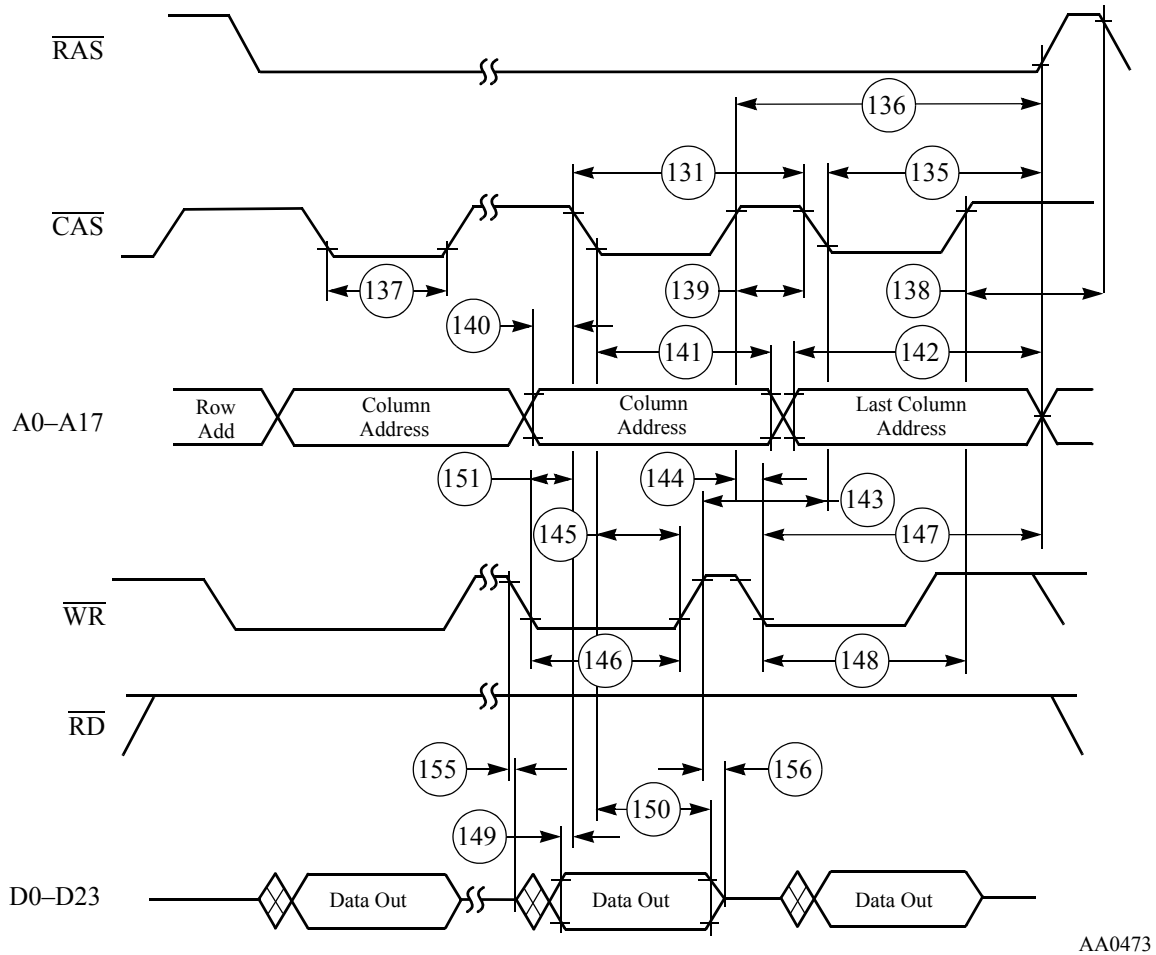
## External Memory Expansion Port (Port A)

Table 2-12 DRAM Page Mode Timings, Four Wait States<sup>1, 2, 3</sup>

| No. | Characteristics                                                                                                                                                  | Symbol     | Expression              | Min  | Max  |    |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------------|------|------|----|
| 131 | Page mode cycle time for two consecutive accesses of the same direction.                                                                                         | $t_{PC}$   | $5 \times T_C$          | 41.7 | —    | ns |
|     | Page mode cycle time for mixed (read and write) accesses                                                                                                         |            | $4.5 \times T_C$        | 37.5 | —    |    |
| 132 | $\overline{CAS}$ assertion to data valid (read)                                                                                                                  | $t_{CAC}$  | $2.75 \times T_C - 7.0$ | —    | 15.9 | ns |
| 133 | Column address valid to data valid (read)                                                                                                                        | $t_{AA}$   | $3.75 \times T_C - 7.0$ | —    | 24.2 | ns |
| 134 | $\overline{CAS}$ deassertion to data not valid (read hold time)                                                                                                  | $t_{OFF}$  |                         | 0.0  | —    | ns |
| 135 | Last $\overline{CAS}$ assertion to $\overline{RAS}$ deassertion                                                                                                  | $t_{RSH}$  | $3.5 \times T_C - 4.0$  | 25.2 | —    | ns |
| 136 | Previous $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion                                                                                            | $t_{RHCP}$ | $6 \times T_C - 4.0$    | 46.0 | —    | ns |
| 137 | $\overline{CAS}$ assertion pulse width                                                                                                                           | $t_{CAS}$  | $2.5 \times T_C - 4.0$  | 16.8 | —    | ns |
| 138 | Last $\overline{CAS}$ deassertion to $\overline{RAS}$ assertion <sup>5</sup><br>• $BRW[1:0] = 00$<br>• $BRW[1:0] = 01$<br>• $BRW[1:0] = 10$<br>• $BRW[1:0] = 11$ | $t_{CRP}$  | $2.75 \times T_C - 6.0$ | —    | —    | ns |
|     |                                                                                                                                                                  |            | $4.25 \times T_C - 6.0$ | —    | —    |    |
|     |                                                                                                                                                                  |            | $5.25 \times T_C - 6.0$ | 37.7 | —    |    |
|     |                                                                                                                                                                  |            | $7.25 \times T_C - 6.0$ | 54.4 | —    |    |
| 139 | $\overline{CAS}$ deassertion pulse width                                                                                                                         | $t_{CP}$   | $2 \times T_C - 4.0$    | 12.7 | —    | ns |
| 140 | Column address valid to $\overline{CAS}$ assertion                                                                                                               | $t_{ASC}$  | $T_C - 4.0$             | 4.3  | —    | ns |
| 141 | $\overline{CAS}$ assertion to column address not valid                                                                                                           | $t_{CAH}$  | $3.5 \times T_C - 4.0$  | 25.2 | —    | ns |
| 142 | Last column address valid to $\overline{RAS}$ deassertion                                                                                                        | $t_{RAL}$  | $5 \times T_C - 4.0$    | 37.7 | —    | ns |
| 143 | $\overline{WR}$ deassertion to $\overline{CAS}$ assertion                                                                                                        | $t_{RCS}$  | $1.25 \times T_C - 4.0$ | 6.4  | —    | ns |
| 144 | $\overline{CAS}$ deassertion to $\overline{WR}$ assertion                                                                                                        | $t_{RCH}$  | $1.25 \times T_C - 4.0$ | 6.4  | —    | ns |
| 145 | $\overline{CAS}$ assertion to $\overline{WR}$ deassertion                                                                                                        | $t_{WCH}$  | $3.25 \times T_C - 4.2$ | 22.9 | —    | ns |
| 146 | $\overline{WR}$ assertion pulse width                                                                                                                            | $t_{WP}$   | $4.5 \times T_C - 4.5$  | 33.0 | —    | ns |
| 147 | Last $\overline{WR}$ assertion to $\overline{RAS}$ deassertion                                                                                                   | $t_{RWL}$  | $4.75 \times T_C - 4.3$ | 35.3 | —    | ns |
| 148 | $\overline{WR}$ assertion to $\overline{CAS}$ deassertion                                                                                                        | $t_{CWL}$  | $3.75 \times T_C - 4.3$ | 26.9 | —    | ns |
| 149 | Data valid to $\overline{CAS}$ assertion (write)                                                                                                                 | $t_{DS}$   | $0.5 \times T_C - 4.0$  | 0.2  | —    | ns |
| 150 | $\overline{CAS}$ assertion to data not valid (write)                                                                                                             | $t_{DH}$   | $3.5 \times T_C - 4.0$  | 25.2 | —    | ns |
| 151 | $\overline{WR}$ assertion to $\overline{CAS}$ assertion                                                                                                          | $t_{WCS}$  | $1.25 \times T_C - 4.3$ | 6.1  | —    | ns |
| 152 | Last $\overline{RD}$ assertion to $\overline{RAS}$ deassertion                                                                                                   | $t_{ROH}$  | $4.5 \times T_C - 4.0$  | 33.5 | —    | ns |
| 153 | $\overline{RD}$ assertion to data valid                                                                                                                          | $t_{GA}$   | $3.25 \times T_C - 7.0$ | —    | 20.1 | ns |
| 154 | $\overline{RD}$ deassertion to data not valid <sup>6</sup>                                                                                                       | $t_{GZ}$   |                         | 0.0  | —    | ns |
| 155 | $\overline{WR}$ assertion to data active                                                                                                                         |            | $0.75 \times T_C - 0.3$ | 5.9  | —    | ns |
| 156 | $\overline{WR}$ deassertion to data high impedance                                                                                                               |            | $0.25 \times T_C$       | —    | 2.1  | ns |

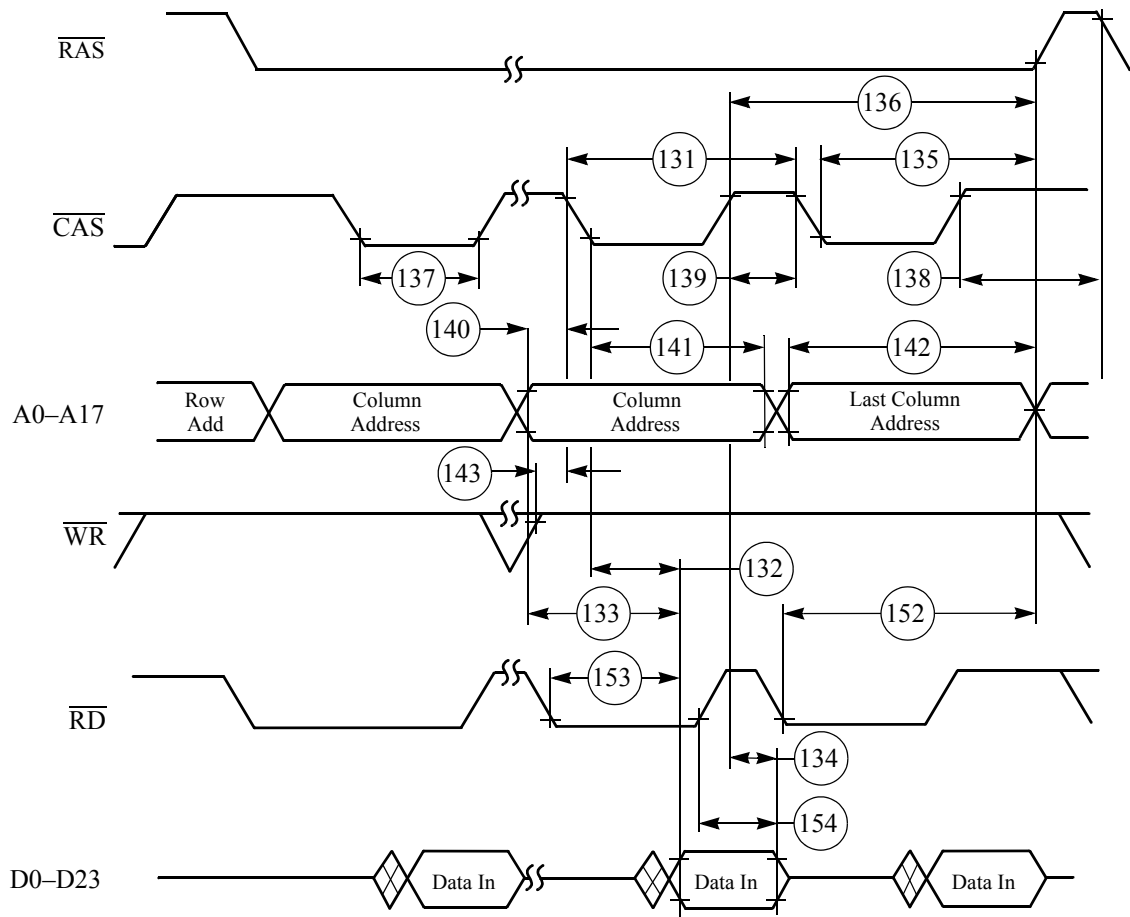
Table 2-12 DRAM Page Mode Timings, Four Wait States<sup>1, 2, 3</sup> (Continued)

| No.    | Characteristics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Symbol | Expression | Min | Max |  |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|-----|-----|--|
| Notes: | <div>1. The number of wait states for Page mode access is specified in the DCR.</div> <div>2. The refresh period is specified in the DCR.</div> <div>3. The asynchronous delays specified in the expressions are valid for DSP56366.</div> <div>4. All the timings are calculated for the worst case. Some of the timings are better for specific cases (e.g., <math>t_{PC}</math> equals <math>3 \times T_C</math> for read-after-read or write-after-write sequences).</div> <div>5. BRW[1:0] (DRAM control register bits) defines the number of wait states that should be inserted in each DRAM out-of-page access.</div> <div>6. <math>\overline{RD}</math> deassertion will always occur after <math>\overline{CAS}</math> deassertion; therefore, the restricted timing is <math>t_{OFF}</math> and not <math>t_{GZ}</math>.</div> |        |            |     |     |  |



AA0473

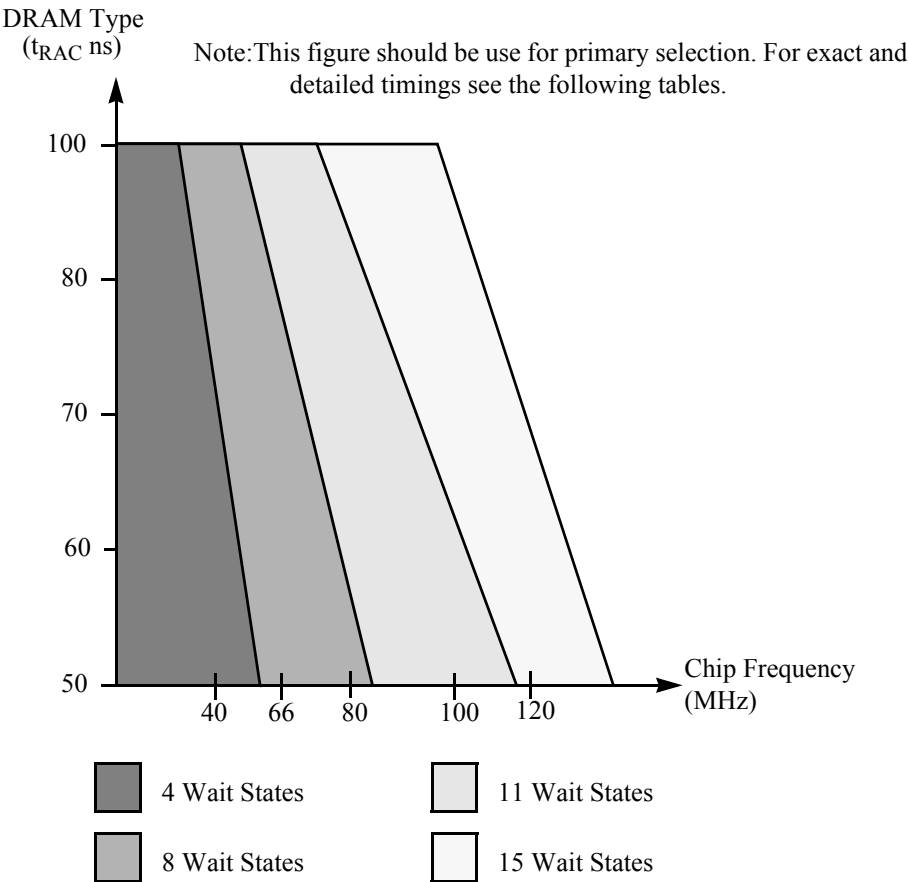
Figure 2-12 DRAM Page Mode Write Accesses



AA0474

Figure 2-13 DRAM Page Mode Read Accesses

External Memory Expansion Port (Port A)



AA0475

Figure 2-14 DRAM Out-of-Page Wait States Selection Guide

Table 2-13 DRAM Out-of-Page and Refresh Timings, Four Wait States<sup>1, 2</sup>

| No. | Characteristics <sup>3</sup>                                             | Symbol           | Expression                       | 20 MHz <sup>4</sup> |       | 30 MHz <sup>4</sup> |      | Unit |
|-----|--------------------------------------------------------------------------|------------------|----------------------------------|---------------------|-------|---------------------|------|------|
|     |                                                                          |                  |                                  | Min                 | Max   | Min                 | Max  |      |
| 157 | Random read or write cycle time                                          | $t_{\text{RC}}$  | $5 \times T_{\text{C}}$          | 250.0               | —     | 166.7               | —    | ns   |
| 158 | $\overline{\text{RAS}}$ assertion to data valid (read)                   | $t_{\text{RAC}}$ | $2.75 \times T_{\text{C}} - 7.5$ | —                   | 130.0 | —                   | 84.2 | ns   |
| 159 | $\overline{\text{CAS}}$ assertion to data valid (read)                   | $t_{\text{CAC}}$ | $1.25 \times T_{\text{C}} - 7.5$ | —                   | 55.0  | —                   | 34.2 | ns   |
| 160 | Column address valid to data valid (read)                                | $t_{\text{AA}}$  | $1.5 \times T_{\text{C}} - 7.5$  | —                   | 67.5  | —                   | 42.5 | ns   |
| 161 | $\overline{\text{CAS}}$ deassertion to data not valid (read hold time)   | $t_{\text{OFF}}$ |                                  | 0.0                 | —     | 0.0                 | —    | ns   |
| 162 | $\overline{\text{RAS}}$ deassertion to $\overline{\text{RAS}}$ assertion | $t_{\text{RP}}$  | $1.75 \times T_{\text{C}} - 4.0$ | 83.5                | —     | 54.3                | —    | ns   |
| 163 | $\overline{\text{RAS}}$ assertion pulse width                            | $t_{\text{RAS}}$ | $3.25 \times T_{\text{C}} - 4.0$ | 158.5               | —     | 104.3               | —    | ns   |

Table 2-13 DRAM Out-of-Page and Refresh Timings, Four Wait States<sup>1, 2</sup> (Continued)

| No. | Characteristics <sup>3</sup>                                             | Symbol           | Expression              | 20 MHz <sup>4</sup> |      | 30 MHz <sup>4</sup> |      | Unit |
|-----|--------------------------------------------------------------------------|------------------|-------------------------|---------------------|------|---------------------|------|------|
|     |                                                                          |                  |                         | Min                 | Max  | Min                 | Max  |      |
| 164 | $\overline{\text{CAS}}$ assertion to $\overline{\text{RAS}}$ deassertion | $t_{\text{RSH}}$ | $1.75 \times T_C - 4.0$ | 83.5                | —    | 54.3                | —    | ns   |
| 165 | $\overline{\text{RAS}}$ assertion to $\overline{\text{CAS}}$ deassertion | $t_{\text{CSH}}$ | $2.75 \times T_C - 4.0$ | 133.5               | —    | 87.7                | —    | ns   |
| 166 | $\overline{\text{CAS}}$ assertion pulse width                            | $t_{\text{CAS}}$ | $1.25 \times T_C - 4.0$ | 58.5                | —    | 37.7                | —    | ns   |
| 167 | $\overline{\text{RAS}}$ assertion to $\overline{\text{CAS}}$ assertion   | $t_{\text{RCD}}$ | $1.5 \times T_C \pm 2$  | 73.0                | 77.0 | 48.0                | 52.0 | ns   |
| 168 | $\overline{\text{RAS}}$ assertion to column address valid                | $t_{\text{RAD}}$ | $1.25 \times T_C \pm 2$ | 60.5                | 64.5 | 39.7                | 43.7 | ns   |
| 169 | $\overline{\text{CAS}}$ deassertion to $\overline{\text{RAS}}$ assertion | $t_{\text{CRP}}$ | $2.25 \times T_C - 4.0$ | 108.5               | —    | 71.0                | —    | ns   |
| 170 | $\overline{\text{CAS}}$ deassertion pulse width                          | $t_{\text{CP}}$  | $1.75 \times T_C - 4.0$ | 83.5                | —    | 54.3                | —    | ns   |
| 171 | Row address valid to $\overline{\text{RAS}}$ assertion                   | $t_{\text{ASR}}$ | $1.75 \times T_C - 4.0$ | 83.5                | —    | 54.3                | —    | ns   |
| 172 | $\overline{\text{RAS}}$ assertion to row address not valid               | $t_{\text{RAH}}$ | $1.25 \times T_C - 4.0$ | 58.5                | —    | 37.7                | —    | ns   |
| 173 | Column address valid to $\overline{\text{CAS}}$ assertion                | $t_{\text{ASC}}$ | $0.25 \times T_C - 4.0$ | 8.5                 | —    | 4.3                 | —    | ns   |
| 174 | $\overline{\text{CAS}}$ assertion to column address not valid            | $t_{\text{CAH}}$ | $1.75 \times T_C - 4.0$ | 83.5                | —    | 54.3                | —    | ns   |
| 175 | $\overline{\text{RAS}}$ assertion to column address not valid            | $t_{\text{AR}}$  | $3.25 \times T_C - 4.0$ | 158.5               | —    | 104.3               | —    | ns   |
| 176 | Column address valid to $\overline{\text{RAS}}$ deassertion              | $t_{\text{RAL}}$ | $2 \times T_C - 4.0$    | 96.0                | —    | 62.7                | —    | ns   |
| 177 | $\overline{\text{WR}}$ deassertion to $\overline{\text{CAS}}$ assertion  | $t_{\text{RCS}}$ | $1.5 \times T_C - 3.8$  | 71.2                | —    | 46.2                | —    | ns   |
| 178 | $\overline{\text{CAS}}$ deassertion to $\overline{\text{WR}}$ assertion  | $t_{\text{RCH}}$ | $0.75 \times T_C - 3.7$ | 33.8                | —    | 21.3                | —    | ns   |
| 179 | $\overline{\text{RAS}}$ deassertion to $\overline{\text{WR}}$ assertion  | $t_{\text{RRH}}$ | $0.25 \times T_C - 3.7$ | 8.8                 | —    | 4.6                 | —    | ns   |
| 180 | $\overline{\text{CAS}}$ assertion to $\overline{\text{WR}}$ deassertion  | $t_{\text{WCH}}$ | $1.5 \times T_C - 4.2$  | 70.8                | —    | 45.8                | —    | ns   |
| 181 | $\overline{\text{RAS}}$ assertion to $\overline{\text{WR}}$ deassertion  | $t_{\text{WCR}}$ | $3 \times T_C - 4.2$    | 145.8               | —    | 95.8                | —    | ns   |
| 182 | $\overline{\text{WR}}$ assertion pulse width                             | $t_{\text{WP}}$  | $4.5 \times T_C - 4.5$  | 220.5               | —    | 145.5               | —    | ns   |
| 183 | $\overline{\text{WR}}$ assertion to $\overline{\text{RAS}}$ deassertion  | $t_{\text{RWL}}$ | $4.75 \times T_C - 4.3$ | 233.2               | —    | 154.0               | —    | ns   |
| 184 | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ deassertion  | $t_{\text{CWL}}$ | $4.25 \times T_C - 4.3$ | 208.2               | —    | 137.4               | —    | ns   |
| 185 | Data valid to $\overline{\text{CAS}}$ assertion (write)                  | $t_{\text{DS}}$  | $2.25 \times T_C - 4.0$ | 108.5               | —    | 71.0                | —    | ns   |
| 186 | $\overline{\text{CAS}}$ assertion to data not valid (write)              | $t_{\text{DH}}$  | $1.75 \times T_C - 4.0$ | 83.5                | —    | 54.3                | —    | ns   |
| 187 | $\overline{\text{RAS}}$ assertion to data not valid (write)              | $t_{\text{DHR}}$ | $3.25 \times T_C - 4.0$ | 158.5               | —    | 104.3               | —    | ns   |
| 188 | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ assertion    | $t_{\text{WCS}}$ | $3 \times T_C - 4.3$    | 145.7               | —    | 95.7                | —    | ns   |

## External Memory Expansion Port (Port A)

Table 2-13 DRAM Out-of-Page and Refresh Timings, Four Wait States<sup>1, 2</sup> (Continued)

| No.                                                                                                                                                                                                                                                                                                                                                                                                                                             | Characteristics <sup>3</sup>                                                       | Symbol           | Expression              | 20 MHz <sup>4</sup> |       | 30 MHz <sup>4</sup> |       | Unit |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------|-------------------------|---------------------|-------|---------------------|-------|------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                    |                  |                         | Min                 | Max   | Min                 | Max   |      |
| 189                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{CAS}}$ assertion to $\overline{\text{RAS}}$ assertion (refresh)   | $t_{\text{CSR}}$ | $0.5 \times T_C - 4.0$  | 21.0                | —     | 12.7                | —     | ns   |
| 190                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RAS}}$ deassertion to $\overline{\text{CAS}}$ assertion (refresh) | $t_{\text{RPC}}$ | $1.25 \times T_C - 4.0$ | 58.5                | —     | 37.7                | —     | ns   |
| 191                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RD}}$ assertion to $\overline{\text{RAS}}$ deassertion            | $t_{\text{ROH}}$ | $4.5 \times T_C - 4.0$  | 221.0               | —     | 146.0               | —     | ns   |
| 192                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RD}}$ assertion to data valid                                     | $t_{\text{GA}}$  | $4 \times T_C - 7.5$    | —                   | 192.5 | —                   | 125.8 | ns   |
| 193                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RD}}$ deassertion to data not valid <sup>3</sup>                  | $t_{\text{GZ}}$  |                         | 0.0                 | —     | 0.0                 | —     | ns   |
| 194                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ assertion to data active                                    |                  | $0.75 \times T_C - 0.3$ | 37.2                | —     | 24.7                | —     | ns   |
| 195                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ deassertion to data high impedance                          |                  | $0.25 \times T_C$       | —                   | 12.5  | —                   | 8.3   | ns   |
| Notes: 1. The number of wait states for out of page access is specified in the DCR.<br>2. The refresh period is specified in the DCR.<br>3. $\overline{\text{RD}}$ deassertion will always occur after $\overline{\text{CAS}}$ deassertion; therefore, the restricted timing is $t_{\text{OFF}}$ and not $t_{\text{GZ}}$ .<br>4. Reduced DSP clock speed allows use of DRAM out-of-page access with four Wait states (See <b>Figure 2-17</b> ). |                                                                                    |                  |                         |                     |       |                     |       |      |

Table 2-14 DRAM Out-of-Page and Refresh Timings, Eight Wait States<sup>1, 2</sup>

| No. | Characteristics <sup>4</sup>                                             | Symbol           | Expression <sup>3</sup> | 66 MHz |      | 80 MHz |      | Unit |
|-----|--------------------------------------------------------------------------|------------------|-------------------------|--------|------|--------|------|------|
|     |                                                                          |                  |                         | Min    | Max  | Min    | Max  |      |
| 157 | Random read or write cycle time                                          | $t_{\text{RC}}$  | $9 \times T_C$          | 136.4  | —    | 112.5  | —    | ns   |
| 158 | $\overline{\text{RAS}}$ assertion to data valid (read)                   | $t_{\text{RAC}}$ | $4.75 \times T_C - 7.5$ | —      | 64.5 | —      | —    | ns   |
|     |                                                                          |                  | $4.75 \times T_C - 6.5$ | —      | —    | —      | 52.9 | ns   |
| 159 | $\overline{\text{CAS}}$ assertion to data valid (read)                   | $t_{\text{CAC}}$ | $2.25 \times T_C - 7.5$ | —      | 26.6 | —      | —    | ns   |
|     |                                                                          |                  | $2.25 \times T_C - 6.5$ | —      | —    | —      | 21.6 | ns   |
| 160 | Column address valid to data valid (read)                                | $t_{\text{AA}}$  | $3 \times T_C - 7.5$    | —      | 40.0 | —      | —    | ns   |
|     |                                                                          |                  | $3 \times T_C - 6.5$    | —      | —    | —      | 31.0 | ns   |
| 161 | $\overline{\text{CAS}}$ deassertion to data not valid (read hold time)   | $t_{\text{OFF}}$ |                         | 0.0    | —    | 0.0    | —    | ns   |
| 162 | $\overline{\text{RAS}}$ deassertion to $\overline{\text{RAS}}$ assertion | $t_{\text{RP}}$  | $3.25 \times T_C - 4.0$ | 45.2   | —    | 36.6   | —    | ns   |
| 163 | $\overline{\text{RAS}}$ assertion pulse width                            | $t_{\text{RAS}}$ | $5.75 \times T_C - 4.0$ | 83.1   | —    | 67.9   | —    | ns   |
| 164 | $\overline{\text{CAS}}$ assertion to $\overline{\text{RAS}}$ deassertion | $t_{\text{RSH}}$ | $3.25 \times T_C - 4.0$ | 45.2   | —    | 36.6   | —    | ns   |
| 165 | $\overline{\text{RAS}}$ assertion to $\overline{\text{CAS}}$ deassertion | $t_{\text{CSH}}$ | $4.75 \times T_C - 4.0$ | 68.0   | —    | 55.5   | —    | ns   |
| 166 | $\overline{\text{CAS}}$ assertion pulse width                            | $t_{\text{CAS}}$ | $2.25 \times T_C - 4.0$ | 30.1   | —    | 24.1   | —    | ns   |
| 167 | $\overline{\text{RAS}}$ assertion to $\overline{\text{CAS}}$ assertion   | $t_{\text{RCD}}$ | $2.5 \times T_C \pm 2$  | 35.9   | 39.9 | 29.3   | 33.3 | ns   |
| 168 | $\overline{\text{RAS}}$ assertion to column address valid                | $t_{\text{RAD}}$ | $1.75 \times T_C \pm 2$ | 24.5   | 28.5 | 19.9   | 23.9 | ns   |

Table 2-14 DRAM Out-of-Page and Refresh Timings, Eight Wait States<sup>1, 2</sup> (Continued)

| No. | Characteristics <sup>4</sup>                                                         | Symbol           | Expression <sup>3</sup> | 66 MHz |       | 80 MHz |      | Unit |
|-----|--------------------------------------------------------------------------------------|------------------|-------------------------|--------|-------|--------|------|------|
|     |                                                                                      |                  |                         | Min    | Max   | Min    | Max  |      |
| 169 | $\overline{\text{CAS}}$ deassertion to $\overline{\text{RAS}}$ assertion             | $t_{\text{CRP}}$ | $4.25 \times T_C - 4.0$ | 59.8   | —     | 49.1   | —    | ns   |
| 170 | $\overline{\text{CAS}}$ deassertion pulse width                                      | $t_{\text{CP}}$  | $2.75 \times T_C - 4.0$ | 37.7   | —     | 30.4   | —    | ns   |
| 171 | Row address valid to $\overline{\text{RAS}}$ assertion                               | $t_{\text{ASR}}$ | $3.25 \times T_C - 4.0$ | 45.2   | —     | 36.6   | —    | ns   |
| 172 | $\overline{\text{RAS}}$ assertion to row address not valid                           | $t_{\text{RAH}}$ | $1.75 \times T_C - 4.0$ | 22.5   | —     | 17.9   | —    | ns   |
| 173 | Column address valid to $\overline{\text{CAS}}$ assertion                            | $t_{\text{ASC}}$ | $0.75 \times T_C - 4.0$ | 7.4    | —     | 5.4    | —    | ns   |
| 174 | $\overline{\text{CAS}}$ assertion to column address not valid                        | $t_{\text{CAH}}$ | $3.25 \times T_C - 4.0$ | 45.2   | —     | 36.6   | —    | ns   |
| 175 | $\overline{\text{RAS}}$ assertion to column address not valid                        | $t_{\text{AR}}$  | $5.75 \times T_C - 4.0$ | 83.1   | —     | 67.9   | —    | ns   |
| 176 | Column address valid to $\overline{\text{RAS}}$ deassertion                          | $t_{\text{RAL}}$ | $4 \times T_C - 4.0$    | 56.6   | —     | 46.0   | —    | ns   |
| 177 | $\overline{\text{WR}}$ deassertion to $\overline{\text{CAS}}$ assertion              | $t_{\text{RCS}}$ | $2 \times T_C - 3.8$    | 26.5   | —     | 21.2   | —    | ns   |
| 178 | $\overline{\text{CAS}}$ deassertion to $\overline{\text{WR}}$ <sup>5</sup> assertion | $t_{\text{RCH}}$ | $1.25 \times T_C - 3.7$ | 15.2   | —     | 11.9   | —    | ns   |
| 179 | $\overline{\text{RAS}}$ deassertion to $\overline{\text{WR}}$ <sup>5</sup> assertion | $t_{\text{RRH}}$ | $0.25 \times T_C - 3.7$ | 0.1    | —     | —      | —    | ns   |
|     |                                                                                      |                  | $0.25 \times T_C - 3.0$ | —      | —     | 0.1    | —    | ns   |
| 180 | $\overline{\text{CAS}}$ assertion to $\overline{\text{WR}}$ deassertion              | $t_{\text{WCH}}$ | $3 \times T_C - 4.2$    | 41.3   | —     | 33.3   | —    | ns   |
| 181 | $\overline{\text{RAS}}$ assertion to $\overline{\text{WR}}$ deassertion              | $t_{\text{WCR}}$ | $5.5 \times T_C - 4.2$  | 79.1   | —     | 64.6   | —    | ns   |
| 182 | $\overline{\text{WR}}$ assertion pulse width                                         | $t_{\text{WP}}$  | $8.5 \times T_C - 4.5$  | 124.3  | —     | 101.8  | —    | ns   |
| 183 | $\overline{\text{WR}}$ assertion to $\overline{\text{RAS}}$ deassertion              | $t_{\text{RWL}}$ | $8.75 \times T_C - 4.3$ | 128.3  | —     | 105.1  | —    | ns   |
| 184 | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ deassertion              | $t_{\text{CWL}}$ | $7.75 \times T_C - 4.3$ | 113.1  | —     | 92.6   | —    | ns   |
| 185 | Data valid to $\overline{\text{CAS}}$ assertion (write)                              | $t_{\text{DS}}$  | $4.75 \times T_C - 4.0$ | 68.0   | —     | 55.4   | —    | ns   |
| 186 | $\overline{\text{CAS}}$ assertion to data not valid (write)                          | $t_{\text{DH}}$  | $3.25 \times T_C - 4.0$ | 45.2   | —     | 36.6   | —    | ns   |
| 187 | $\overline{\text{RAS}}$ assertion to data not valid (write)                          | $t_{\text{DHR}}$ | $5.75 \times T_C - 4.0$ | 83.1   | —     | 67.9   | —    | ns   |
| 188 | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ assertion                | $t_{\text{WCS}}$ | $5.5 \times T_C - 4.3$  | 79.0   | —     | 64.5   | —    | ns   |
| 189 | $\overline{\text{CAS}}$ assertion to $\overline{\text{RAS}}$ assertion (refresh)     | $t_{\text{CSR}}$ | $1.5 \times T_C - 4.0$  | 18.7   | —     | 14.8   | —    | ns   |
| 190 | $\overline{\text{RAS}}$ deassertion to $\overline{\text{CAS}}$ assertion (refresh)   | $t_{\text{RPC}}$ | $1.75 \times T_C - 4.0$ | 22.5   | —     | 17.9   | —    | ns   |
| 191 | $\overline{\text{RD}}$ assertion to $\overline{\text{RAS}}$ deassertion              | $t_{\text{ROH}}$ | $8.5 \times T_C - 4.0$  | 124.8  | —     | 102.3  | —    | ns   |
| 192 | $\overline{\text{RD}}$ assertion to data valid                                       | $t_{\text{GA}}$  | $7.5 \times T_C - 7.5$  | —      | 106.1 | —      | —    | ns   |
|     |                                                                                      |                  | $7.5 \times T_C - 6.5$  | —      | —     | —      | 87.3 | ns   |
| 193 | $\overline{\text{RD}}$ deassertion to data not valid <sup>4</sup>                    | $t_{\text{GZ}}$  | 0.0                     | 0.0    | —     | 0.0    | —    | ns   |
| 194 | $\overline{\text{WR}}$ assertion to data active                                      |                  | $0.75 \times T_C - 0.3$ | 11.1   | —     | 9.1    | —    | ns   |
| 195 | $\overline{\text{WR}}$ deassertion to data high impedance                            |                  | $0.25 \times T_C$       | —      | 3.8   | —      | 3.1  | ns   |

## External Memory Expansion Port (Port A)

Table 2-14 DRAM Out-of-Page and Refresh Timings, Eight Wait States<sup>1, 2</sup> (Continued)

| No.    | Characteristics <sup>4</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Symbol | Expression <sup>3</sup> | 66 MHz |     | 80 MHz |     | Unit |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------|--------|-----|--------|-----|------|
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |                         | Min    | Max | Min    | Max |      |
| Notes: | <div><div>1.</div><div>The number of wait states for out-of-page access is specified in the DCR.</div><div>2.</div><div>The refresh period is specified in the DCR.</div><div>3.</div><div>The asynchronous delays specified in the expressions are valid for DSP56366.</div><div>4.</div><div><math>\overline{RD}</math> deassertion will always occur after <math>\overline{CAS}</math> deassertion; therefore, the restricted timing is <math>t_{OFF}</math> and not <math>t_{GZ}</math>.</div><div>5.</div><div>Either <math>t_{RCH}</math> or <math>t_{RRH}</math> must be satisfied for read cycles.</div></div> |        |                         |        |     |        |     |      |

## External Memory Expansion Port (Port A)

Table 2-15 DRAM Out-of-Page and Refresh Timings, Eleven Wait States<sup>1, 2</sup>

| No. | Characteristics <sup>4</sup>                                           | Symbol    | Expression <sup>3</sup>   | Min   | Max  | Unit |
|-----|------------------------------------------------------------------------|-----------|---------------------------|-------|------|------|
| 157 | Random read or write cycle time                                        | $t_{RC}$  | $12 \times T_C$           | 120.0 | —    | ns   |
| 158 | $\overline{RAS}$ assertion to data valid (read)                        | $t_{RAC}$ | $6.25 \times T_C - 7.0$   | —     | 55.5 | ns   |
| 159 | $\overline{CAS}$ assertion to data valid (read)                        | $t_{CAC}$ | $3.75 \times T_C - 7.0$   | —     | 30.5 | ns   |
| 160 | Column address valid to data valid (read)                              | $t_{AA}$  | $4.5 \times T_C - 7.0$    | —     | 38.0 | ns   |
| 161 | $\overline{CAS}$ deassertion to data not valid (read hold time)        | $t_{OFF}$ |                           | 0.0   | —    | ns   |
| 162 | $\overline{RAS}$ deassertion to $\overline{RAS}$ assertion             | $t_{RP}$  | $4.25 \times T_C - 4.0$   | 38.5  | —    | ns   |
| 163 | $\overline{RAS}$ assertion pulse width                                 | $t_{RAS}$ | $7.75 \times T_C - 4.0$   | 73.5  | —    | ns   |
| 164 | $\overline{CAS}$ assertion to $\overline{RAS}$ deassertion             | $t_{RSH}$ | $5.25 \times T_C - 4.0$   | 48.5  | —    | ns   |
| 165 | $\overline{RAS}$ assertion to $\overline{CAS}$ deassertion             | $t_{CSH}$ | $6.25 \times T_C - 4.0$   | 58.5  | —    | ns   |
| 166 | $\overline{CAS}$ assertion pulse width                                 | $t_{CAS}$ | $3.75 \times T_C - 4.0$   | 33.5  | —    | ns   |
| 167 | $\overline{RAS}$ assertion to $\overline{CAS}$ assertion               | $t_{RCD}$ | $2.5 \times T_C \pm 4.0$  | 21.0  | 29.0 | ns   |
| 168 | $\overline{RAS}$ assertion to column address valid                     | $t_{RAD}$ | $1.75 \times T_C \pm 4.0$ | 13.5  | 21.5 | ns   |
| 169 | $\overline{CAS}$ deassertion to $\overline{RAS}$ assertion             | $t_{CRP}$ | $5.75 \times T_C - 4.0$   | 53.5  | —    | ns   |
| 170 | $\overline{CAS}$ deassertion pulse width                               | $t_{CP}$  | $4.25 \times T_C - 4.0$   | 38.5  | —    | ns   |
| 171 | Row address valid to $\overline{RAS}$ assertion                        | $t_{ASR}$ | $4.25 \times T_C - 4.0$   | 38.5  | —    | ns   |
| 172 | $\overline{RAS}$ assertion to row address not valid                    | $t_{RAH}$ | $1.75 \times T_C - 4.0$   | 13.5  | —    | ns   |
| 173 | Column address valid to $\overline{CAS}$ assertion                     | $t_{ASC}$ | $0.75 \times T_C - 4.0$   | 3.5   | —    | ns   |
| 174 | $\overline{CAS}$ assertion to column address not valid                 | $t_{CAH}$ | $5.25 \times T_C - 4.0$   | 48.5  | —    | ns   |
| 175 | $\overline{RAS}$ assertion to column address not valid                 | $t_{AR}$  | $7.75 \times T_C - 4.0$   | 73.5  | —    | ns   |
| 176 | Column address valid to $\overline{RAS}$ deassertion                   | $t_{RAL}$ | $6 \times T_C - 4.0$      | 56.0  | —    | ns   |
| 177 | $\overline{WR}$ deassertion to $\overline{CAS}$ assertion              | $t_{RCS}$ | $3.0 \times T_C - 4.0$    | 26.0  | —    | ns   |
| 178 | $\overline{CAS}$ deassertion to $\overline{WR}$ <sup>5</sup> assertion | $t_{RCH}$ | $1.75 \times T_C - 4.0$   | 13.5  | —    | ns   |
| 179 | $\overline{RAS}$ deassertion to $\overline{WR}$ <sup>5</sup> assertion | $t_{RRH}$ | $0.25 \times T_C - 2.0$   | 0.5   | —    | ns   |
| 180 | $\overline{CAS}$ assertion to $\overline{WR}$ deassertion              | $t_{WCH}$ | $5 \times T_C - 4.2$      | 45.8  | —    | ns   |
| 181 | $\overline{RAS}$ assertion to $\overline{WR}$ deassertion              | $t_{WCR}$ | $7.5 \times T_C - 4.2$    | 70.8  | —    | ns   |
| 182 | $\overline{WR}$ assertion pulse width                                  | $t_{WP}$  | $11.5 \times T_C - 4.5$   | 110.5 | —    | ns   |
| 183 | $\overline{WR}$ assertion to $\overline{RAS}$ deassertion              | $t_{RWL}$ | $11.75 \times T_C - 4.3$  | 113.2 | —    | ns   |
| 184 | $\overline{WR}$ assertion to $\overline{CAS}$ deassertion              | $t_{CWL}$ | $10.25 \times T_C - 4.3$  | 103.2 | —    | ns   |
| 185 | Data valid to $\overline{CAS}$ assertion (write)                       | $t_{DS}$  | $5.75 \times T_C - 4.0$   | 53.5  | —    | ns   |
| 186 | $\overline{CAS}$ assertion to data not valid (write)                   | $t_{DH}$  | $5.25 \times T_C - 4.0$   | 48.5  | —    | ns   |
| 187 | $\overline{RAS}$ assertion to data not valid (write)                   | $t_{DHR}$ | $7.75 \times T_C - 4.0$   | 73.5  | —    | ns   |
| 188 | $\overline{WR}$ assertion to $\overline{CAS}$ assertion                | $t_{WCS}$ | $6.5 \times T_C - 4.3$    | 60.7  | —    | ns   |
| 189 | $\overline{CAS}$ assertion to $\overline{RAS}$ assertion (refresh)     | $t_{CSR}$ | $1.5 \times T_C - 4.0$    | 11.0  | —    | ns   |
| 190 | $\overline{RAS}$ deassertion to $\overline{CAS}$ assertion (refresh)   | $t_{RPC}$ | $2.75 \times T_C - 4.0$   | 23.5  | —    | ns   |
| 191 | $\overline{RD}$ assertion to $\overline{RAS}$ deassertion              | $t_{ROH}$ | $11.5 \times T_C - 4.0$   | 111.0 | —    | ns   |

## External Memory Expansion Port (Port A)

Table 2-15 DRAM Out-of-Page and Refresh Timings, Eleven Wait States<sup>1, 2</sup> (Continued)

| No.                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Characteristics <sup>4</sup>                               | Symbol   | Expression <sup>3</sup> | Min | Max  | Unit |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------|-------------------------|-----|------|------|
| 192                                                                                                                                                                                                                                                                                                                                                                                                                                                      | $\overline{RD}$ assertion to data valid                    | $t_{GA}$ | $10 \times T_C - 7.0$   | —   | 93.0 | ns   |
| 193                                                                                                                                                                                                                                                                                                                                                                                                                                                      | $\overline{RD}$ deassertion to data not valid <sup>4</sup> | $t_{GZ}$ |                         | 0.0 | —    | ns   |
| 194                                                                                                                                                                                                                                                                                                                                                                                                                                                      | $\overline{WR}$ assertion to data active                   |          | $0.75 \times T_C - 0.3$ | 7.2 | —    | ns   |
| 195                                                                                                                                                                                                                                                                                                                                                                                                                                                      | $\overline{WR}$ deassertion to data high impedance         |          | $0.25 \times T_C$       | —   | 2.5  | ns   |
| Notes: 1. The number of wait states for out-of-page access is specified in the DCR.<br>2. The refresh period is specified in the DCR.<br>3. The asynchronous delays specified in the expressions are valid for DSP56366.<br>4. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is $t_{OFF}$ and not $t_{GZ}$ .<br>5. Either $t_{RCH}$ or $t_{RRH}$ must be satisfied for read cycles. |                                                            |          |                         |     |      |      |

Table 2-16 DRAM Out-of-Page and Refresh Timings, Fifteen Wait States<sup>1, 2</sup>

| No. | Characteristics <sup>3</sup>                                           | Symbol    | Expression              | Min   | Max  | Unit |
|-----|------------------------------------------------------------------------|-----------|-------------------------|-------|------|------|
| 157 | Random read or write cycle time                                        | $t_{RC}$  | $16 \times T_C$         | 133.3 | —    | ns   |
| 158 | $\overline{RAS}$ assertion to data valid (read)                        | $t_{RAC}$ | $8.25 \times T_C - 5.7$ | —     | 63.0 | ns   |
| 159 | $\overline{CAS}$ assertion to data valid (read)                        | $t_{CAC}$ | $4.75 \times T_C - 5.7$ | —     | 33.9 | ns   |
| 160 | Column address valid to data valid (read)                              | $t_{AA}$  | $5.5 \times T_C - 5.7$  | —     | 40.1 | ns   |
| 161 | $\overline{CAS}$ deassertion to data not valid (read hold time)        | $t_{OFF}$ | 0.0                     | 0.0   | —    | ns   |
| 162 | $\overline{RAS}$ deassertion to $\overline{RAS}$ assertion             | $t_{RP}$  | $6.25 \times T_C - 4.0$ | 48.1  | —    | ns   |
| 163 | $\overline{RAS}$ assertion pulse width                                 | $t_{RAS}$ | $9.75 \times T_C - 4.0$ | 77.2  | —    | ns   |
| 164 | $\overline{CAS}$ assertion to $\overline{RAS}$ deassertion             | $t_{RSH}$ | $6.25 \times T_C - 4.0$ | 48.1  | —    | ns   |
| 165 | $\overline{RAS}$ assertion to $\overline{CAS}$ deassertion             | $t_{CSH}$ | $8.25 \times T_C - 4.0$ | 64.7  | —    | ns   |
| 166 | $\overline{CAS}$ assertion pulse width                                 | $t_{CAS}$ | $4.75 \times T_C - 4.0$ | 35.6  | —    | ns   |
| 167 | $\overline{RAS}$ assertion to $\overline{CAS}$ assertion               | $t_{RCD}$ | $3.5 \times T_C \pm 2$  | 27.2  | 31.2 | ns   |
| 168 | $\overline{RAS}$ assertion to column address valid                     | $t_{RAD}$ | $2.75 \times T_C \pm 2$ | 20.9  | 24.9 | ns   |
| 169 | $\overline{CAS}$ deassertion to $\overline{RAS}$ assertion             | $t_{CRP}$ | $7.75 \times T_C - 4.0$ | 60.6  | —    | ns   |
| 170 | $\overline{CAS}$ deassertion pulse width                               | $t_{CP}$  | $6.25 \times T_C - 4.0$ | 48.1  | —    | ns   |
| 171 | Row address valid to $\overline{RAS}$ assertion                        | $t_{ASR}$ | $6.25 \times T_C - 4.0$ | 48.1  | —    | ns   |
| 172 | $\overline{RAS}$ assertion to row address not valid                    | $t_{RAH}$ | $2.75 \times T_C - 4.0$ | 18.9  | —    | ns   |
| 173 | Column address valid to $\overline{CAS}$ assertion                     | $t_{ASC}$ | $0.75 \times T_C - 4.0$ | 2.2   | —    | ns   |
| 174 | $\overline{CAS}$ assertion to column address not valid                 | $t_{CAH}$ | $6.25 \times T_C - 4.0$ | 48.1  | —    | ns   |
| 175 | $\overline{RAS}$ assertion to column address not valid                 | $t_{AR}$  | $9.75 \times T_C - 4.0$ | 77.2  | —    | ns   |
| 176 | Column address valid to $\overline{RAS}$ deassertion                   | $t_{RAL}$ | $7 \times T_C - 4.0$    | 54.3  | —    | ns   |
| 177 | $\overline{WR}$ deassertion to $\overline{CAS}$ assertion              | $t_{RCS}$ | $5 \times T_C - 3.8$    | 37.9  | —    | ns   |
| 178 | $\overline{CAS}$ deassertion to $\overline{WR}$ <sup>5</sup> assertion | $t_{RCH}$ | $1.75 \times T_C - 3.7$ | 10.9  | —    | ns   |

## External Memory Expansion Port (Port A)

Table 2-16 DRAM Out-of-Page and Refresh Timings, Fifteen Wait States<sup>1, 2</sup> (Continued)

| No.                                                                                                                                                                                                                                                                                                                                                                                                             | Characteristics <sup>3</sup>                                                       | Symbol           | Expression               | Min   | Max   | Unit |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------|--------------------------|-------|-------|------|
| 179                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RAS}}$ deassertion to $\overline{\text{WR}}^5$ assertion          | $t_{\text{RRH}}$ | $0.25 \times T_C - 2.0$  | 0.1   | —     | ns   |
| 180                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{CAS}}$ assertion to $\overline{\text{WR}}$ deassertion            | $t_{\text{WCH}}$ | $6 \times T_C - 4.2$     | 45.8  | —     | ns   |
| 181                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RAS}}$ assertion to $\overline{\text{WR}}$ deassertion            | $t_{\text{WCR}}$ | $9.5 \times T_C - 4.2$   | 75.0  | —     | ns   |
| 182                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ assertion pulse width                                       | $t_{\text{WP}}$  | $15.5 \times T_C - 4.5$  | 124.7 | —     | ns   |
| 183                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ assertion to $\overline{\text{RAS}}$ deassertion            | $t_{\text{RWL}}$ | $15.75 \times T_C - 4.3$ | 126.9 | —     | ns   |
| 184                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ deassertion            | $t_{\text{CWL}}$ | $14.25 \times T_C - 4.3$ | 114.4 | —     | ns   |
| 185                                                                                                                                                                                                                                                                                                                                                                                                             | Data valid to $\overline{\text{CAS}}$ assertion (write)                            | $t_{\text{DS}}$  | $8.75 \times T_C - 4.0$  | 68.9  | —     | ns   |
| 186                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{CAS}}$ assertion to data not valid (write)                        | $t_{\text{DH}}$  | $6.25 \times T_C - 4.0$  | 48.1  | —     | ns   |
| 187                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RAS}}$ assertion to data not valid (write)                        | $t_{\text{DHR}}$ | $9.75 \times T_C - 4.0$  | 77.2  | —     | ns   |
| 188                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ assertion to $\overline{\text{CAS}}$ assertion              | $t_{\text{WCS}}$ | $9.5 \times T_C - 4.3$   | 74.9  | —     | ns   |
| 189                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{CAS}}$ assertion to $\overline{\text{RAS}}$ assertion (refresh)   | $t_{\text{CSR}}$ | $1.5 \times T_C - 4.0$   | 8.5   | —     | ns   |
| 190                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RAS}}$ deassertion to $\overline{\text{CAS}}$ assertion (refresh) | $t_{\text{RPC}}$ | $4.75 \times T_C - 4.0$  | 35.6  | —     | ns   |
| 191                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RD}}$ assertion to $\overline{\text{RAS}}$ deassertion            | $t_{\text{ROH}}$ | $15.5 \times T_C - 4.0$  | 125.2 | —     | ns   |
| 192                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RD}}$ assertion to data valid                                     | $t_{\text{GA}}$  | $14 \times T_C - 5.7$    | —     | 111.0 | ns   |
| 193                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{RD}}$ deassertion to data not valid <sup>3</sup>                  | $t_{\text{GZ}}$  |                          | 0.0   | —     | ns   |
| 194                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ assertion to data active                                    |                  | $0.75 \times T_C - 0.3$  | 5.9   | —     | ns   |
| 195                                                                                                                                                                                                                                                                                                                                                                                                             | $\overline{\text{WR}}$ deassertion to data high impedance                          |                  | $0.25 \times T_C$        | —     | 2.1   | ns   |
| Notes: 1. The number of wait states for out-of-page access is specified in the DCR.<br>2. The refresh period is specified in the DCR.<br>3. $\overline{\text{RD}}$ deassertion will always occur after $\overline{\text{CAS}}$ deassertion; therefore, the restricted timing is $t_{\text{OFF}}$ and not $t_{\text{GZ}}$ .<br>4. Either $t_{\text{RCH}}$ or $t_{\text{RRH}}$ must be satisfied for read cycles. |                                                                                    |                  |                          |       |       |      |

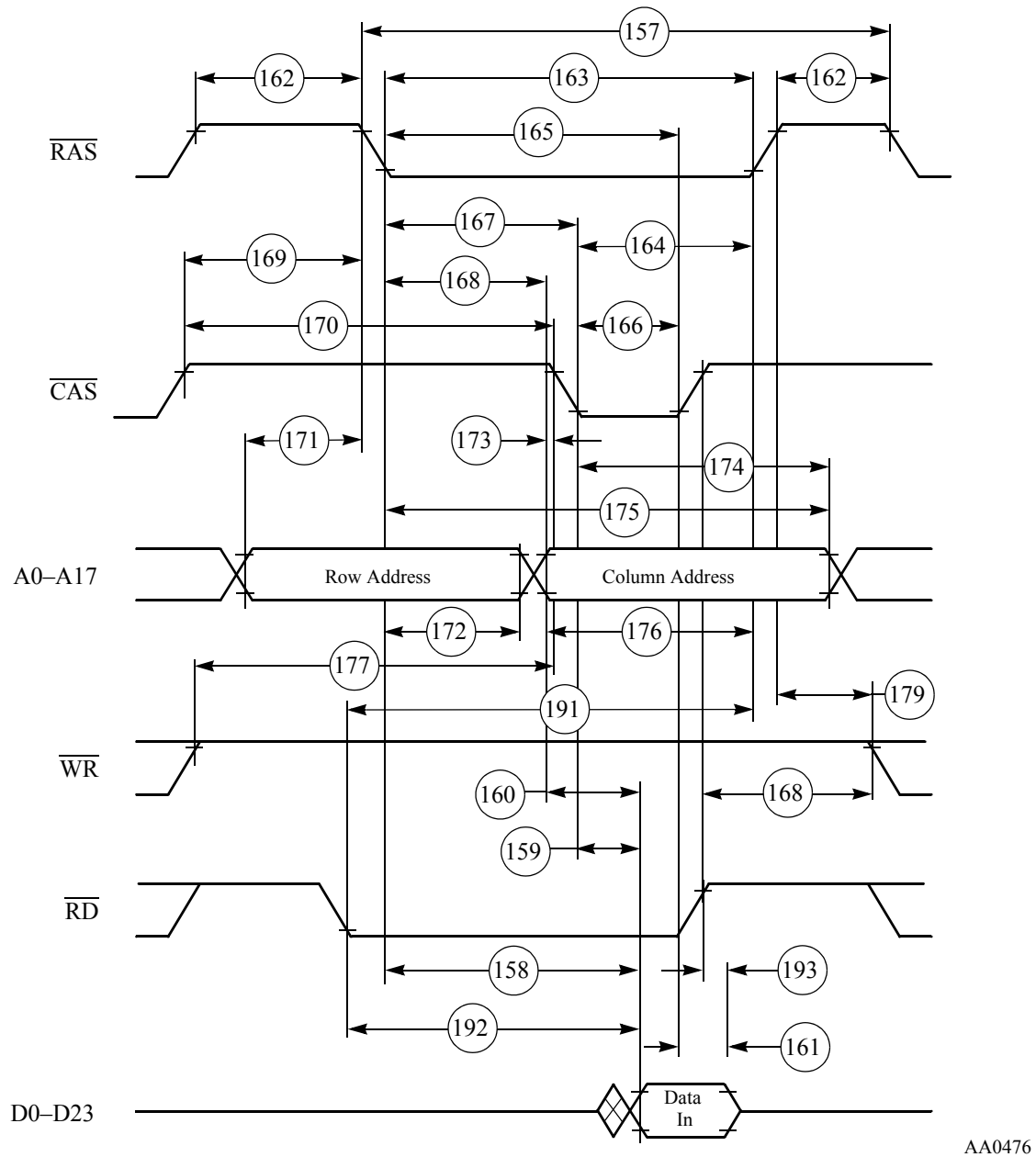


Figure 2-15 DRAM Out-of-Page Read Access

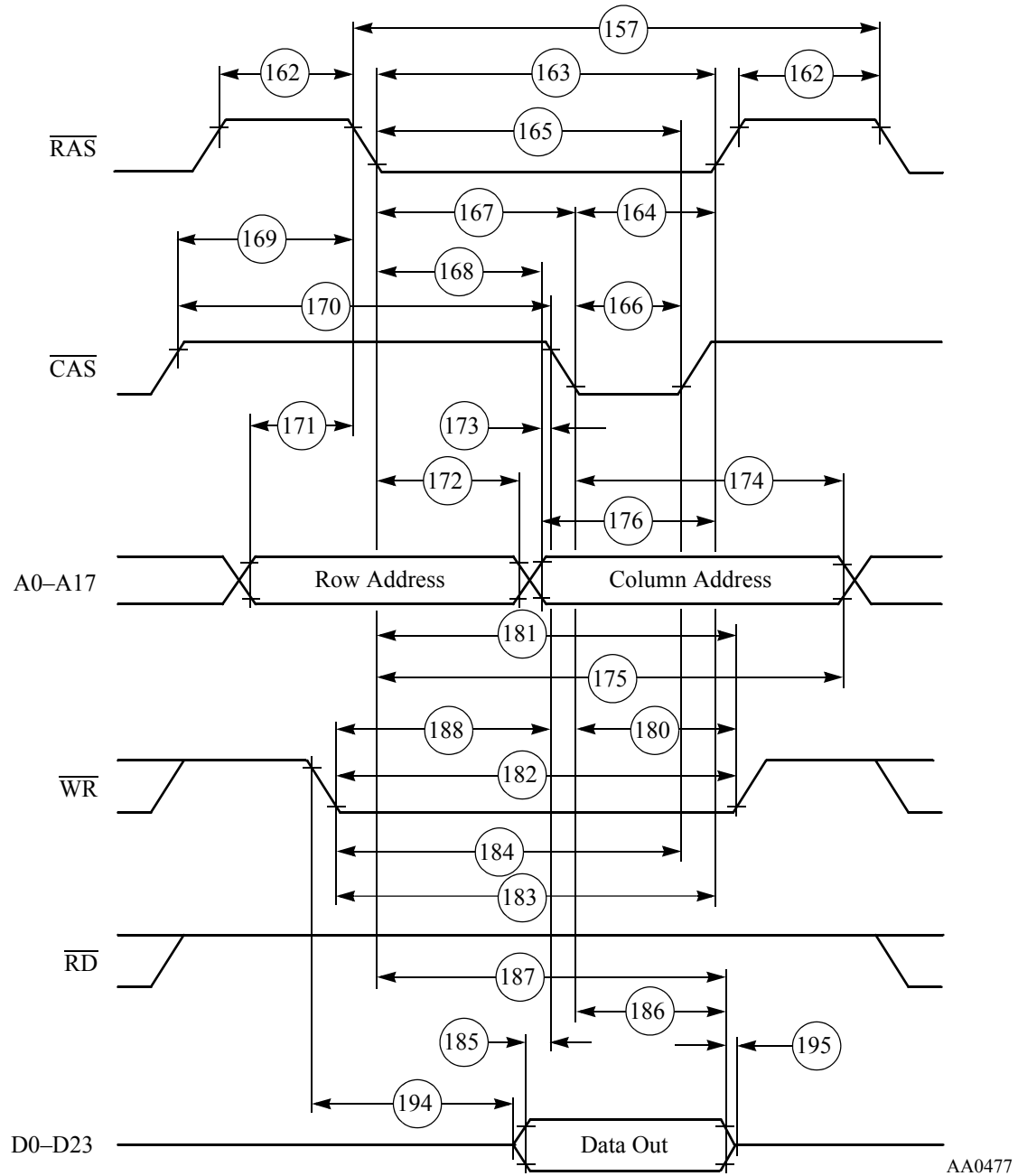


Figure 2-16 DRAM Out-of-Page Write Access

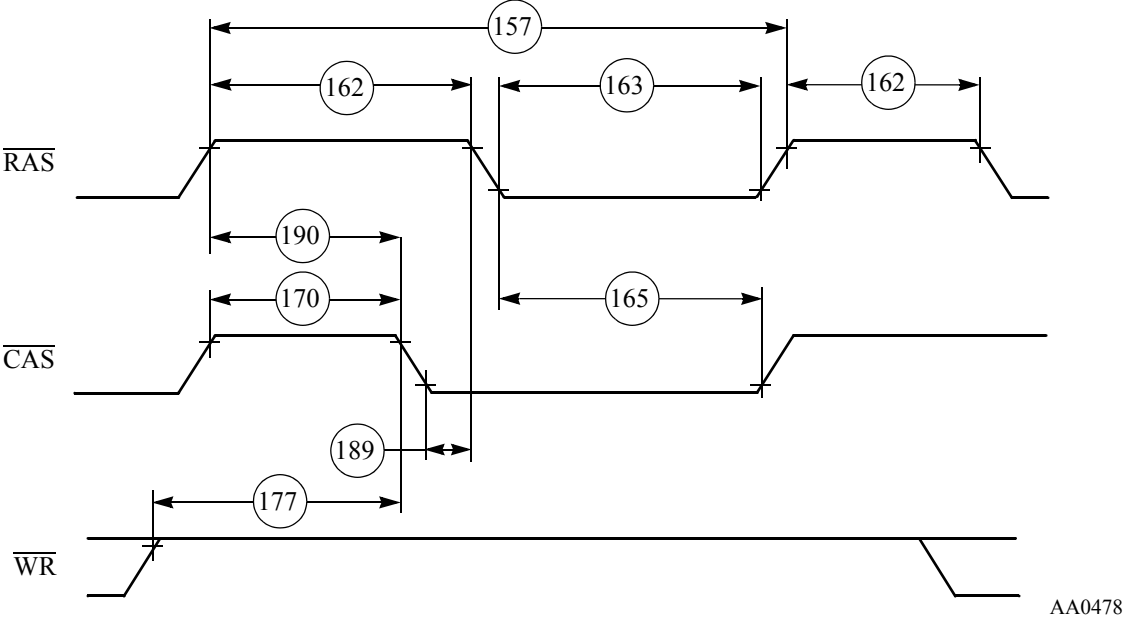
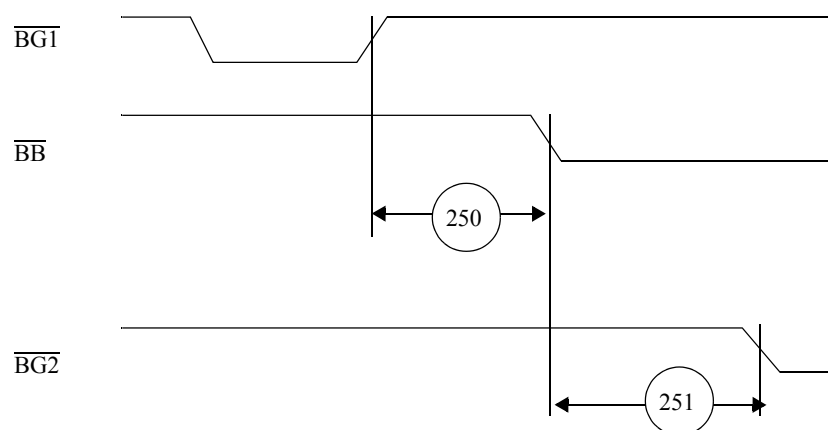


Figure 2-17 DRAM Refresh Access

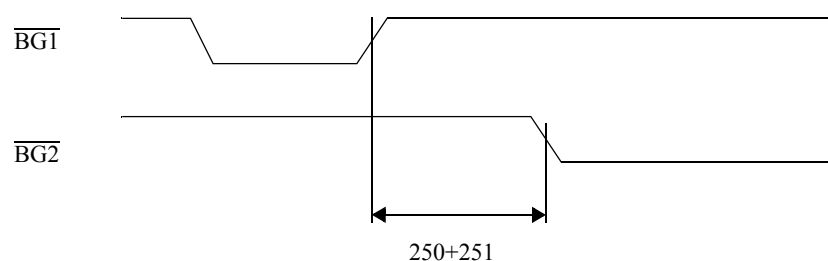
## Arbitration Timings

**Table 2-17 Asynchronous Bus Arbitration timing**

| No.                                                                                                                                                                                                                                                                                                                                                                                                              | Characteristics                                                       | Expression      | 120 MHz |      | Unit |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|-----------------|---------|------|------|
|                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                       |                 | Min     | Max  |      |
| 250                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{BB}$ assertion window from $\overline{BG}$ input negation. | $2.5 * T_c + 5$ | —       | 25.8 | ns   |
| 251                                                                                                                                                                                                                                                                                                                                                                                                              | Delay from $\overline{BB}$ assertion to $\overline{BG}$ assertion     | $2 * T_c + 5$   | 21.7    | —    | ns   |
| Comments:<br>1. Bit 13 in the OMR register must be set to enter Asynchronous Arbitration mode<br>2. If Asynchronous Arbitration mode is active, none of the timings in <b>Table 2-17</b> is required.<br>3. In order to guarantee timings 250, and 251, it is recommended to assert $\overline{BG}$ inputs to different 56300 devices (on the same bus) in a non overlap manner as shown in <b>Figure 2-18</b> . |                                                                       |                 |         |      |      |



**Figure 2-18 Asynchronous Bus Arbitration Timing**



**Figure 2-19 Asynchronous Bus Arbitration Timing**

### External Memory Expansion Port (Port A)

Background explanation for Asynchronous Bus Arbitration:

The asynchronous bus arbitration is enabled by internal synchronization circuits on  $\overline{BG}$  and  $\overline{BB}$  inputs. These synchronization circuits add delay from the external signal until it is exposed to internal logic. As a result of this delay, a 56300 part may assume mastership and assert  $\overline{BB}$  for some time after  $\overline{BG}$  is negated. This is the reason for timing 250.

Once  $\overline{BB}$  is asserted, there is a synchronization delay from  $\overline{BB}$  assertion to the time this assertion is exposed to other 56300 components which are potential masters on the same bus. If  $\overline{BG}$  input is asserted before that time, a situation of  $\overline{BG}$  asserted, and  $\overline{BB}$  negated, may cause another 56300 component to assume mastership at the same time. Therefore some non-overlap period between one  $\overline{BG}$  input active to another  $\overline{BG}$  input active is required. Timing 251 ensures that such a situation is avoided.

## PARALLEL HOST INTERFACE (HDI08) TIMING

Table 2-18 Host Interface (HDI08) Timing<sup>1, 2</sup>

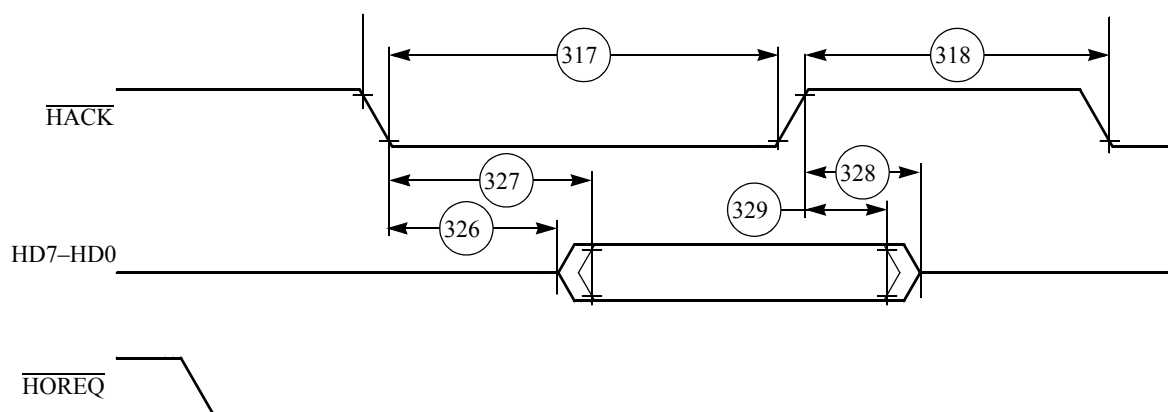
| No. | Characteristics <sup>3</sup>                                                                                                                                                                                                                                   | Expression             | 120 MHz |      | Unit |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------|------|------|
|     |                                                                                                                                                                                                                                                                |                        | Min     | Max  |      |
| 317 | Read data strobe assertion width <sup>4</sup><br>$\overline{\text{HACK}}$ read assertion width                                                                                                                                                                 | $T_C + 9.9$            | 18.3    | —    | ns   |
| 318 | Read data strobe deassertion width <sup>4</sup><br>$\overline{\text{HACK}}$ read deassertion width                                                                                                                                                             | —                      | 9.9     | —    | ns   |
| 319 | Read data strobe deassertion width <sup>4</sup> after “Last Data Register” reads <sup>5,6</sup> , or between two consecutive CVR, ICR, or ISR reads <sup>7</sup><br>$\overline{\text{HACK}}$ deassertion width after “Last Data Register” reads <sup>5,6</sup> | $2.5 \times T_C + 6.6$ | 27.4    | —    | ns   |
| 320 | Write data strobe assertion width <sup>8</sup><br>$\overline{\text{HACK}}$ write assertion width                                                                                                                                                               | —                      | 13.2    | —    | ns   |
| 321 | Write data strobe deassertion width <sup>8</sup><br>$\overline{\text{HACK}}$ write deassertion width                                                                                                                                                           | $2.5 \times T_C + 6.6$ | 27.4    | —    | ns   |
|     | • after ICR, CVR and “Last Data Register” writes <sup>5</sup>                                                                                                                                                                                                  |                        | 16.5    | —    |      |
|     | • after IVR writes, or                                                                                                                                                                                                                                         |                        | —       | —    |      |
|     | • after TXH:TXM writes (with HBE=0), or<br>• after TXL:TXM writes (with HBE=1)                                                                                                                                                                                 |                        | —       | —    |      |
| 322 | $\overline{\text{HAS}}$ assertion width                                                                                                                                                                                                                        | —                      | 9.9     | —    | ns   |
| 323 | $\overline{\text{HAS}}$ deassertion to data strobe assertion <sup>9</sup>                                                                                                                                                                                      | —                      | 0.0     | —    | ns   |
| 324 | Host data input setup time before write data strobe deassertion <sup>8</sup><br>Host data input setup time before $\overline{\text{HACK}}$ write deassertion                                                                                                   | —                      | 9.9     | —    | ns   |
| 325 | Host data input hold time after write data strobe deassertion <sup>8</sup><br>Host data input hold time after $\overline{\text{HACK}}$ write deassertion                                                                                                       | —                      | 3.3     | —    | ns   |
| 326 | Read data strobe assertion to output data active from high impedance <sup>4</sup><br>$\overline{\text{HACK}}$ read assertion to output data active from high impedance                                                                                         | —                      | 3.3     | —    | ns   |
| 327 | Read data strobe assertion to output data valid <sup>4</sup><br>$\overline{\text{HACK}}$ read assertion to output data valid                                                                                                                                   | —                      | —       | 24.2 | ns   |
| 328 | Read data strobe deassertion to output data high impedance <sup>4</sup><br>$\overline{\text{HACK}}$ read deassertion to output data high impedance                                                                                                             | —                      | —       | 9.9  | ns   |
| 329 | Output data hold time after read data strobe deassertion <sup>4</sup><br>Output data hold time after $\overline{\text{HACK}}$ read deassertion                                                                                                                 | —                      | 3.3     | —    | ns   |
| 330 | $\overline{\text{HCS}}$ assertion to read data strobe deassertion <sup>4</sup>                                                                                                                                                                                 | $T_C + 9.9$            | 18.2    | —    | ns   |
| 331 | $\overline{\text{HCS}}$ assertion to write data strobe deassertion <sup>8</sup>                                                                                                                                                                                | —                      | 9.9     | —    | ns   |
| 332 | $\overline{\text{HCS}}$ assertion to output data valid                                                                                                                                                                                                         | —                      | —       | 19.1 | ns   |

Table 2-18 Host Interface (HDI08) Timing<sup>1, 2</sup> (Continued)

| No. | Characteristics <sup>3</sup>                                                                                                                                                                 | Expression                                       | 120 MHz |       | Unit |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|---------|-------|------|
|     |                                                                                                                                                                                              |                                                  | Min     | Max   |      |
| 333 | $\overline{\text{HCS}}$ hold time after data strobe deassertion <sup>9</sup>                                                                                                                 | —                                                | 0.0     | —     | ns   |
| 334 | Address (AD7–AD0) setup time before $\overline{\text{HAS}}$ deassertion (HMUX=1)                                                                                                             | —                                                | 4.7     | —     | ns   |
| 335 | Address (AD7–AD0) hold time after $\overline{\text{HAS}}$ deassertion (HMUX=1)                                                                                                               | —                                                | 3.3     | —     | ns   |
| 336 | A10–A8 (HMUX=1), A2–A0 (HMUX=0), $\text{HR}/\overline{\text{W}}$ setup time before data strobe assertion <sup>9</sup><br>• Read<br>• Write                                                   | —                                                | 0       | —     | ns   |
|     |                                                                                                                                                                                              |                                                  | 4.7     | —     |      |
| 337 | A10–A8 (HMUX=1), A2–A0 (HMUX=0), $\text{HR}/\overline{\text{W}}$ hold time after data strobe deassertion <sup>9</sup>                                                                        | —                                                | 3.3     | —     | ns   |
| 338 | Delay from read data strobe deassertion to host request assertion for “Last Data Register” read <sup>4, 5, 10</sup>                                                                          | $T_C$                                            | 8.3     | —     | ns   |
| 339 | Delay from write data strobe deassertion to host request assertion for “Last Data Register” write <sup>5, 8, 10</sup>                                                                        | $2 \times T_C$                                   | 16.7    | —     | ns   |
| 340 | Delay from data strobe assertion to host request deassertion for “Last Data Register” read or write (HROD = 0) <sup>5, 9, 10</sup>                                                           | —                                                | —       | 19.1  | ns   |
| 341 | Delay from data strobe assertion to host request deassertion for “Last Data Register” read or write (HROD = 1, open drain Host Request) <sup>5, 9, 10, 11</sup>                              | —                                                | —       | 300.0 | ns   |
| 342 | Delay from DMA $\overline{\text{HACK}}$ deassertion to HOREQ assertion<br>• For “Last Data Register” read <sup>5</sup><br>• For “Last Data Register” write <sup>5</sup><br>• For other cases | $2 \times T_C + 19.1$<br>$1.5 \times T_C + 19.1$ | 35.8    | —     | ns   |
|     |                                                                                                                                                                                              |                                                  | 31.6    | —     |      |
|     |                                                                                                                                                                                              |                                                  | 0.0     | —     |      |
| 343 | Delay from DMA $\overline{\text{HACK}}$ assertion to HOREQ deassertion<br>• HROD = 0 <sup>5</sup>                                                                                            | —                                                | —       | 20.2  | ns   |
| 344 | Delay from DMA $\overline{\text{HACK}}$ assertion to HOREQ deassertion for “Last Data Register” read or write<br>• HROD = 1, open drain Host Request <sup>5, 11</sup>                        | —                                                | —       | 300.0 | ns   |

Table 2-18 Host Interface (HDI08) Timing<sup>1, 2</sup> (Continued)

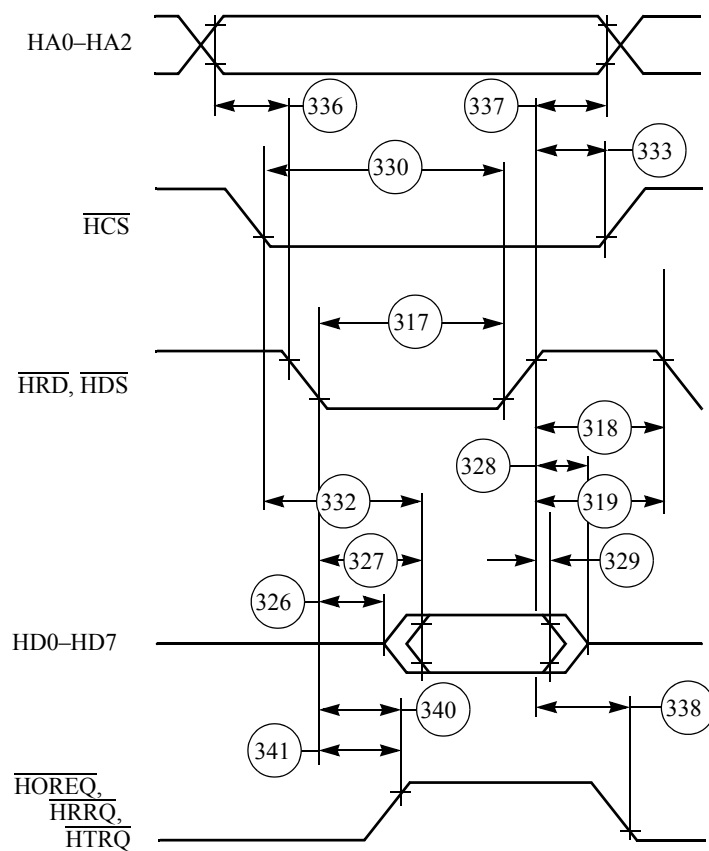
| No.    | Characteristics <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Expression | 120 MHz |     | Unit |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------|-----|------|
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |            | Min     | Max |      |
| Notes: | <div><div>1.</div><div>See <b>Host Port Usage Considerations</b> in the DSP56366 User’s Manual.</div><div>2.</div><div>In the timing diagrams below, the controls pins are drawn as active low. The pin polarity is programmable.</div><div>3.</div><div><math>V_{CC} = 3.3\text{ V} \pm 0.16\text{ V}</math>; <math>T_J = -40^{\circ}\text{C}</math> to <math>+105^{\circ}\text{C}</math>, <math>C_L = 50\text{ pF}</math></div><div>4.</div><div>The read data strobe is HRD in the dual data strobe mode and HDS in the single data strobe mode.</div><div>5.</div><div>The “last data register” is the register at address \$7, which is the last location to be read or written in data transfers.</div><div>6.</div><div>This timing is applicable only if a read from the “last data register” is followed by a read from the RXL, RXM, or RXH registers without first polling RXDF or HREQ bits, or waiting for the assertion of the HOREQ signal.</div><div>7.</div><div>This timing is applicable only if two consecutive reads from one of these registers are executed.</div><div>8.</div><div>The write data strobe is HWR in the dual data strobe mode and HDS in the single data strobe mode.</div><div>9.</div><div>The data strobe is host read (HRD) or host write (HWR) in the dual data strobe mode and host data strobe (HDS) in the single data strobe mode.</div><div>10.</div><div>The host request is HOREQ in the single host request mode and HRRQ and HTRQ in the double host request mode.</div><div>11.</div><div>In this calculation, the host request signal is pulled up by a 4.7 kΩ resistor in the open-drain mode.</div></div> |            |         |     |      |



AA1105

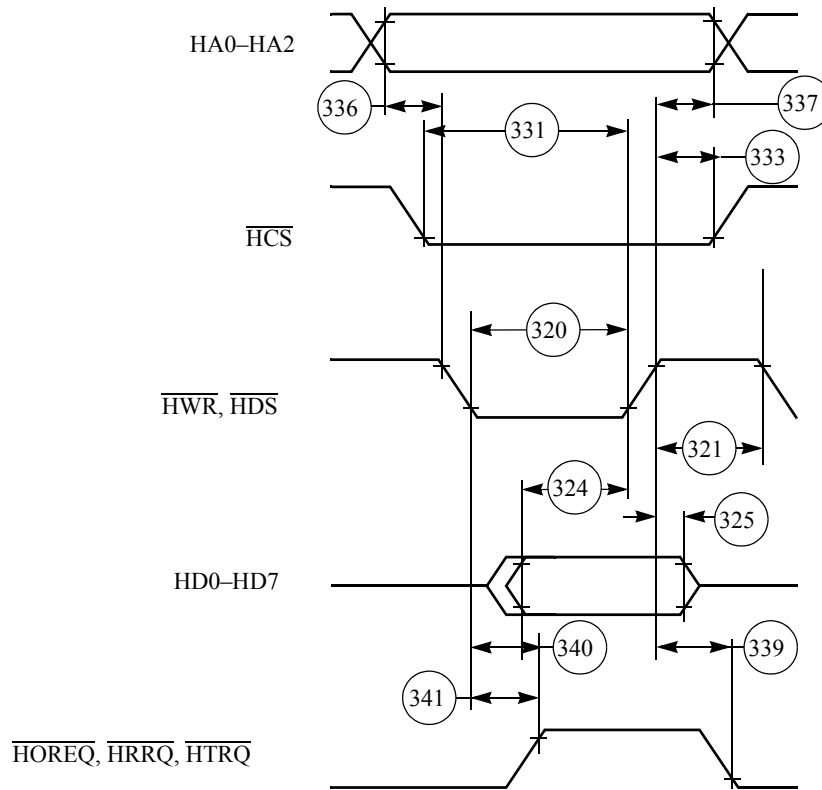
Figure 2-20 Host Interrupt Vector Register (IVR) Read Timing Diagram

## Parallel Host Interface (HDI08) Timing



AA0484

Figure 2-21 Read Timing Diagram, Non-Multiplexed Bus



AA0485

Figure 2-22 Write Timing Diagram, Non-Multiplexed Bus

Parallel Host Interface (HDI08) Timing

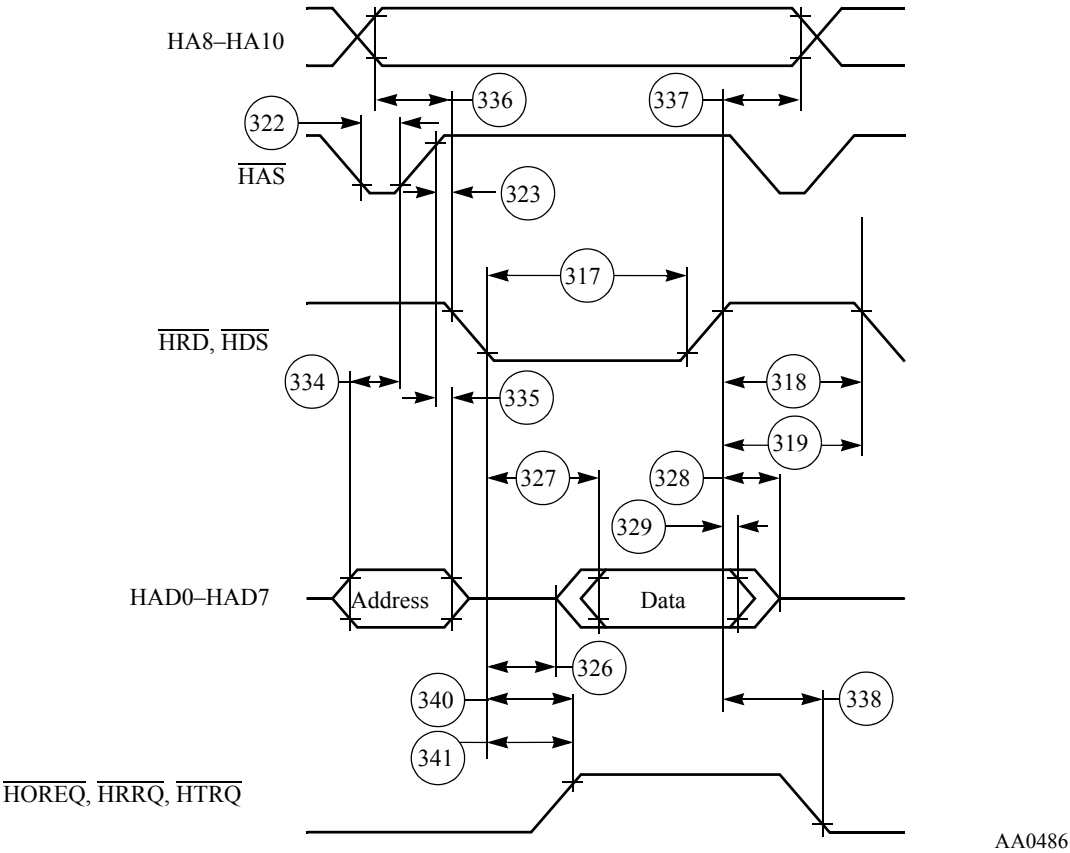


Figure 2-23 Read Timing Diagram, Multiplexed Bus

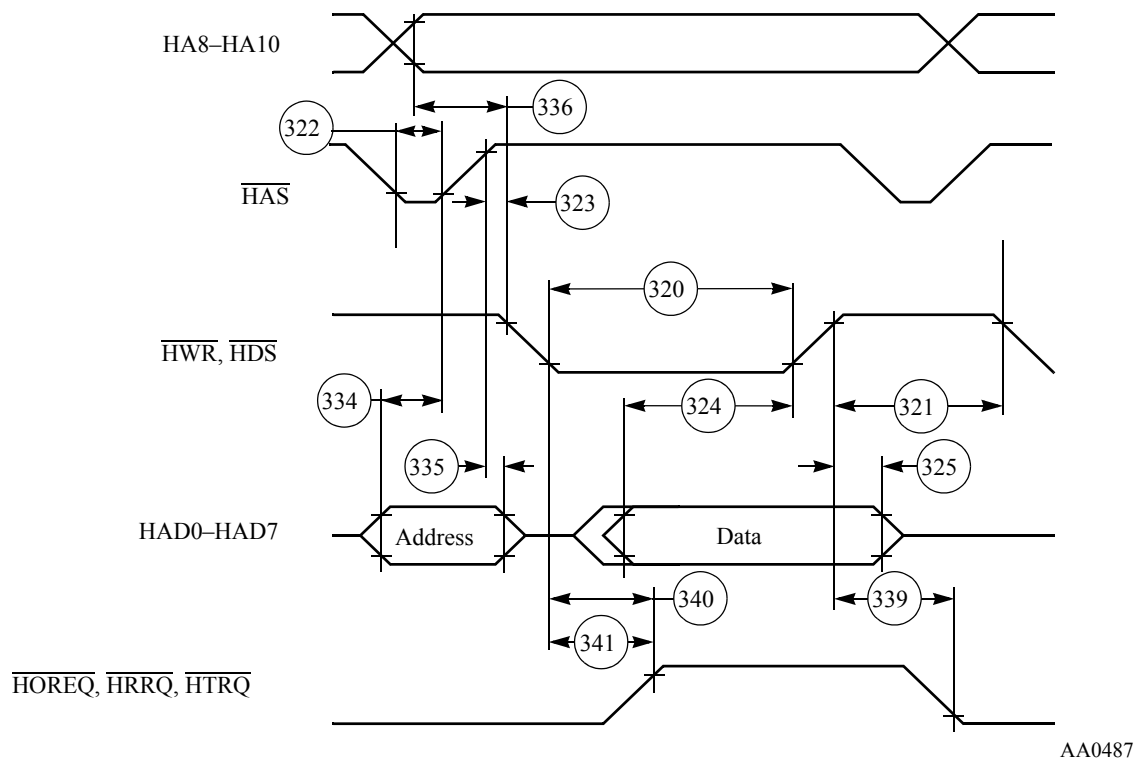


Figure 2-24 Write Timing Diagram, Multiplexed Bus

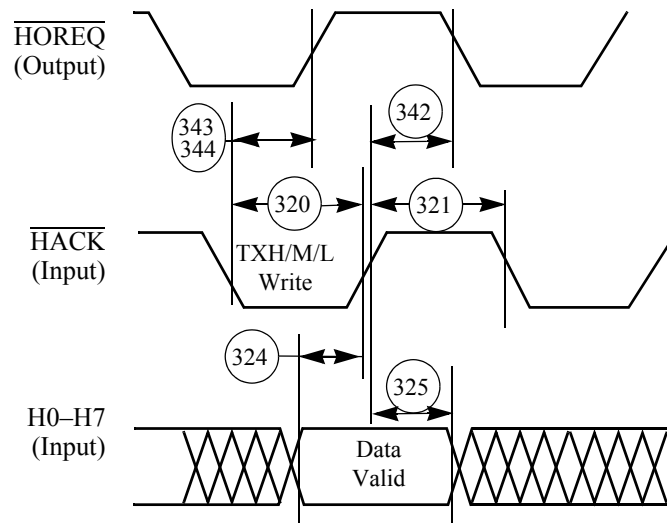


Figure 2-25 Host DMA Write Timing Diagram

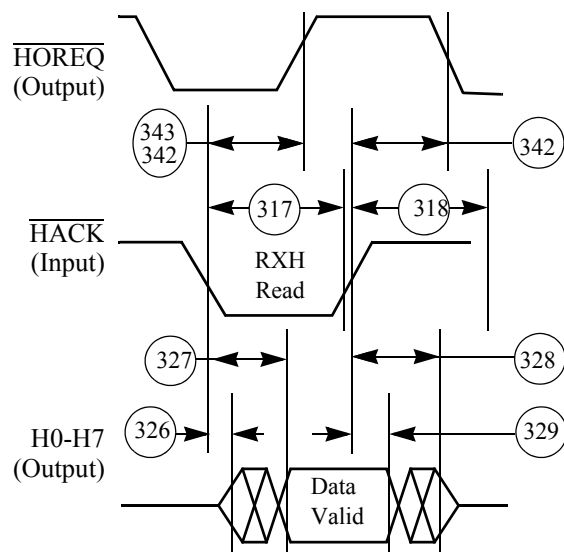


Figure 2-26 Host DMA Read Timing Diagram

## SERIAL HOST INTERFACE SPI PROTOCOL TIMING

Table 2-19 Serial Host Interface SPI Protocol Timing

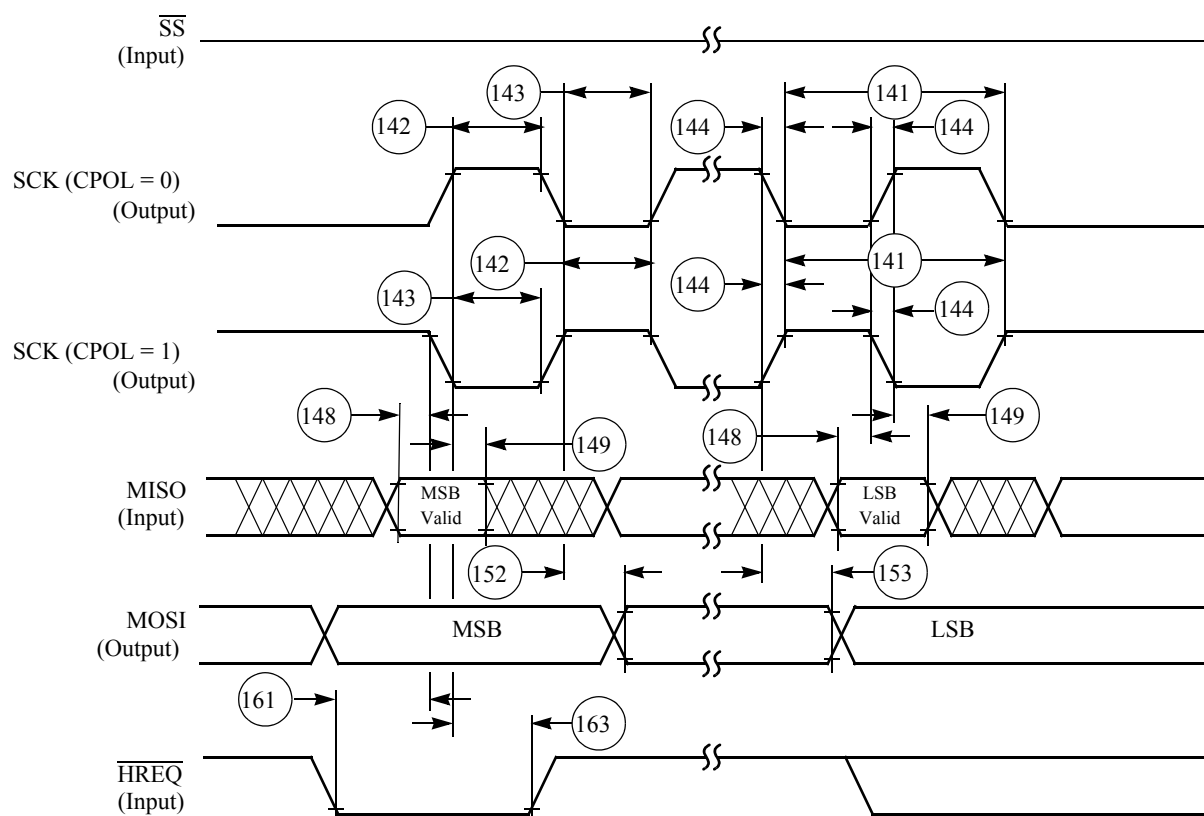
| No. | Characteristics <sup>1</sup>                            | Mode             | Filter Mode | Expression                    | Min   | Max  | Unit |
|-----|---------------------------------------------------------|------------------|-------------|-------------------------------|-------|------|------|
| 140 | Tolerable spike width on clock or data in               | —                | Bypassed    | —                             | —     | 0    | ns   |
|     |                                                         |                  | Narrow      | —                             | —     | 50   | ns   |
|     |                                                         |                  | Wide        | —                             | —     | 100  | ns   |
| 141 | Minimum serial clock cycle = $t_{SPICC}(\text{min})$    | Master           | Bypassed    | $6 \times T_C + 46$           | 96    | —    | ns   |
|     |                                                         |                  | Narrow      | $6 \times T_C + 152$          | 202   | —    | ns   |
|     |                                                         |                  | Wide        | $6 \times T_C + 223$          | 273   | —    | ns   |
| 142 | Serial clock high period                                | Master           | Bypassed    | $0.5 \times t_{SPICC} - 10$   | 38    | —    | ns   |
|     |                                                         |                  | Narrow      | $0.5 \times t_{SPICC} - 10$   | 91    | —    | ns   |
|     |                                                         |                  | Wide        | $0.5 \times t_{SPICC} - 10$   | 126.5 | —    | ns   |
|     |                                                         | Slave            | Bypassed    | $2.5 \times T_C + 12$         | 32.8  | —    | ns   |
|     |                                                         |                  | Narrow      | $2.5 \times T_C + 102$        | 122.8 | —    | ns   |
|     |                                                         |                  | Wide        | $2.5 \times T_C + 189$        | 209.8 | —    | ns   |
| 143 | Serial clock low period                                 | Master           | Bypassed    | $0.5 \times t_{SPICC} - 10$   | 38    | —    | ns   |
|     |                                                         |                  | Narrow      | $0.5 \times t_{SPICC} - 10$   | 91    | —    | ns   |
|     |                                                         |                  | Wide        | $0.5 \times t_{SPICC} - 10$   | 126.5 | —    | ns   |
|     |                                                         | Slave            | Bypassed    | $2.5 \times T_C + 12$         | 32.8  | —    | ns   |
|     |                                                         |                  | Narrow      | $2.5 \times T_C + 102$        | 122.8 | —    | ns   |
|     |                                                         |                  | Wide        | $2.5 \times T_C + 189$        | 209.8 | —    | ns   |
| 144 | Serial clock rise/fall time                             | Master           | —           | —                             | —     | 10   | ns   |
|     |                                                         | Slave            | —           | —                             | —     | 2000 | ns   |
| 146 | $\overline{SS}$ assertion to first SCK edge<br>CPHA = 0 | Slave            | Bypassed    | $3.5 \times T_C + 15$         | 44.2  | —    | ns   |
|     |                                                         |                  | Narrow      | 0                             | 0     | —    | ns   |
|     |                                                         |                  | Wide        | 0                             | 0     | —    | ns   |
|     | CPHA = 1                                                | Slave            | Bypassed    | 10                            | 10    | —    | ns   |
|     |                                                         |                  | Narrow      | 0                             | 0     | —    | ns   |
|     |                                                         |                  | Wide        | 0                             | 0     | —    | ns   |
| 147 | Last SCK edge to $\overline{SS}$ not asserted           | Slave            | Bypassed    | 12                            | 12    | —    | ns   |
|     |                                                         |                  | Narrow      | 102                           | 102   | —    | ns   |
|     |                                                         |                  | Wide        | 189                           | 189   | —    | ns   |
| 148 | Data input valid to SCK edge (data input set-up time)   | Master/<br>Slave | Bypassed    | 0                             | 0     | —    | ns   |
|     |                                                         |                  | Narrow      | $\text{MAX}\{(20 - T_C), 0\}$ | 11.7  | —    | ns   |
|     |                                                         |                  | Wide        | $\text{MAX}\{(40 - T_C), 0\}$ | 31.7  | —    | ns   |

## Serial Host Interface SPI Protocol Timing

Table 2-19 Serial Host Interface SPI Protocol Timing (Continued)

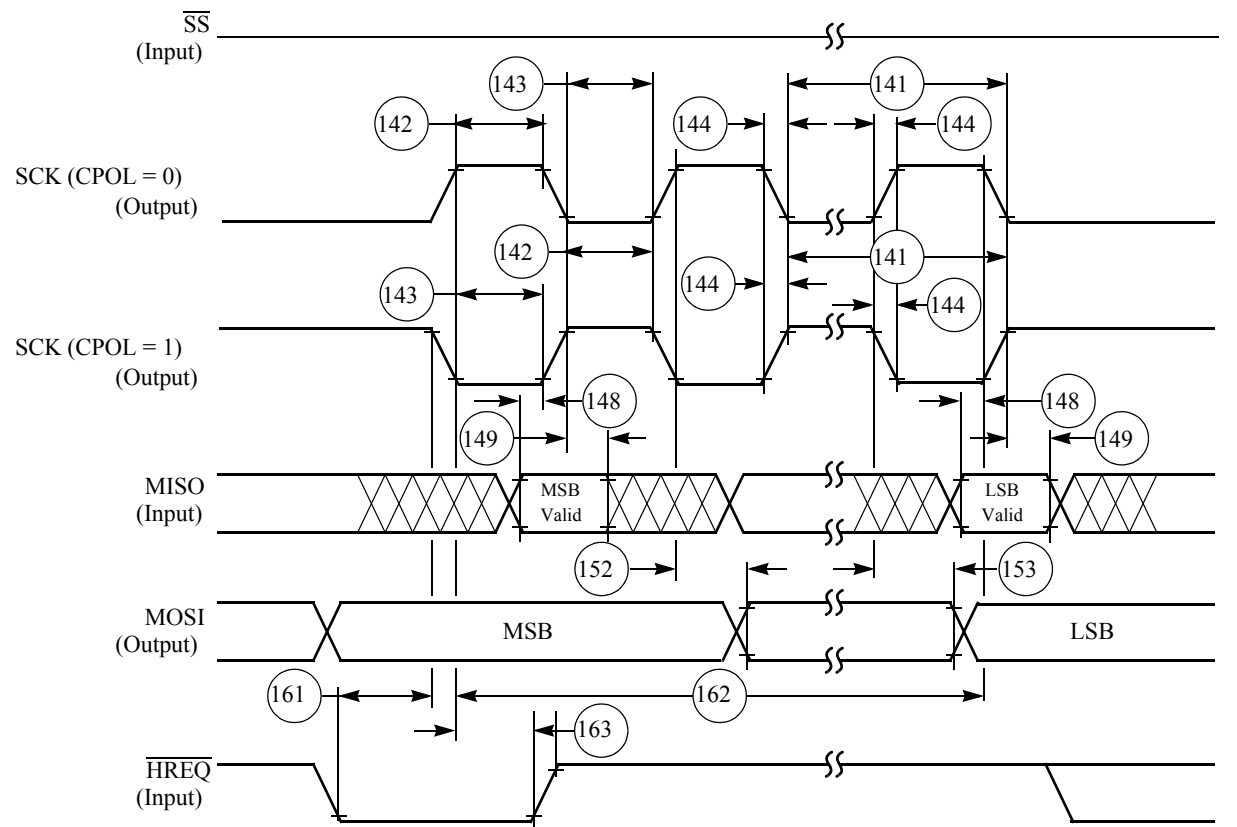
| No. | Characteristics <sup>1</sup>                                                                              | Mode         | Filter Mode                | Expression                                                                                                                                   | Min                     | Max                    | Unit           |
|-----|-----------------------------------------------------------------------------------------------------------|--------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------------------|----------------|
| 149 | SCK last sampling edge to data input not valid                                                            | Master/Slave | Bypassed<br>Narrow<br>Wide | $2.5 \times T_C + 10$<br>$2.5 \times T_C + 30$<br>$2.5 \times T_C + 50$                                                                      | 30.8<br>50.8<br>70.8    | —<br>—<br>—            | ns<br>ns<br>ns |
| 150 | $\overline{SS}$ assertion to data out active                                                              | Slave        | —                          | 2                                                                                                                                            | 2                       | —                      | ns             |
| 151 | $\overline{SS}$ deassertion to data high impedance <sup>2</sup>                                           | Slave        | —                          | 9                                                                                                                                            | —                       | 9                      | ns             |
| 152 | SCK edge to data out valid (data out delay time)                                                          | Master/Slave | Bypassed<br>Narrow<br>Wide | $2 \times T_C + 33$<br>$2 \times T_C + 123$<br>$2 \times T_C + 210$                                                                          | —<br>—<br>—             | 49.7<br>139.7<br>226.7 | ns<br>ns<br>ns |
| 153 | SCK edge to data out not valid (data out hold time)                                                       | Master/Slave | Bypassed<br>Narrow<br>Wide | $T_C + 5$<br>$T_C + 55$<br>$T_C + 106$                                                                                                       | 13.3<br>63.3<br>114.3   | —<br>—<br>—            | ns<br>ns<br>ns |
| 154 | $\overline{SS}$ assertion to data out valid (CPHA = 0)                                                    | Slave        | —                          | $T_C + 33$                                                                                                                                   | —                       | 41.3                   | ns             |
| 157 | First SCK sampling edge to $\overline{HREQ}$ output deassertion                                           | Slave        | Bypassed<br>Narrow<br>Wide | $2.5 \times T_C + 30$<br>$2.5 \times T_C + 120$<br>$2.5 \times T_C + 217$                                                                    | —<br>—<br>—             | 50.8<br>140.8<br>237.8 | ns<br>ns<br>ns |
| 158 | Last SCK sampling edge to $\overline{HREQ}$ output not deasserted (CPHA = 1)                              | Slave        | Bypassed<br>Narrow<br>Wide | $2.5 \times T_C + 30$<br>$2.5 \times T_C + 80$<br>$2.5 \times T_C + 136$                                                                     | 50.8<br>100.8<br>156.8  | —<br>—<br>—            | ns<br>ns<br>ns |
| 159 | $\overline{SS}$ deassertion to $\overline{HREQ}$ output not deasserted (CPHA = 0)                         | Slave        | —                          | $2.5 \times T_C + 30$                                                                                                                        | 50.8                    | —                      | ns             |
| 160 | $\overline{SS}$ deassertion pulse width (CPHA = 0)                                                        | Slave        | —                          | $T_C + 6$                                                                                                                                    | 14.3                    | —                      | ns             |
| 161 | $\overline{HREQ}$ in assertion to first SCK edge                                                          | Master       | Bypassed<br>Narrow<br>Wide | $0.5 \times t_{SPICC} + 2.5 \times T_C + 43$<br>$0.5 \times t_{SPICC} + 2.5 \times T_C + 43$<br>$0.5 \times t_{SPICC} + 2.5 \times T_C + 43$ | 111.8<br>164.8<br>200.3 | —<br>—<br>—            | ns<br>ns<br>ns |
| 162 | $\overline{HREQ}$ in deassertion to last SCK sampling edge ( $\overline{HREQ}$ in set-up time) (CPHA = 1) | Master       | —                          | 0                                                                                                                                            | 0                       | —                      | ns             |
| 163 | First SCK edge to $\overline{HREQ}$ in not asserted ( $\overline{HREQ}$ in hold time)                     | Master       | —                          | 0                                                                                                                                            | 0                       | —                      | ns             |

Notes: 1.  $V_{CC} = 3.16 \text{ V} \pm 0.16 \text{ V}$ ;  $T_J = -40^\circ\text{C}$  to  $+105^\circ\text{C}$ ,  $C_L = 50 \text{ pF}$   
2. Periodically sampled, not 100% tested



AA0271

Figure 2-27 SPI Master Timing (CPHA = 0)



AA0272

Figure 2-28 SPI Master Timing (CPHA = 1)

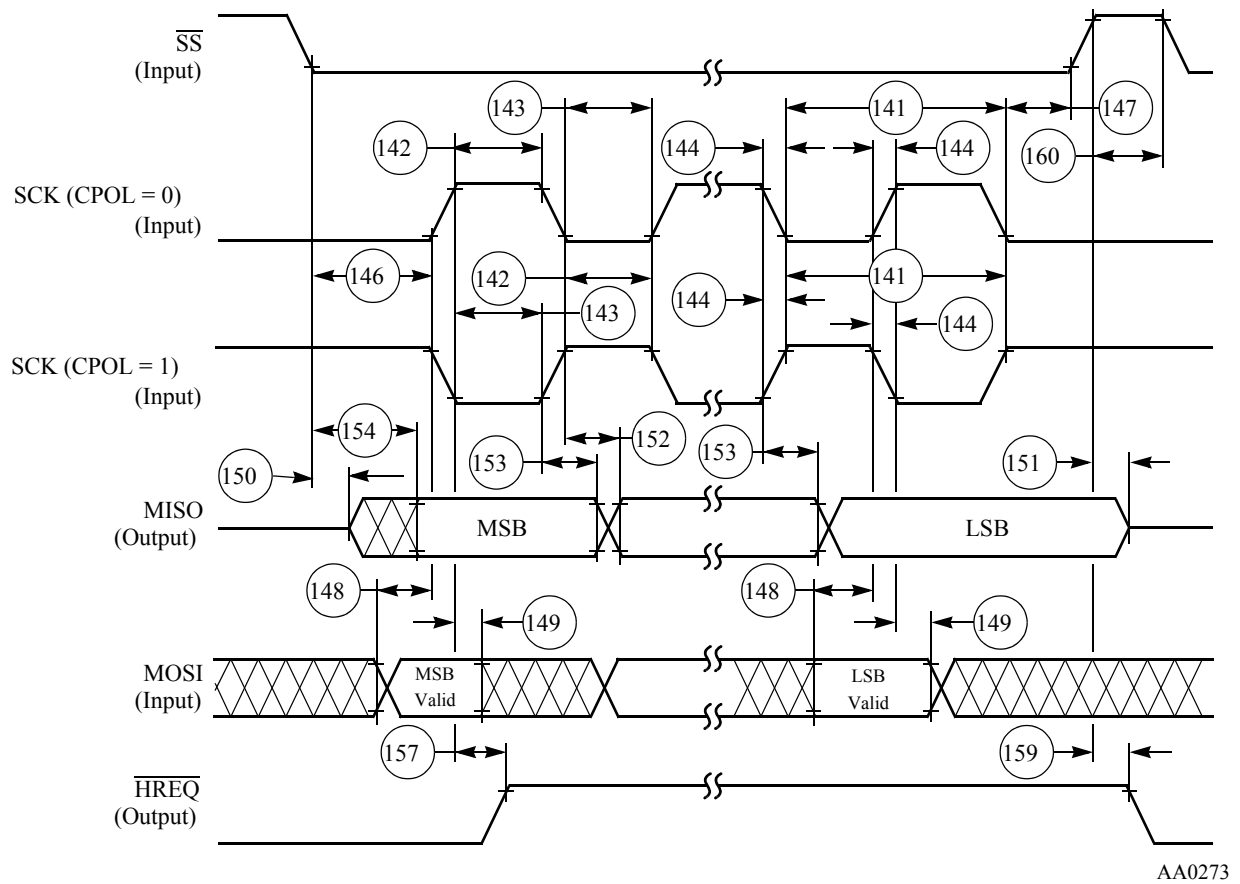
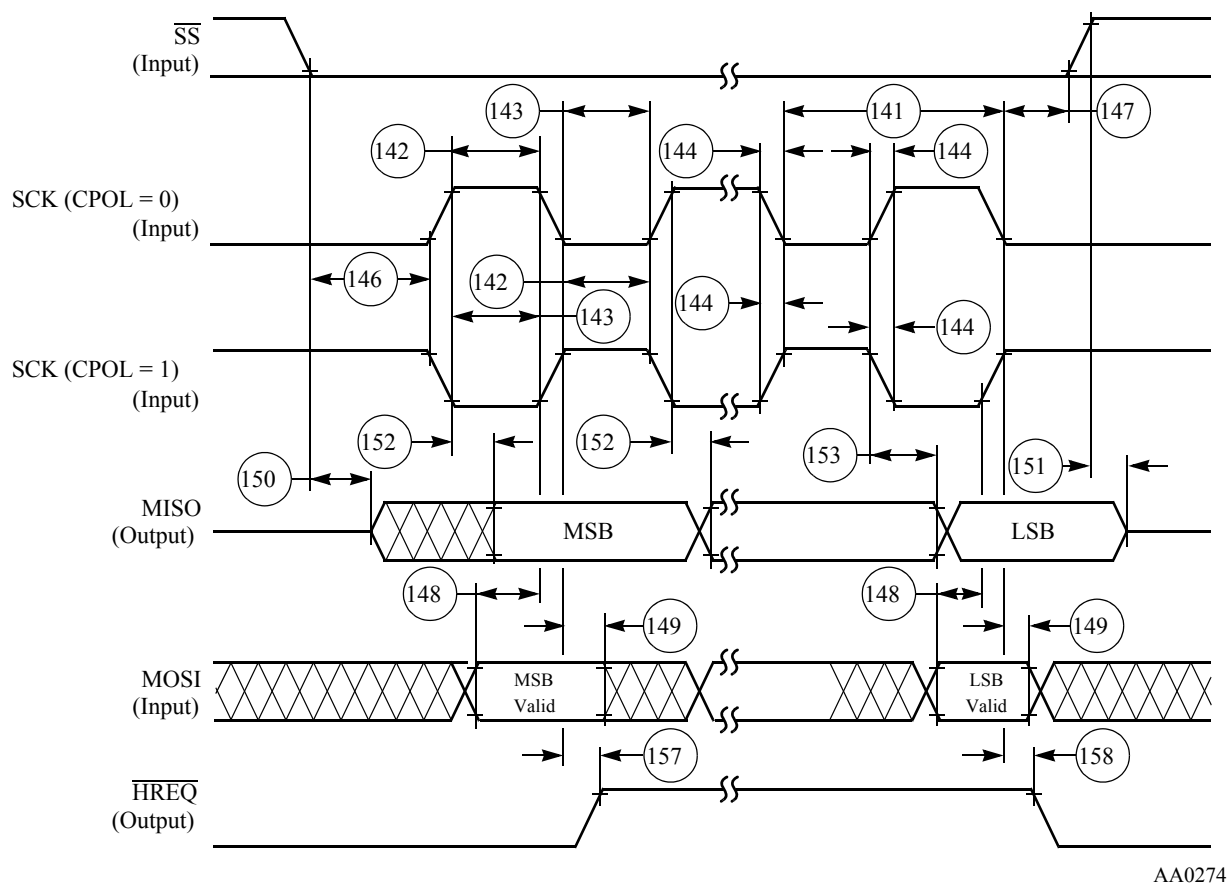


Figure 2-29 SPI Slave Timing (CPHA = 0)



AA0274

Figure 2-30 SPI Slave Timing (CPHA = 1)

SERIAL HOST INTERFACE (SHI) I<sup>2</sup>C PROTOCOL TIMINGTable 2-20 SHI I<sup>2</sup>C Protocol Timing

| No. | Characteristics <sup>1,2,3</sup>                                               | Symbol/<br>Expression    | Standard Mode <sup>4</sup> |       | Fast Mode <sup>5</sup>    |       | Unit |
|-----|--------------------------------------------------------------------------------|--------------------------|----------------------------|-------|---------------------------|-------|------|
|     |                                                                                |                          | Min                        | Max   | Min                       | Max   |      |
|     | Tolerable spike width on SCL or SDA                                            |                          |                            |       |                           |       |      |
|     | Filters bypassed                                                               | —                        | —                          | 0     | —                         | 0     | ns   |
|     | Narrow filters enabled                                                         |                          | —                          | 50    | —                         | 50    | ns   |
|     | Wide filters enabled                                                           |                          | —                          | 100   | —                         | 100   | ns   |
| 171 | SCL clock frequency                                                            | F <sub>SCL</sub>         | —                          | 100   | —                         | 400   | kHz  |
| 171 | SCL clock cycle                                                                | T <sub>SCL</sub>         | 10                         | —     | 2.5                       | —     | μs   |
| 172 | Bus free time                                                                  | T <sub>BUF</sub>         | 4.7                        | —     | 1.3                       | —     | μs   |
| 173 | Start condition set-up time                                                    | T <sub>SU;STA</sub>      | 4.7                        | —     | 0.6                       | —     | μs   |
| 174 | Start condition hold time                                                      | T <sub>HD;STA</sub>      | 4.0                        | —     | 0.6                       | —     | μs   |
| 175 | SCL low period                                                                 | T <sub>LOW</sub>         | 4.7                        | —     | 1.3                       | —     | μs   |
| 176 | SCL high period                                                                | T <sub>HIGH</sub>        | 4.0                        | —     | 1.3                       | —     | μs   |
| 177 | SCL and SDA rise time                                                          | T <sub>R</sub>           | —                          | 1000  | 20 + 0.1 × C <sub>b</sub> | 300   | ns   |
| 178 | SCL and SDA fall time                                                          | T <sub>F</sub>           | —                          | 300   | 20 + 0.1 × C <sub>b</sub> | 300   | ns   |
| 179 | Data set-up time                                                               | T <sub>SU;DAT</sub>      | 250                        | —     | 100                       | —     | ns   |
| 180 | Data hold time                                                                 | T <sub>HD;DAT</sub>      | 0.0                        | —     | 0.0                       | 0.9   | μs   |
| 181 | DSP clock frequency                                                            | F <sub>DSP</sub>         |                            |       |                           |       |      |
|     | Filters bypassed                                                               |                          | 10.6                       | —     | 28.5                      | —     | MHz  |
|     | Narrow filters enabled                                                         |                          | 11.8                       | —     | 39.7                      | —     | MHz  |
|     | Wide filters enabled                                                           |                          | 13.1                       | —     | 61.0                      | —     | MHz  |
| 182 | SCL low to data out valid                                                      | T <sub>VD;DAT</sub>      | —                          | 3.4   | —                         | 0.9   | μs   |
| 183 | Stop condition set-up time                                                     | T <sub>SU;STO</sub>      | 4.0                        | —     | 0.6                       | —     | μs   |
| 184 | $\overline{\text{HREQ}}$ in deassertion to last SCL edge (HREQ in set-up time) | t <sub>SU;RQI</sub>      | 0.0                        | —     | 0.0                       | —     | ns   |
| 186 | First SCL sampling edge to $\overline{\text{HREQ}}$ output deassertion         | T <sub>NG;RQO</sub>      |                            |       |                           |       |      |
|     | Filters bypassed                                                               | 2 × T <sub>C</sub> + 30  | —                          | 46.7  | —                         | 46.7  | ns   |
|     | Narrow filters enabled                                                         | 2 × T <sub>C</sub> + 120 | —                          | 136.7 | —                         | 136.7 |      |
|     | Wide filters enabled                                                           | 2 × T <sub>C</sub> + 208 | —                          | 224.7 | —                         | 224.7 |      |
| 187 | Last SCL edge to $\overline{\text{HREQ}}$ output not deasserted                | T <sub>AS;RQO</sub>      |                            |       |                           |       |      |
|     | Filters bypassed                                                               | 2 × T <sub>C</sub> + 30  | 46.7                       | —     | 46.7                      | —     | ns   |
|     | Narrow filters enabled                                                         | 2 × T <sub>C</sub> + 80  | 96.7                       | —     | 96.7                      | —     |      |
|     | Wide filters enabled                                                           | 2 × T <sub>C</sub> + 135 | 151.6                      | —     | 151.6                     | —     |      |

Table 2-20 SHI I<sup>2</sup>C Protocol Timing (Continued)

| No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Characteristics <sup>1,2,3</sup>                                                                    | Symbol/<br>Expression                                                | Standard Mode <sup>4</sup> |     | Fast Mode <sup>5</sup> |     | Unit |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------|-----|------------------------|-----|------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                     |                                                                      | Min                        | Max | Min                    | Max |      |
| 188                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | $\overline{\text{HREQ}}$ in assertion to first SCL edge                                             |                                                                      |                            |     |                        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Filters bypassed                                                                                    | $T_{\text{AS;RQI}}$                                                  | 4440                       | —   | 1041                   | —   | ns   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Narrow filters enabled                                                                              | $0.5 \times T_{\text{I}^2\text{CCP}} - 0.5 \times T_{\text{C}} - 21$ | 4373                       | —   | 999                    | —   |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Wide filters enabled                                                                                |                                                                      | 4373                       | —   | 958                    | —   |      |
| 189                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | First SCL edge to $\overline{\text{HREQ}}$ in not asserted ( $\overline{\text{HREQ}}$ in hold time) | $t_{\text{HO;RQI}}$                                                  | 0.0                        | —   | 0.0                    | —   | ns   |
| Notes: 1. $V_{\text{CC}} = 3.16 \text{ V} \pm 0.16 \text{ V}$ ; $T_{\text{J}} = -40^{\circ}\text{C}$ to $+105^{\circ}\text{C}$<br>2. Pull-up resistor: $R_{\text{P}} (\text{min}) = 1.5 \text{ k}\Omega$<br>3. Capacitive load: $C_{\text{b}} (\text{max}) = 400 \text{ pF}$<br>4. It is recommended to enable the wide filters when operating in the I <sup>2</sup> C Standard Mode.<br>5. It is recommended to enable the narrow filters when operating in the I <sup>2</sup> C Fast Mode. |                                                                                                     |                                                                      |                            |     |                        |     |      |

## Programming the Serial Clock

The programmed serial clock cycle,  $T_{\text{I}^2\text{CCP}}$ , is specified by the value of the HDM[7:0] and HRS bits of the HCKR (SHI clock control register).

The expression for  $T_{\text{I}^2\text{CCP}}$  is

$$T_{\text{I}^2\text{CCP}} = [T_{\text{C}} \times 2 \times (\text{HDM}[7:0] + 1) \times (7 \times (1 - \text{HRS}) + 1)]$$

where

- HRS is the prescaler rate select bit. When HRS is cleared, the fixed divide-by-eight prescaler is operational. When HRS is set, the prescaler is bypassed.
- HDM[7:0] are the divider modulus select bits. A divide ratio from 1 to 256 (HDM[7:0] = \$00 to \$FF) may be selected.

In I<sup>2</sup>C mode, the user may select a value for the programmed serial clock cycle from

$$6 \times T_{\text{C}} \quad (\text{if HDM}[7:0] = \$02 \text{ and HRS} = 1)$$

to

$$4096 \times T_{\text{C}} \quad (\text{if HDM}[7:0] = \$FF \text{ and HRS} = 0)$$

The programmed serial clock cycle ( $T_{I^2CCP}$ ), SCL rise time ( $T_R$ ), and the filters selected should be chosen in order to achieve the desired SCL serial clock cycle ( $T_{SCL}$ ), as shown in Table 2-21.

**Table 2-21 SCL Serial Clock Cycle ( $T_{SCL}$ ) generated as Master**

|                        |                                                    |
|------------------------|----------------------------------------------------|
| Filters bypassed       | $T_{I^2CCP} + 2.5 \times T_C + 45\text{ns} + T_R$  |
| Narrow filters enabled | $T_{I^2CCP} + 2.5 \times T_C + 135\text{ns} + T_R$ |
| Wide filters enabled   | $T_{I^2CCP} + 2.5 \times T_C + 223\text{ns} + T_R$ |

EXAMPLE:

For DSP clock frequency of 120 MHz (i.e.  $T_C = 8.33\text{ns}$ ), operating in a standard mode I<sup>2</sup>C environment ( $F_{SCL} = 100\text{ kHz}$  (i.e.  $T_{SCL} = 10\mu\text{s}$ ),  $T_R = 1000\text{ns}$ ), with wide filters enabled:

$$T_{I^2CCP} = 10\mu\text{s} - 2.5 \times 8.33\text{ns} - 223\text{ns} - 1000\text{ns} = 8756\text{ns}$$

Choosing  $HRS = 0$  gives

$$HDM[7:0] = 8756\text{ns} / (2 \times 8.33\text{ns} \times 8) - 1 = 64.67$$

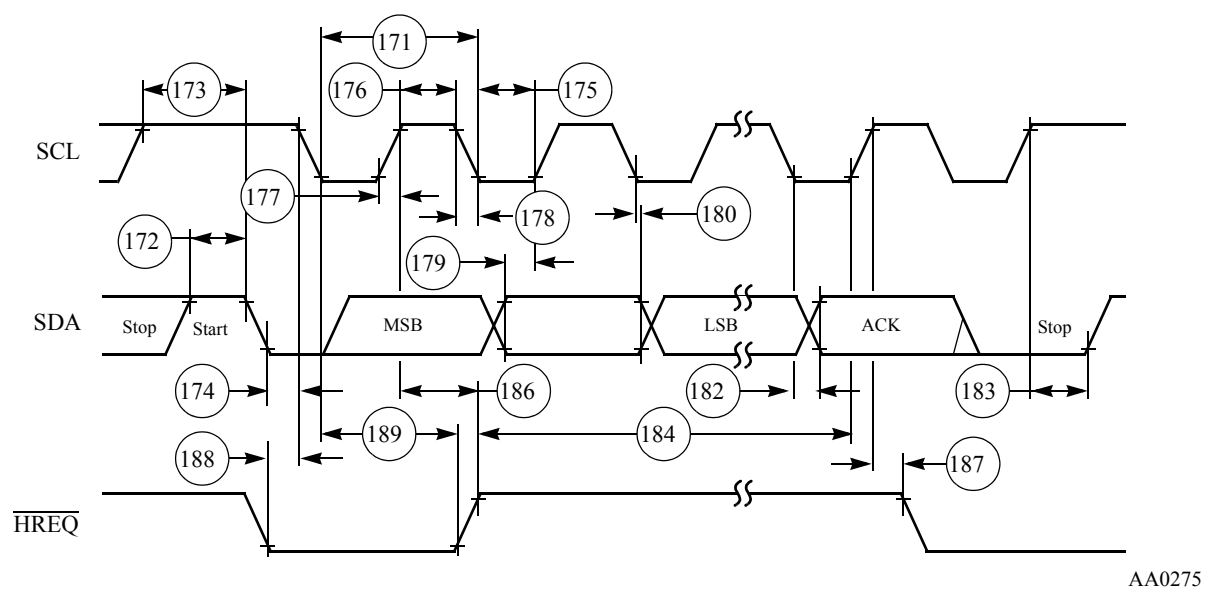
Thus the  $HDM[7:0]$  value should be programmed to \$41 (=65).

The resulting  $T_{I^2CCP}$  will be:

$$T_{I^2CCP} = [T_C \times 2 \times (HDM[7:0] + 1) \times (7 \times (1 - HRS) + 1)]$$

$$T_{I^2CCP} = [8.33\text{ns} \times 2 \times (65 + 1) \times (7 \times (1 - 0) + 1)]$$

$$T_{I^2CCP} = [8.33\text{ns} \times 2 \times 66 \times 8] = 8796.48\text{ns}$$

Figure 2-31 I<sup>2</sup>C Timing

## ENHANCED SERIAL AUDIO INTERFACE TIMING

**Table 2-22 Enhanced Serial Audio Interface Timing**

| No. | Characteristics <sup>1, 2, 3</sup>                                   | Symbol      | Expression                                                            | Min                  | Max          | Condition <sup>4</sup> | Unit |
|-----|----------------------------------------------------------------------|-------------|-----------------------------------------------------------------------|----------------------|--------------|------------------------|------|
| 430 | Clock cycle <sup>5</sup>                                             | $t_{SSICC}$ | $4 \times T_C$<br>$3 \times T_C$<br>$TXC:\max[3 \times t_c; t_{454}]$ | 33.3<br>25.0<br>27.2 | —<br>—<br>—  | i ck<br>x ck<br>x ck   | ns   |
| 431 | Clock high period<br>• For internal clock<br>• For external clock    | —           | $2 \times T_C - 10.0$<br>$1.5 \times T_C$                             | 6.7<br>12.5          | —<br>—       |                        | ns   |
| 432 | Clock low period<br>• For internal clock<br>• For external clock     | —           | $2 \times T_C - 10.0$<br>$1.5 \times T_C$                             | 6.7<br>12.5          | —<br>—       |                        | ns   |
| 433 | RXC rising edge to FSR out (bl) high                                 | —           | —                                                                     | —<br>—               | 37.0<br>22.0 | x ck<br>i ck a         | ns   |
| 434 | RXC rising edge to FSR out (bl) low                                  | —           | —                                                                     | —<br>—               | 37.0<br>22.0 | x ck<br>i ck a         | ns   |
| 435 | RXC rising edge to FSR out (wr) high <sup>6</sup>                    | —           | —                                                                     | —<br>—               | 39.0<br>24.0 | x ck<br>i ck a         | ns   |
| 436 | RXC rising edge to FSR out (wr) low <sup>6</sup>                     | —           | —                                                                     | —<br>—               | 39.0<br>24.0 | x ck<br>i ck a         | ns   |
| 437 | RXC rising edge to FSR out (wl) high                                 | —           | —                                                                     | —<br>—               | 36.0<br>21.0 | x ck<br>i ck a         | ns   |
| 438 | RXC rising edge to FSR out (wl) low                                  | —           | —                                                                     | —<br>—               | 37.0<br>22.0 | x ck<br>i ck a         | ns   |
| 439 | Data in setup time before RXC (SCK in synchronous mode) falling edge | —           | —                                                                     | 0.0<br>19.0          | —<br>—       | x ck<br>i ck           | ns   |
| 440 | Data in hold time after RXC falling edge                             | —           | —                                                                     | 5.0<br>3.0           | —<br>—       | x ck<br>i ck           | ns   |
| 441 | FSR input (bl, wr) high before RXC falling edge <sup>6</sup>         | —           | —                                                                     | 23.0<br>1.0          | —<br>—       | x ck<br>i ck a         | ns   |
| 442 | FSR input (wl) high before RXC falling edge                          | —           | —                                                                     | 1.0<br>23.0          | —<br>—       | x ck<br>i ck a         | ns   |
| 443 | FSR input hold time after RXC falling edge                           | —           | —                                                                     | 3.0<br>0.0           | —<br>—       | x ck<br>i ck a         | ns   |
| 444 | Flags input setup before RXC falling edge                            | —           | —                                                                     | 0.0<br>19.0          | —<br>—       | x ck<br>i ck s         | ns   |
| 445 | Flags input hold time after RXC falling edge                         | —           | —                                                                     | 6.0<br>0.0           | —<br>—       | x ck<br>i ck s         | ns   |
| 446 | TXC rising edge to FST out (bl) high                                 | —           | —                                                                     | —<br>—               | 29.0<br>15.0 | x ck<br>i ck           | ns   |
| 447 | TXC rising edge to FST out (bl) low                                  | —           | —                                                                     | —<br>—               | 31.0<br>17.0 | x ck<br>i ck           | ns   |
| 448 | TXC rising edge to FST out (wr) high <sup>6</sup>                    | —           | —                                                                     | —<br>—               | 31.0<br>17.0 | x ck<br>i ck           | ns   |
| 449 | TXC rising edge to FST out (wr) low <sup>6</sup>                     | —           | —                                                                     | —<br>—               | 33.0<br>19.0 | x ck<br>i ck           | ns   |

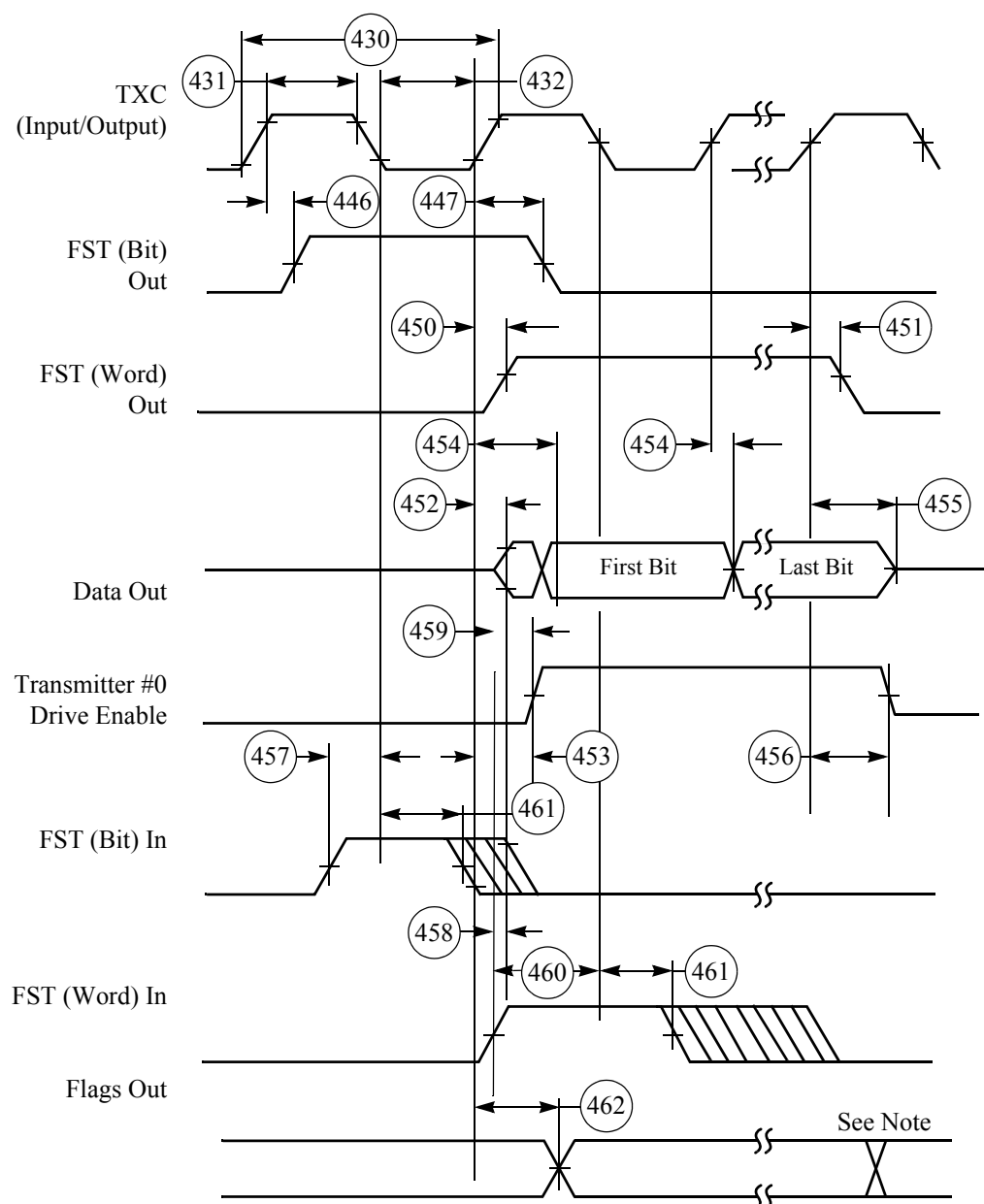
## Enhanced Serial Audio Interface Timing

Table 2-22 Enhanced Serial Audio Interface Timing (Continued)

| No. | Characteristics <sup>1, 2, 3</sup>                                      | Symbol | Expression                    | Min         | Max          | Condition <sup>4</sup> | Unit |
|-----|-------------------------------------------------------------------------|--------|-------------------------------|-------------|--------------|------------------------|------|
| 450 | TXC rising edge to FST out (wl) high                                    | —      | —                             | —<br>—      | 30.0<br>16.0 | x ck<br>i ck           | ns   |
| 451 | TXC rising edge to FST out (wl) low                                     | —      | —                             | —<br>—      | 31.0<br>17.0 | x ck<br>i ck           | ns   |
| 452 | TXC rising edge to data out enable from high impedance                  | —      | —                             | —<br>—      | 31.0<br>17.0 | x ck<br>i ck           | ns   |
| 453 | TXC rising edge to transmitter #0 drive enable assertion                | —      | —                             | —<br>—      | 34.0<br>20.0 | x ck<br>i ck           | ns   |
| 454 | TXC rising edge to data out valid                                       | —      | $23 + 0.5 \times T_C$<br>21.0 | —<br>—      | 27.2<br>21.0 | x ck<br>i ck           | ns   |
| 455 | TXC rising edge to data out high impedance <sup>7</sup>                 | —      | —                             | —<br>—      | 31.0<br>16.0 | x ck<br>i ck           | ns   |
| 456 | TXC rising edge to transmitter #0 drive enable deassertion <sup>7</sup> | —      | —                             | —<br>—      | 34.0<br>20.0 | x ck<br>i ck           | ns   |
| 457 | FST input (bl, wr) setup time before TXC falling edge <sup>6</sup>      | —      | —                             | 2.0<br>21.0 | —<br>—       | x ck<br>i ck           | ns   |
| 458 | FST input (wl) to data out enable from high impedance                   | —      | —                             | —           | 27.0         | —                      | ns   |
| 459 | FST input (wl) to transmitter #0 drive enable assertion                 | —      | —                             | —           | 31.0         | —                      | ns   |
| 460 | FST input (wl) setup time before TXC falling edge                       | —      | —                             | 2.0<br>21.0 | —<br>—       | x ck<br>i ck           | ns   |
| 461 | FST input hold time after TXC falling edge                              | —      | —                             | 4.0<br>0.0  | —<br>—       | x ck<br>i ck           | ns   |
| 462 | Flag output valid after TXC rising edge                                 | —      | —                             | —<br>—      | 32.0<br>18.0 | x ck<br>i ck           | ns   |
| 463 | HCKR/HCKT clock cycle                                                   | —      | —                             | 40.0        | —            |                        | ns   |
| 464 | HCKT input rising edge to TXC output                                    | —      | —                             | —           | 27.5         |                        | ns   |
| 465 | HCKR input rising edge to RXC output                                    | —      | —                             | —           | 27.5         |                        | ns   |

Table 2-22 Enhanced Serial Audio Interface Timing (Continued)

| No.    | Characteristics <sup>1, 2, 3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Symbol | Expression | Min | Max | Condition <sup>4</sup> | Unit |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------|-----|-----|------------------------|------|
| Notes: | <ol style="list-style-type: none"> <li><math>V_{CC} = 3.16 \text{ V} \pm 0.16 \text{ V}</math>; <math>T_J = -40^\circ\text{C}</math> to <math>+105^\circ\text{C}</math>, <math>C_L = 50 \text{ pF}</math></li> <li> <ul style="list-style-type: none"> <li>i ck = internal clock</li> <li>x ck = external clock</li> <li>i ck a = internal clock, asynchronous mode<br/>(asynchronous implies that TXC and RXC are two different clocks)</li> <li>i ck s = internal clock, synchronous mode<br/>(synchronous implies that TXC and RXC are the same clock)</li> </ul> </li> <li> <ul style="list-style-type: none"> <li>bl = bit length</li> <li>wl = word length</li> <li>wr = word length relative</li> </ul> </li> <li> <ul style="list-style-type: none"> <li>TXC(SCKT pin) = transmit clock</li> <li>RXC(SCKR pin) = receive clock</li> <li>FST(FST pin) = transmit frame sync</li> <li>FSR(FSR pin) = receive frame sync</li> <li>HCKT(HCKT pin) = transmit high frequency clock</li> <li>HCKR(HCKR pin) = receive high frequency clock</li> </ul> </li> <li>For the internal clock, the external clock cycle is defined by <math>I_{cyc}</math> and the ESAI control register.</li> <li>The word-relative frame sync signal waveform relative to the clock operates in the same manner as the bit-length frame sync signal waveform, but spreads from one serial clock before first bit clock (same as bit length frame sync signal), until the one before last bit clock of the first word in frame.</li> <li>Periodically sampled and not 100% tested</li> </ol> |        |            |     |     |                        |      |



Note: In network mode, output flag transitions can occur at the start of each time slot within the frame. In normal mode, the output flag state is asserted for the entire frame period.

AA0490

Figure 2-32 ESAI Transmitter Timing

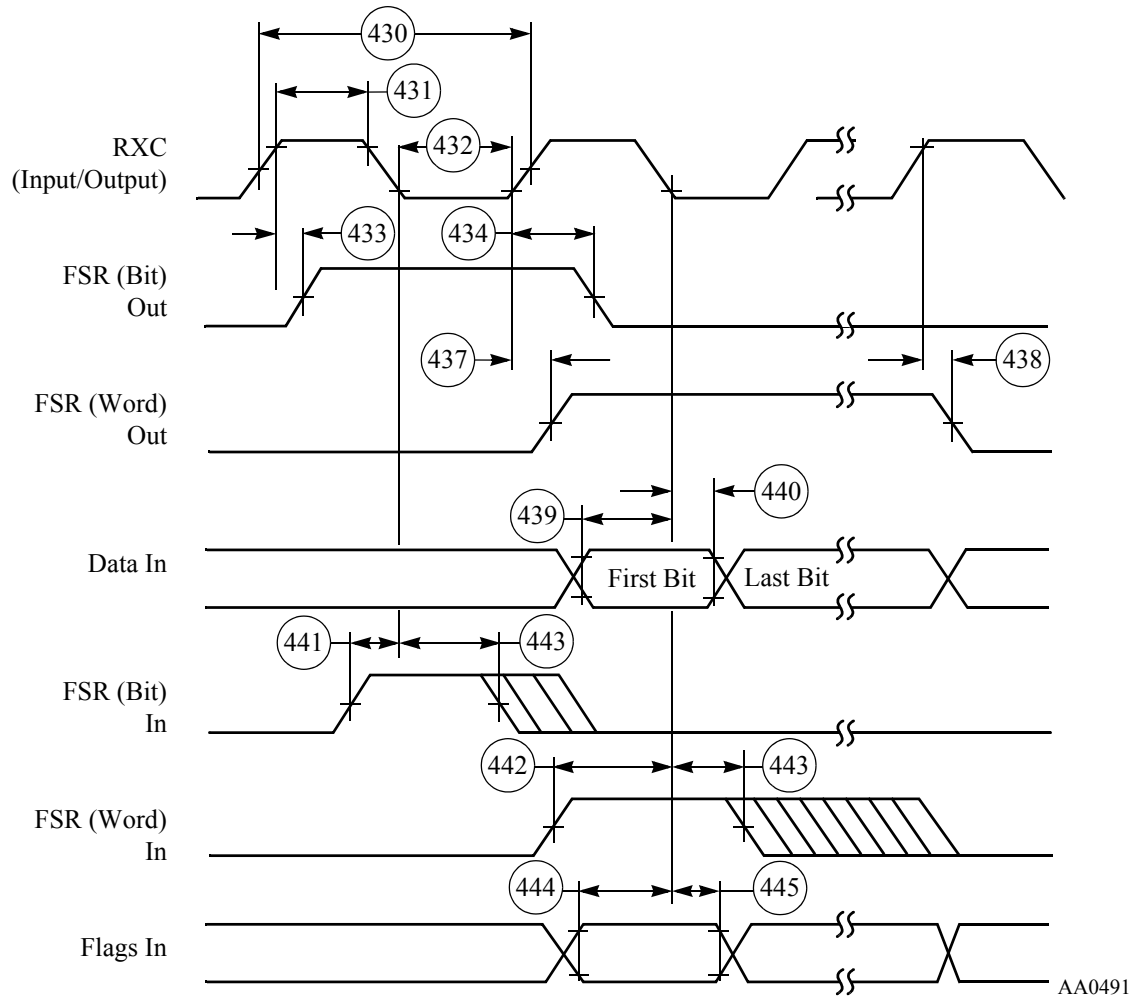
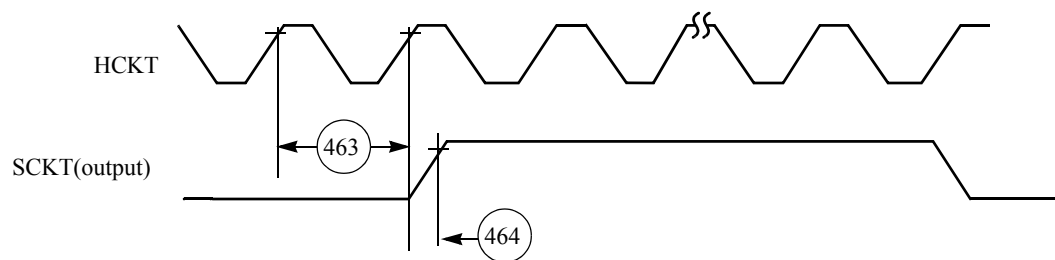
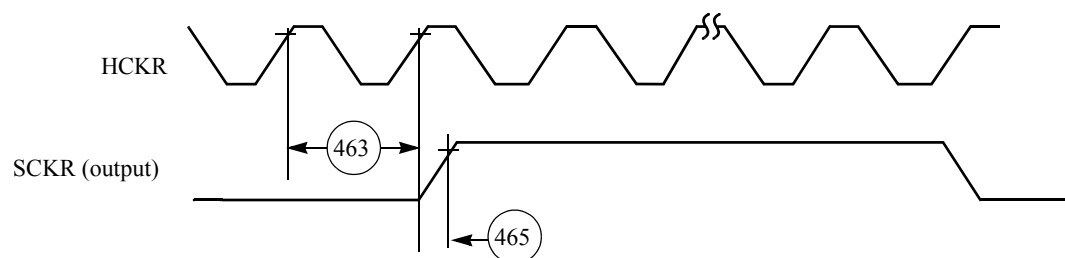


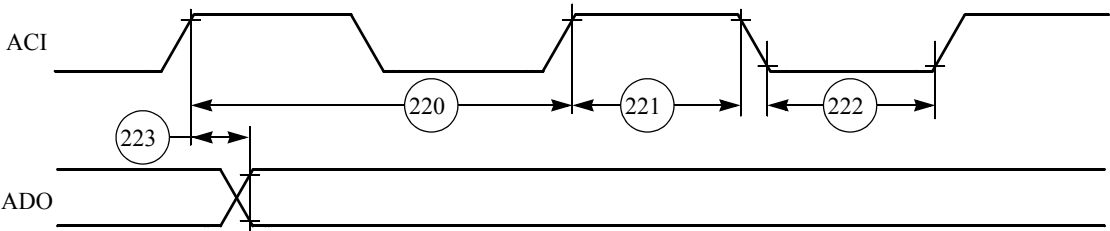
Figure 2-33 ESAI Receiver Timing

**Figure 2-34 ESAI HCKT Timing****Figure 2-35 ESAI HCKR Timing**

DIGITAL AUDIO TRANSMITTER TIMING

Table 2-23 Digital Audio Transmitter Timing

| No.                                                                                                                                                                                                                                                    | Characteristic               | Expression           | 120 MHz |      | Unit |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|----------------------|---------|------|------|
|                                                                                                                                                                                                                                                        |                              |                      | Min     | Max  |      |
|                                                                                                                                                                                                                                                        | ACI frequency (see note)     | $1 / (2 \times T_C)$ | —       | 60   | MHz  |
| 220                                                                                                                                                                                                                                                    | ACI period                   | $2 \times T_C$       | 16.7    | —    | ns   |
| 221                                                                                                                                                                                                                                                    | ACI high duration            | $0.5 \times T_C$     | 4.2     | —    | ns   |
| 222                                                                                                                                                                                                                                                    | ACI low duration             | $0.5 \times T_C$     | 4.2     | —    | ns   |
| 223                                                                                                                                                                                                                                                    | ACI rising edge to ADO valid | $1.5 \times T_C$     | —       | 12.5 | ns   |
| Note: In order to assure proper operation of the DAX, the ACI frequency should be less than 1/2 of the DSP56366 internal clock frequency. For example, if the DSP56366 is running at 120 MHz internally, the ACI frequency should be less than 60 MHz. |                              |                      |         |      |      |



AA1280

Figure 2-36 Digital Audio Transmitter Timing

TIMER TIMING

Table 2-24 Timer Timing

| No.                                                                                                                        | Characteristics | Expression           | 120 MHz |     | Unit |
|----------------------------------------------------------------------------------------------------------------------------|-----------------|----------------------|---------|-----|------|
|                                                                                                                            |                 |                      | Min     | Max |      |
| 480                                                                                                                        | TIO Low         | $2 \times T_C + 2.0$ | 18.7    | —   | ns   |
| 481                                                                                                                        | TIO High        | $2 \times T_C + 2.0$ | 18.7    | —   | ns   |
| Note: $V_{CC} = 3.3\text{ V} \pm 0.16\text{ V}$ ; $T_J = -40^\circ\text{C}$ to $+105^\circ\text{C}$ , $C_L = 50\text{ pF}$ |                 |                      |         |     |      |

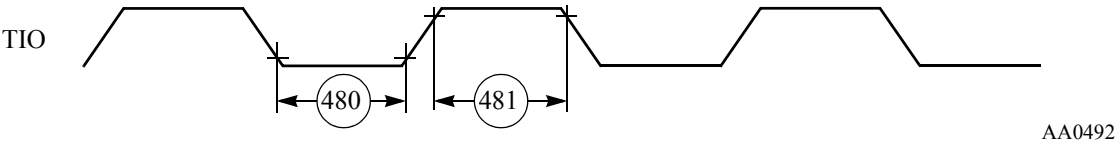


Figure 2-37 TIO Timer Event Input Restrictions

## GPIO TIMING

Table 2-25 GPIO Timing

| No.              | Characteristics <sup>1</sup>                          | Expression              | Min  | Max  | Unit |
|------------------|-------------------------------------------------------|-------------------------|------|------|------|
| 490 <sup>2</sup> | EXTAL edge to GPIO out valid (GPIO out delay time)    |                         | —    | 32.8 | ns   |
| 491              | EXTAL edge to GPIO out not valid (GPIO out hold time) |                         | 4.8  | —    | ns   |
| 492              | GPIO In valid to EXTAL edge (GPIO in set-up time)     |                         | 10.2 | —    | ns   |
| 493              | EXTAL edge to GPIO in not valid (GPIO in hold time)   |                         | 1.8  | —    | ns   |
| 494 <sup>2</sup> | Fetch to EXTAL edge before GPIO change                | $6.75 \times T_C - 1.8$ | 54.5 | —    | ns   |
| 495              | GPIO out rise time                                    | —                       | —    | 13   | ns   |
| 496              | GPIO out fall time                                    | —                       | —    | 13   | ns   |

Notes: 1.  $V_{CC} = 3.3 \text{ V} \pm 0.16 \text{ V}$ ;  $T_J = -40^\circ\text{C}$  to  $+105^\circ\text{C}$ ,  $C_L = 50 \text{ pF}$   
2. Valid only when PLL enabled with multiplication factor equal to one.

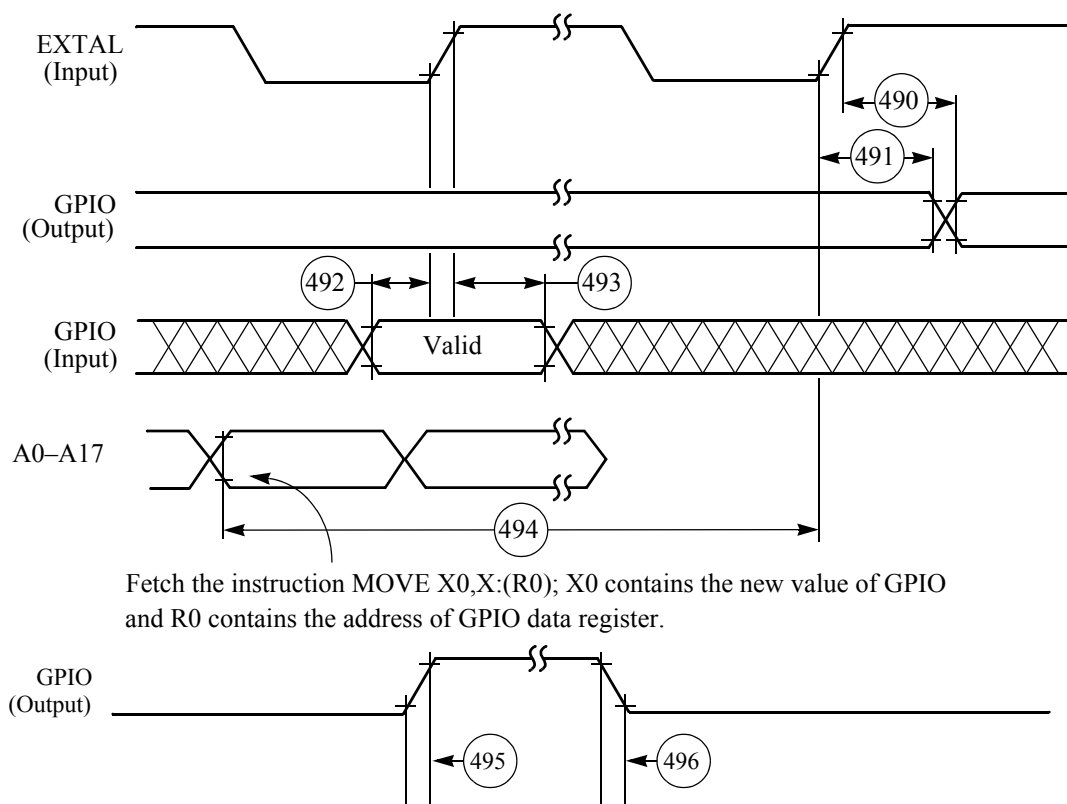


Figure 2-38 GPIO Timing

JTAG TIMING

Table 2-26 JTAG Timing

| No.                                                                                                                                                                                                                                 | Characteristics                                                   | All frequencies |      | Unit |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-----------------|------|------|
|                                                                                                                                                                                                                                     |                                                                   | Min             | Max  |      |
| 500                                                                                                                                                                                                                                 | TCK frequency of operation ( $1/(T_C \times 3)$ ; maximum 22 MHz) | 0.0             | 22.0 | MHz  |
| 501                                                                                                                                                                                                                                 | TCK cycle time in Crystal mode                                    | 45.0            | —    | ns   |
| 502                                                                                                                                                                                                                                 | TCK clock pulse width measured at 1.5 V                           | 20.0            | —    | ns   |
| 503                                                                                                                                                                                                                                 | TCK rise and fall times                                           | 0.0             | 3.0  | ns   |
| 504                                                                                                                                                                                                                                 | Boundary scan input data setup time                               | 5.0             | —    | ns   |
| 505                                                                                                                                                                                                                                 | Boundary scan input data hold time                                | 24.0            | —    | ns   |
| 506                                                                                                                                                                                                                                 | TCK low to output data valid                                      | 0.0             | 40.0 | ns   |
| 507                                                                                                                                                                                                                                 | TCK low to output high impedance                                  | 0.0             | 40.0 | ns   |
| 508                                                                                                                                                                                                                                 | TMS, TDI data setup time                                          | 5.0             | —    | ns   |
| 509                                                                                                                                                                                                                                 | TMS, TDI data hold time                                           | 25.0            | —    | ns   |
| 510                                                                                                                                                                                                                                 | TCK low to TDO data valid                                         | 0.0             | 44.0 | ns   |
| 511                                                                                                                                                                                                                                 | TCK low to TDO high impedance                                     | 0.0             | 44.0 | ns   |
| Notes: 1. $V_{CC} = 3.3\text{ V} \pm 0.16\text{ V}$ ; $T_J = -40^\circ\text{C}$ to $+105^\circ\text{C}$ , $C_L = 50\text{ pF}$<br>2. All timings apply to OnCE module data transfers because it uses the JTAG port as an interface. |                                                                   |                 |      |      |

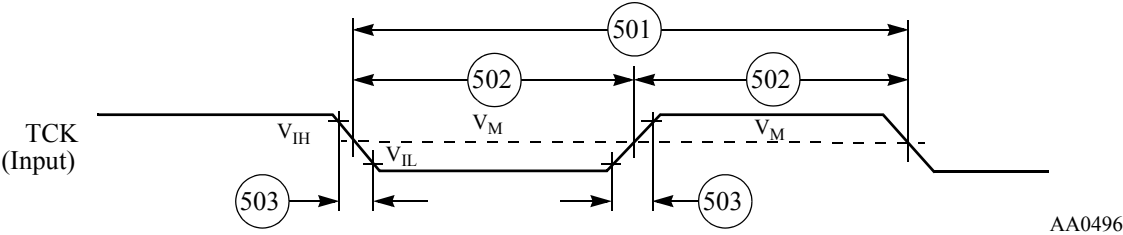


Figure 2-39 Test Clock Input Timing Diagram

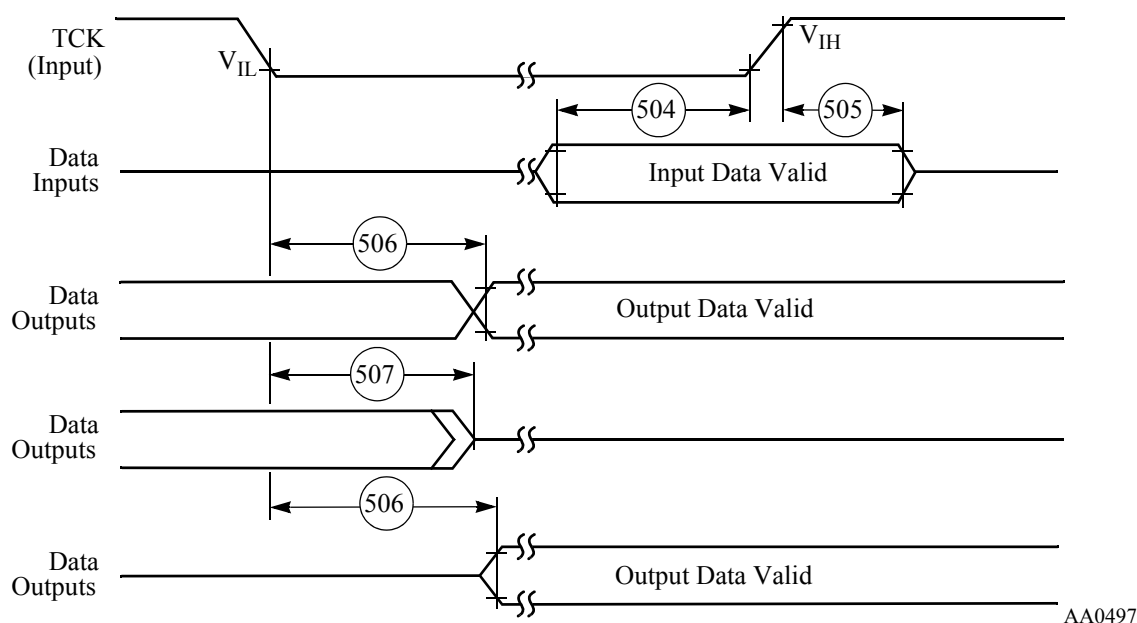


Figure 2-40 Boundary Scan (JTAG) Timing Diagram

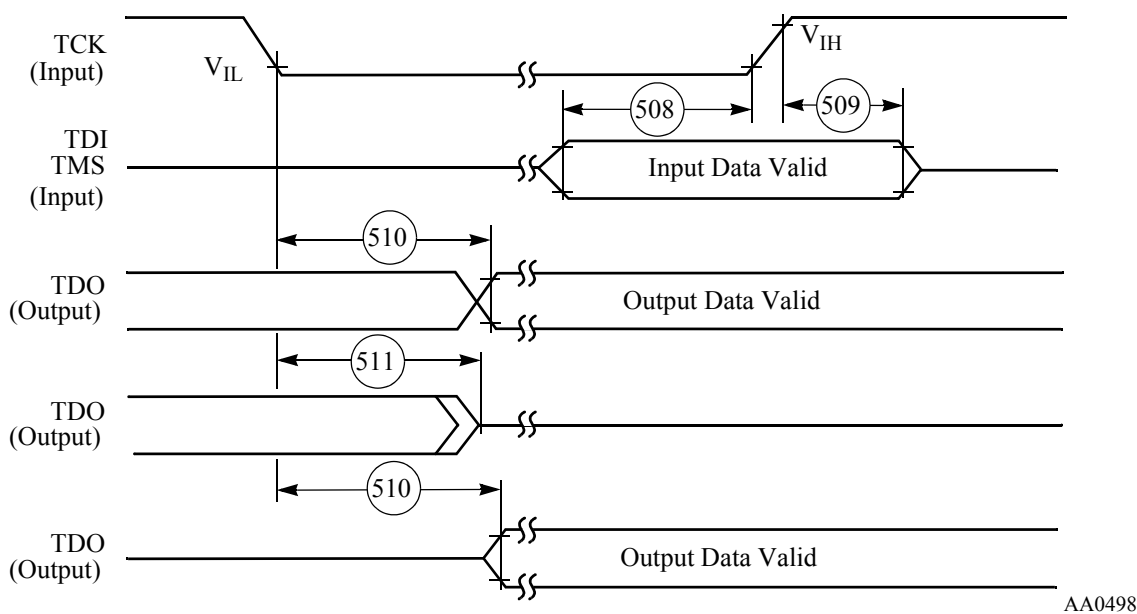


Figure 2-41 Test Access Port Timing Diagram



# SECTION 3

## PACKAGING

---

### PIN-OUT AND PACKAGE INFORMATION

This section provides information about the available package for this product, including diagrams of the package pinouts and tables describing how the signals described in **Section 1** are allocated for the package. The DSP56366 is available in a 144-pin LQFP package. Table 3-1 and Table 3-2 show the pin/name assignments for the packages.

#### LQFP Package Description

Top view of the 144-pin LQFP package is shown in **Figure 3-1** with its pin-outs. The package drawing is shown in **Figure 3-2**.

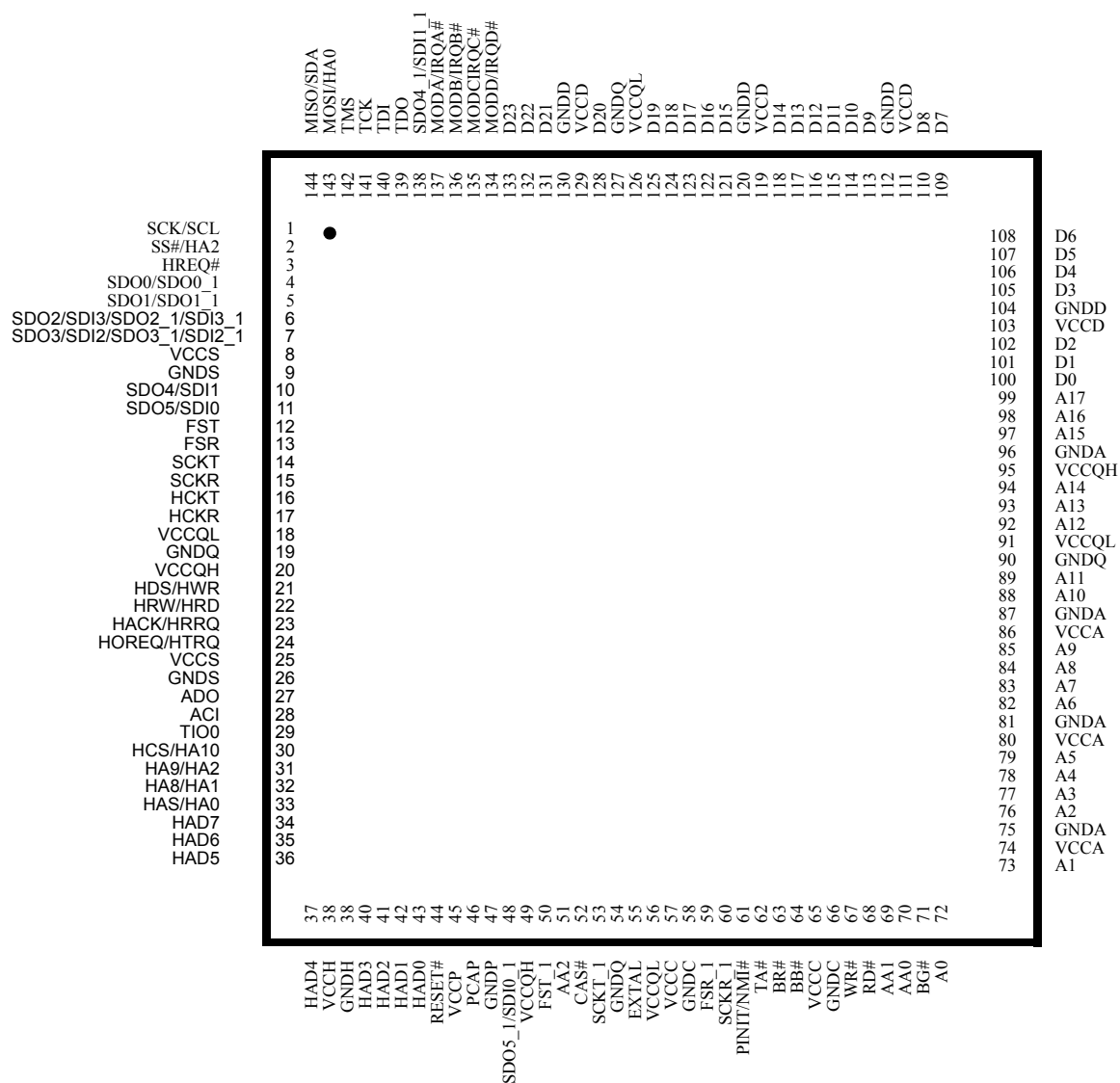


Table 3-1 Signal Identification by Name

| Signal Name | Pin No. | Signal Name | Pin No. | Signal Name | Pin No. | Signal Name             | Pin No. |
|-------------|---------|-------------|---------|-------------|---------|-------------------------|---------|
| A0          | 72      | D9          | 113     | GNDS        | 9       | SDO0/SDO0_1             | 4       |
| A1          | 73      | D10         | 114     | GNDS        | 26      | SDO1/SDO1_1             | 5       |
| A2          | 76      | D11         | 115     | HA8/HA1     | 32      | SDO2/SDI3/SDO2_1/SDI3_1 | 6       |
| A3          | 77      | D12         | 116     | HA9/HA2     | 31      | SDO3/SDI2/SDO3_1/SDI2_1 | 7       |
| A4          | 78      | D13         | 117     | HACK/HRRQ   | 23      | SDO4/SDI1               | 10      |
| A5          | 79      | D14         | 118     | HAD0        | 43      | SDO4_1/SDI1_1           | 138     |
| A6          | 82      | D15         | 121     | HAD1        | 42      | SDO5/SDI0               | 11      |
| A7          | 83      | D16         | 122     | HAD2        | 41      | SDO5_1/SDI0_1           | 48      |
| A8          | 84      | D17         | 123     | HAD3        | 40      | SS#/HA2                 | 2       |
| A9          | 85      | D18         | 124     | HAD4        | 37      | TA#                     | 62      |
| A10         | 88      | D19         | 125     | HAD5        | 36      | TCK                     | 141     |
| A11         | 89      | D20         | 128     | HAD6        | 35      | TDI                     | 140     |
| A12         | 92      | D21         | 131     | HAD7        | 34      | TDO                     | 139     |
| A13         | 93      | D22         | 132     | HAS/HA0     | 33      | TIO0                    | 29      |
| A14         | 94      | D23         | 133     | HCKR        | 17      | TMS                     | 142     |
| A15         | 97      | EXTAL       | 55      | HCKT        | 16      | VCCA                    | 74      |
| A16         | 98      | FSR         | 13      | HCS/HA10    | 30      | VCCA                    | 80      |
| A17         | 99      | FSR_1       | 59      | HDS/HWR     | 21      | VCCA                    | 86      |
| AA0         | 70      | FST         | 12      | HOREQ/HTRQ  | 24      | VCCC                    | 57      |
| AA1         | 69      | FST_1       | 50      | HREQ#       | 3       | VCCC                    | 65      |
| AA2         | 51      | GND A       | 75      | HRW/HRD     | 22      | VCCD                    | 103     |
| ACI         | 28      | GND A       | 81      | MODA/IRQA#  | 137     | VCCD                    | 111     |
| ADO         | 27      | GND A       | 87      | MODB/IRQB#  | 136     | VCCD                    | 119     |
| BB#         | 64      | GND A       | 96      | MODC/IRQC#  | 135     | VCCD                    | 129     |
| BG#         | 71      | GND C       | 58      | MODD/IRQD#  | 134     | VCCH                    | 38      |
| BR#         | 63      | GND C       | 66      | MISO/SDA    | 144     | VCCQH                   | 20      |
| CAS#        | 52      | GND D       | 104     | MOSI/HA0    | 143     | VCCQH                   | 95      |
| D0          | 100     | GND D       | 112     | PCAP        | 46      | VCCQH                   | 49      |
| D1          | 101     | GND D       | 120     | PINIT/NMI#  | 61      | VCCQL                   | 18      |
| D2          | 102     | GND D       | 130     | RD#         | 68      | VCCQL                   | 56      |
| D3          | 105     | GND H       | 39      | RESET#      | 44      | VCCQL                   | 91      |
| D4          | 106     | GND P       | 47      | SCK/SCL     | 1       | VCCQL                   | 126     |
| D5          | 107     | GND Q       | 19      | SCKR        | 15      | VCCP                    | 45      |
| D6          | 108     | GND Q       | 54      | SCKR_1      | 60      | VCCS                    | 8       |
| D7          | 109     | GND Q       | 90      | SCKT        | 14      | VCCS                    | 25      |
| D8          | 110     | GND Q       | 127     | SCKT_1      | 53      | WR#                     | 67      |

Table 3-2 Signal Identification by Pin Number

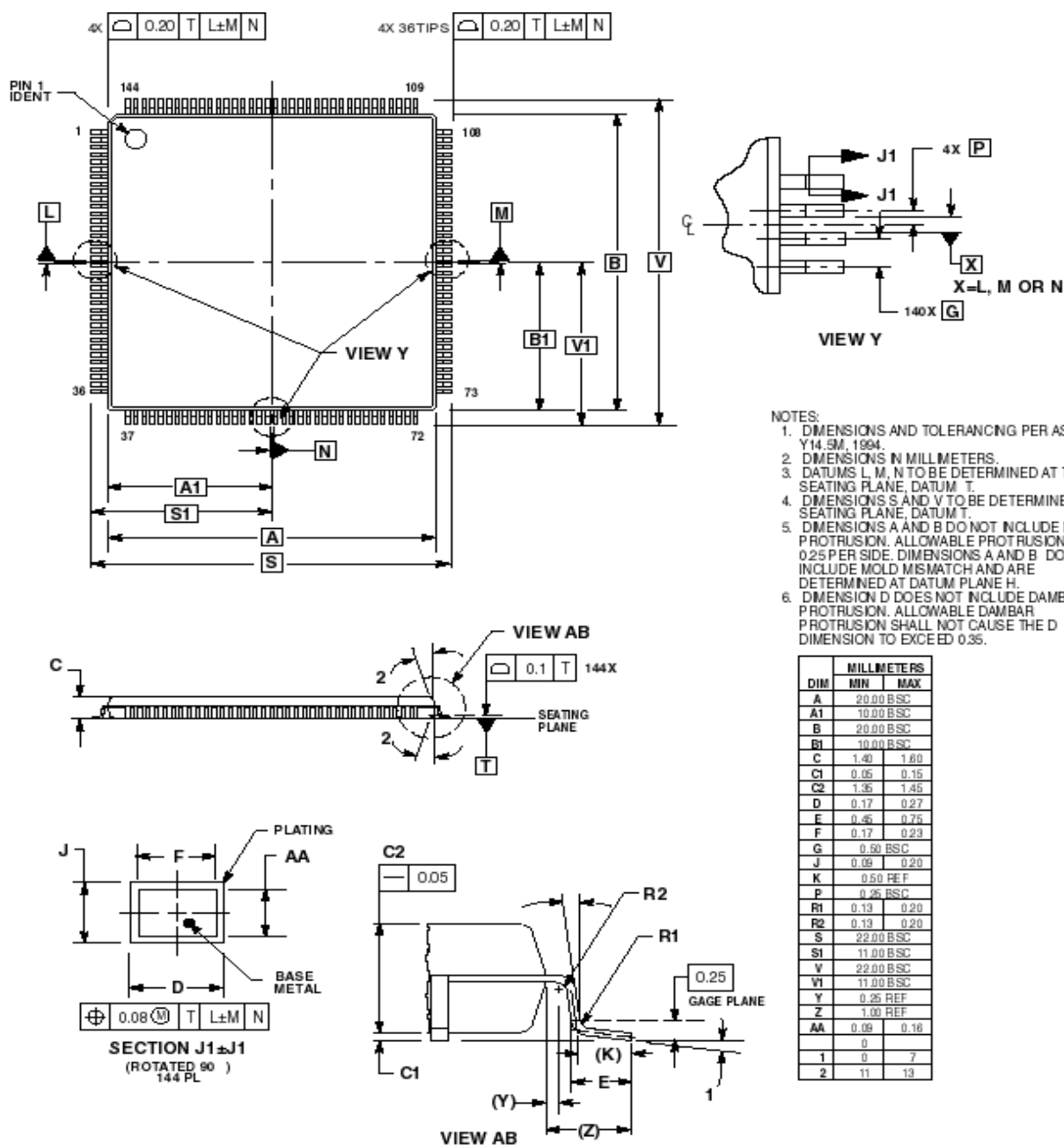
| Pin No. | Signal Name | Pin No. | Signal Name | Pin No. | Signal Name | Pin No. | Signal Name |
|---------|-------------|---------|-------------|---------|-------------|---------|-------------|
| 1       | SCK/SCL     | 37      | HAD4        | 73      | A1          | 109     | D7          |
| 2       | SS#/HA2     | 38      | VCCH        | 74      | VCCA        | 110     | D8          |
| 3       | HREQ#       | 39      | GNDH        | 75      | GND A       | 111     | VCCD        |
| 4       | SDO0/SDO0_1 | 40      | HAD3        | 76      | A2          | 112     | GNDD        |

## Pin-out and Package Information

Table 3-2 Signal Identification by Pin Number (Continued)

|    |                             |    |               |     |       |     |               |
|----|-----------------------------|----|---------------|-----|-------|-----|---------------|
| 5  | SDO1/SDO1_1                 | 41 | HAD2          | 77  | A3    | 113 | D9            |
| 6  | SDO2/SDI3/SDO2_1/<br>SDI3_1 | 42 | HAD1          | 78  | A4    | 114 | D10           |
| 7  | SDO3/SDI2/SDO3_1/<br>SDI2_1 | 43 | HAD0          | 79  | A5    | 115 | D11           |
| 8  | VCCS                        | 44 | RESET#        | 80  | VCCA  | 116 | D12           |
| 9  | GNDS                        | 45 | VCCP          | 81  | GNDA  | 117 | D13           |
| 10 | SDO4/SDI1                   | 46 | PCAP          | 82  | A6    | 118 | D14           |
| 11 | SDO5/SDI0                   | 47 | GNDP          | 83  | A7    | 119 | VCCD          |
| 12 | FST                         | 48 | SDO5_1/SDI0_1 | 84  | A8    | 120 | GNDD          |
| 13 | FSR                         | 49 | VCCQH         | 85  | A9    | 121 | D15           |
| 14 | SCKT                        | 50 | FST_1         | 86  | VCCA  | 122 | D16           |
| 15 | SCKR                        | 51 | AA2           | 87  | GNDA  | 123 | D17           |
| 16 | HCKT                        | 52 | CAS#          | 88  | A10   | 124 | D18           |
| 17 | HCKR                        | 53 | SCKT_1        | 89  | A11   | 125 | D19           |
| 18 | VCCQL                       | 54 | GNDQ          | 90  | GNDQ  | 126 | VCCQL         |
| 19 | GNDQ                        | 55 | EXTAL         | 91  | VCCQL | 127 | GNDQ          |
| 20 | VCCQH                       | 56 | VCCQL         | 92  | A12   | 128 | D20           |
| 21 | HDS/HWR                     | 57 | VCCC          | 93  | A13   | 129 | VCCD          |
| 22 | HRW/HRD                     | 58 | GNDC          | 94  | A14   | 130 | GNDD          |
| 23 | HACK/HRRQ                   | 59 | FSR_1         | 95  | VCCQH | 131 | D21           |
| 24 | HOREQ/HTRQ                  | 60 | SCKR_1        | 96  | GNDA  | 132 | D22           |
| 25 | VCCS                        | 61 | PINIT/NMI#    | 97  | A15   | 133 | D23           |
| 26 | GNDS                        | 62 | TA#           | 98  | A16   | 134 | MODD/IRQD#    |
| 27 | ADO                         | 63 | BR#           | 99  | A17   | 135 | MODC/IRQC#    |
| 28 | ACI                         | 64 | BB#           | 100 | D0    | 136 | MODB/IRQB#    |
| 29 | TIO0                        | 65 | VCCC          | 101 | D1    | 137 | MODA/IRQA#    |
| 30 | HCS/HA10                    | 66 | GNDC          | 102 | D2    | 138 | SDO4_1/SDI1_1 |
| 31 | HA9/HA2                     | 67 | WR#           | 103 | VCCD  | 139 | TDO           |
| 32 | HA8/HA1                     | 68 | RD#           | 104 | GNDD  | 140 | TDI           |
| 33 | HAS/HA0                     | 69 | AA1           | 105 | D3    | 141 | TCK           |
| 34 | HAD7                        | 70 | AA0           | 106 | D4    | 142 | TMS           |
| 35 | HAD6                        | 71 | BG#           | 107 | D5    | 143 | MOSI/HA0      |
| 36 | HAD5                        | 72 | A0            | 108 | D6    | 144 | MISO/SDA      |

## LQFP Package Mechanical Drawing

CASE 918±03  
ISSUE C

DATE 01/30/96

Figure 3-2 DSP56366 144-pin LQFP Package

## **ORDERING DRAWINGS**

The detailed package drawing is available on the Motorola web page at:

**<http://www.mot-sps.com/cgi-bin/cases.pl>**

Use package 918-03 for the search.

# SECTION 4

## DESIGN CONSIDERATIONS

---

### THERMAL DESIGN CONSIDERATIONS

An estimation of the chip junction temperature,  $T_J$ , in °C can be obtained from the following equation:

$$T_J = T_A + (P_D \times R_{\theta JA})$$

Where:  $T_A$  = ambient temperature °C  
 $R_{\theta JA}$  = package junction-to-ambient thermal resistance °C/W  
 $P_D$  = power dissipation in package W

Historically, thermal resistance has been expressed as the sum of a junction-to-case thermal resistance and a case-to-ambient thermal resistance.

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CA}$$

Where:  $R_{\theta JA}$  = package junction-to-ambient thermal resistance °C/W  
 $R_{\theta JC}$  = package junction-to-case thermal resistance °C/W  
 $R_{\theta CA}$  = package case-to-ambient thermal resistance °C/W

$R_{\theta JC}$  is device-related and cannot be influenced by the user. The user controls the thermal environment to change the case-to-ambient thermal resistance,  $R_{\theta CA}$ . For example, the user can change the air flow around the device, add a heat sink, change the mounting arrangement on the printed circuit board (PCB), or otherwise change the thermal dissipation capability of the area surrounding the device on a PCB. This model is most useful for ceramic packages with heat sinks; some 90% of the heat flow is dissipated through the case to the heat sink and out to the ambient environment. For ceramic packages, in situations where the heat flow is split between a path to the case and an alternate path through the PCB, analysis of the device thermal performance may need the additional modeling capability of a system level thermal simulation tool.

The thermal performance of plastic packages is more dependent on the temperature of the PCB to which the package is mounted. Again, if the estimations obtained from  $R_{\theta JA}$  do not satisfactorily answer whether the thermal performance is adequate, a system level model may be appropriate.

A complicating factor is the existence of three common ways for determining the junction-to-case thermal resistance in plastic packages.

- To minimize temperature variation across the surface, the thermal resistance is measured from the junction to the outside surface of the package (case) closest to the chip mounting area when that surface has a proper heat sink.

### Electrical Design Considerations

- To define a value approximately equal to a junction-to-board thermal resistance, the thermal resistance is measured from the junction to where the leads are attached to the case.
- If the temperature of the package case ( $T_T$ ) is determined by a thermocouple, the thermal resistance is computed using the value obtained by the equation  $(T_J - T_T)/P_D$ .

As noted above, the junction-to-case thermal resistances quoted in this data sheet are determined using the first definition. From a practical standpoint, that value is also suitable for determining the junction temperature from a case thermocouple reading in forced convection environments. In natural convection, using the junction-to-case thermal resistance to estimate junction temperature from a thermocouple reading on the case of the package will estimate a junction temperature slightly hotter than actual temperature. Hence, the new thermal metric, thermal characterization parameter or  $\Psi_{JT}$ , has been defined to be  $(T_J - T_T)/P_D$ . This value gives a better estimate of the junction temperature in natural convection when using the surface temperature of the package. Remember that surface temperature readings of packages are subject to significant errors caused by inadequate attachment of the sensor to the surface and to errors caused by heat loss to the sensor. The recommended technique is to attach a 40-gauge thermocouple wire and bead to the top center of the package with thermally conductive epoxy.

## ELECTRICAL DESIGN CONSIDERATIONS

### CAUTION

**This device contains circuitry protecting against damage due to high static voltage or electrical fields. However, normal precautions should be taken to avoid exceeding maximum voltage ratings. Reliability of operation is enhanced if unused inputs are tied to an appropriate logic voltage level (e.g., either GND or  $V_{CC}$ ). The suggested value for a pullup or pulldown resistor is 10 kOhm.**

Use the following list of recommendations to assure correct DSP operation:

- Provide a low-impedance path from the board power supply to each  $V_{CC}$  pin on the DSP and from the board ground to each GND pin.
- Use at least six 0.01–0.1  $\mu\text{F}$  bypass capacitors positioned as close as possible to the four sides of the package to connect the  $V_{CC}$  power source to GND.
- Ensure that capacitor leads and associated printed circuit traces that connect to the chip  $V_{CC}$  and GND pins are less than 1.2 cm (0.5 inch) per capacitor lead.
- Use at least a four-layer PCB with two inner layers for  $V_{CC}$  and GND.

- Because the DSP output signals have fast rise and fall times, PCB trace lengths should be minimal. This recommendation particularly applies to the address and data buses as well as the  $\overline{\text{IRQA}}$ ,  $\overline{\text{IRQB}}$ ,  $\overline{\text{IRQC}}$ ,  $\overline{\text{IRQD}}$ ,  $\overline{\text{TA}}$  and  $\overline{\text{BG}}$  pins. Maximum PCB trace lengths on the order of 15 cm (6 inches) are recommended.
- Consider all device loads as well as parasitic capacitance due to PCB traces when calculating capacitance. This is especially critical in systems with higher capacitive loads that could create higher transient currents in the  $V_{CC}$  and GND circuits.
- All inputs must be terminated (i.e., not allowed to float) using CMOS levels, except for the three pins with internal pull-up resistors ( $\text{TMS}$ ,  $\overline{\text{TDI}}$ ,  $\overline{\text{TCK}}$ ).
- Take special care to minimize noise levels on the  $V_{CCP}$  and  $\text{GND}_P$  pins.
- If multiple DSP56366 devices are on the same board, check for cross-talk or excessive spikes on the supplies due to synchronous operation of the devices.
- $\overline{\text{RESET}}$  must be asserted when the chip is powered up. A stable EXTAL signal must be supplied while  $\overline{\text{RESET}}$  is being asserted.
- At power-up, ensure that the voltage difference between the 5 V tolerant pins and the chip  $V_{CC}$  never exceeds 3.95 V.

## POWER CONSUMPTION CONSIDERATIONS

Power dissipation is a key issue in portable DSP applications. Some of the factors which affect current consumption are described in this section. Most of the current consumed by CMOS devices is alternating current (ac), which is charging and discharging the capacitances of the pins and internal nodes.

Current consumption is described by the following formula:

$$I = C \times V \times f$$

where

$C$  = node/pin capacitance

$V$  = voltage swing

$f$  = frequency of node/pin toggle

### Example 1 Current Consumption

For a Port A address pin loaded with 50 pF capacitance, operating at 3.3 V, and with a 120 MHz clock, toggling at its maximum possible rate (60 MHz), the current consumption is

$$I = 50 \times 10^{-12} \times 3.3 \times 60 \times 10^6 = 9.9 \text{ mA}$$

### PLL Performance Issues

The maximum internal current ( $I_{CC1max}$ ) value reflects the typical possible switching of the internal buses on best-case operation conditions, which is not necessarily a real application case. The typical internal current ( $I_{CC1typ}$ ) value reflects the average switching of the internal buses on typical operating conditions.

For applications that require very low current consumption, do the following:

- Set the EBD bit when not accessing external memory.
- Minimize external memory accesses and use internal memory accesses.
- Minimize the number of pins that are switching.
- Minimize the capacitive load on the pins.
- Connect the unused inputs to pull-up or pull-down resistors.
- Disable unused peripherals.

One way to evaluate power consumption is to use a current per MIPS measurement methodology to minimize specific board effects (i.e., to compensate for measured board current not caused by the DSP). A benchmark power consumption test algorithm is listed in **Appendix A**. Use the test algorithm, specific test current measurements, and the following equation to derive the current per MIPS value.

$$I/MIPS = I/MHz = (I_{typF2} - I_{typF1}) / (F2 - F1)$$

where :  $I_{typF2}$  = current at F2

$I_{typF1}$  = current at F1

F2 = high frequency (any specified operating frequency)

F1 = low frequency (any specified operating frequency lower than F2)

**Note:** F1 should be significantly less than F2. For example, F2 could be 66 MHz and F1 could be 33 MHz. The degree of difference between F1 and F2 determines the amount of precision with which the current rating can be determined for an application.

## PLL PERFORMANCE ISSUES

The following explanations should be considered as general observations on expected PLL behavior. There is no testing that verifies these exact numbers. These observations were measured on a limited number of parts and were not verified over the entire temperature and voltage ranges.

### Phase Jitter Performance

The phase jitter of the PLL is defined as the variations in the skew between the falling edges of EXTAL and the internal DSP clock for a given device in specific temperature, voltage, input frequency and MF. These variations are a result of the PLL locking mechanism. For input frequencies greater than 15 MHz

and  $MF \leq 4$ , this jitter is less than  $\pm 0.6$  ns; otherwise, this jitter is not guaranteed. However, for  $MF < 10$  and input frequencies greater than 10 MHz, this jitter is less than  $\pm 2$  ns.

## Frequency Jitter Performance

The frequency jitter of the PLL is defined as the variation of the frequency of the internal DSP clock. For small MF ( $MF < 10$ ) this jitter is smaller than 0.5%. For mid-range MF ( $10 < MF < 500$ ) this jitter is between 0.5% and approximately 2%. For large MF ( $MF > 500$ ), the frequency jitter is 2–3%.

## Input (EXTAL) Jitter Requirements

The allowed jitter on the frequency of EXTAL is 0.5%. If the rate of change of the frequency of EXTAL is slow (i.e., it does not jump between the minimum and maximum values in one cycle) or the frequency of the jitter is fast (i.e., it does not stay at an extreme value for a long time), then the allowed jitter can be 2%. The phase and frequency jitter performance results are only valid if the input jitter is less than the prescribed values.

## HOST PORT CONSIDERATIONS

Careful synchronization is required when reading multi-bit registers that are written by another asynchronous system. This synchronization is a common problem when two asynchronous systems are connected, as they are in the host interface. The following paragraphs present considerations for proper operation.

### Host Programming Considerations

- **Unsynchronized Reading of Receive Byte Registers**—When reading the receive byte registers, receive register high (RXH), receive register middle (RXM), or receive register low (RXL), the host interface programmer should use interrupts or poll the receive register data full (RXDF) flag that indicates whether data is available. This ensures that the data in the receive byte registers will be valid.
- **Overwriting Transmit Byte Registers**—The host interface programmer should not write to the transmit byte registers, transmit register high (TXH), transmit register middle (TXM), or transmit register low (TXL), unless the transmit register data empty (TXDE) bit is set, indicating that the transmit byte registers are empty. This ensures that the transmit byte registers will transfer valid data to the host receive (HRX) register.
- **Synchronization of Status Bits from DSP to Host**—HC,  $\overline{\text{HOREQ}}$ , DMA, HF3, HF2, TRDY, TXDE, and RXDF status bits are set or cleared from inside the DSP and read by the host processor (refer to the user's manual for descriptions of these status bits). The host can read these status bits

### Host Port Considerations

very quickly without regard to the clock rate used by the DSP, but the state of the bit could be changing during the read operation. This is not generally a system problem, because the bit will be read correctly in the next pass of any host polling routine.

However, if the host asserts  $\overline{\text{H\!EN}}$  for more than timing number 31, with a minimum cycle time of timing number 31 + 32, then these status bits are guaranteed to be stable. Exercise care when reading status bits HF3 and HF2 as an encoded pair. If the DSP changes HF3 and HF2 from 00 to 11, there is a small probability that the host could read the bits during the transition and receive 01 or 10 instead of 11. If the combination of HF3 and HF2 has significance, the host could read the wrong combination. Therefore, read the bits twice and check for consensus.

- **Overwriting the Host Vector**—The host interface programmer should change the host vector (HV) register only when the host command (HC) bit is clear. This ensures that the DSP interrupt control logic will receive a stable vector.
- **Cancelling a Pending Host Command Exception**—The host processor may elect to clear the HC bit to cancel the host command exception request at any time before it is recognized by the DSP. Because the host does not know exactly when the exception will be recognized (due to exception processing synchronization and pipeline delays), the DSP may execute the host command exception after the HC bit is cleared. For these reasons, the HV bits must not be changed at the same time that the HC bit is cleared.
- **Variance in the Host Interface Timing**—The host interface (HDI) may vary (e.g. due to the PLL lock time at reset). Therefore, a host which attempts to load (bootstrap) the DSP should first make sure that the part has completed its HI port programming (e.g., by setting the INIT bit in ICR then polling it and waiting it to be cleared, then reading the ISR or by writing the TREQ/RREQ together with the INIT and then polling INIT, ISR, and the  $\overline{\text{HOREQ}}$  pin).

### DSP Programming Considerations

- **Synchronization of Status Bits from Host to DSP**—DMA, HF1, HF0, HCP, HTDE, and HRDF status bits are set or cleared by the host processor side of the interface. These bits are individually synchronized to the DSP clock. (Refer to the user's manual for descriptions of these status bits.)
- **Reading HF0 and HF1 as an Encoded Pair**—Care must be exercised when reading status bits HF0 and HF1 as an encoded pair, (i.e., the four combinations 00, 01, 10, and 11 each have significance). A very small probability exists that the DSP will read the status bits synchronized during transition. Therefore, HF0 and HF1 should be read twice and checked for consensus.

# SECTION 5

## ORDERING INFORMATION

---

Consult a Motorola Semiconductor sales office or authorized distributor to determine product availability and to place an order.

**Table 5-1 Ordering Information**

| Part                                                                                                                                                                                                                                                                                                                                                                                                                     | Supply Voltage | Package Type               | Pin Count | Frequency (MHz) | Order Number  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------------|-----------|-----------------|---------------|
| DSP56366                                                                                                                                                                                                                                                                                                                                                                                                                 | 3.3 V          | Thin quad flat pack (TQFP) | 144       | 120             | XCD56366PV120 |
| Notes: 1. Please consult the web site at <a href="http://www.dsppaudio.motorola.com">www.dsppaudio.motorola.com</a> for current availability.<br>2. Future products in the DSP56366 family may include other ROM-based options. For additional information on future part development, or to request customer-specific ROM-based support, call your local Motorola Semiconductor sales office or authorized distributor. |                |                            |           |                 |               |



# APPENDIX A

## POWER CONSUMPTION BENCHMARK

---

The following benchmark program permits evaluation of DSP power usage in a test situation. It enables the PLL, disables the external clock, and uses repeated multiply-accumulate instructions with a set of synthetic DSP application data to emulate intensive sustained DSP operation.

```

;*****
;*****
;
;* ;* CHECKS    Typical Power Consumption
;*****
;
        page      200,55,0,0,0
        nolist

I_VEC EQU $000000 ; Interrupt vectors for program debug only
START EQU $8000    ; MAIN (external) program starting address
INT_PROG EQU $100  ; INTERNAL program memory starting address
INT_XDAT EQU $0    ; INTERNAL X-data memory starting address
INT_YDAT EQU $0    ; INTERNAL Y-data memory starting address

        INCLUDE "ioequ.asm"
        INCLUDE "intequ.asm"

        list

        org      P:START
;
        movep    #$0123FF,x:M_BCR; BCR: Area 3 : 1 w.s (SRAM)
; Default: 1 w.s (SRAM)
;
        movep    #$0d0000,x:M_PCTL          ; XTAL disable
                                   ; PLL enable
                                   ; CLKOUT disable
;
; Load the program
;
        move     #INT_PROG,r0
        move     #PROG_START,r1
        do       #(PROG_END-PROG_START),PLOAD_LOOP
        move     p:(r1)+,x0
        move     x0,p:(r0)+
        nop
PLOAD_LOOP
;
; Load the X-data
;

```

```
        move    #INT_XDAT, r0
        move    #XDAT_START, r1
        do      #(XDAT_END-XDAT_START), XLOAD_LOOP
        move    p:(r1)+, x0
        move    x0, x:(r0)+
XLOAD_LOOP
;
; Load the Y-data
;
        move    #INT_YDAT, r0
        move    #YDAT_START, r1
        do      #(YDAT_END-YDAT_START), YLOAD_LOOP
        move    p:(r1)+, x0
        move    x0, y:(r0)+
YLOAD_LOOP
;

        jmp     INT_PROG

PROG_START
        move    #$0, r0
        move    #$0, r4
        move    #$3f, m0
        move    #$3f, m4
;
        clr     a
        clr     b
        move    #$0, x0
        move    #$0, x1
        move    #$0, y0
        move    #$0, y1
        bset    #4, omr                ; ebd
;
sbr      dor     #60, _end
        mac     x0, y0, a    x:(r0)+, x1        y:(r4)+, y1
        mac     x1, y1, a    x:(r0)+, x0        y:(r4)+, y0
        add     a, b
        mac     x0, y0, a    x:(r0)+, x1
        mac     x1, y1, a    y:(r4)+, y0
        move    b1, x:$ff
_end
        bra     sbr
        nop
        nop
        nop
        nop
PROG_END
        nop
        nop

XDAT_START
;      org     x:0
```

|    |          |
|----|----------|
| dc | \$262EB9 |
| dc | \$86F2FE |
| dc | \$E56A5F |
| dc | \$616CAC |
| dc | \$8FFD75 |
| dc | \$9210A  |
| dc | \$A06D7B |
| dc | \$CEA798 |
| dc | \$8DFBF1 |
| dc | \$A063D6 |
| dc | \$6C6657 |
| dc | \$C2A544 |
| dc | \$A3662D |
| dc | \$A4E762 |
| dc | \$84F0F3 |
| dc | \$E6F1B0 |
| dc | \$B3829  |
| dc | \$8BF7AE |
| dc | \$63A94F |
| dc | \$EF78DC |
| dc | \$242DE5 |
| dc | \$A3E0BA |
| dc | \$EBAB6B |
| dc | \$8726C8 |
| dc | \$CA361  |
| dc | \$2F6E86 |
| dc | \$A57347 |
| dc | \$4BE774 |
| dc | \$8F349D |
| dc | \$A1ED12 |
| dc | \$4BFCE3 |
| dc | \$EA26E0 |
| dc | \$CD7D99 |
| dc | \$4BA85E |
| dc | \$27A43F |
| dc | \$A8B10C |
| dc | \$D3A55  |
| dc | \$25EC6A |
| dc | \$2A255B |
| dc | \$A5F1F8 |
| dc | \$2426D1 |
| dc | \$AE6536 |
| dc | \$CBBC37 |
| dc | \$6235A4 |
| dc | \$37F0D  |
| dc | \$63BEC2 |
| dc | \$A5E4D3 |
| dc | \$8CE810 |
| dc | \$3FF09  |
| dc | \$60E50E |
| dc | \$CFFB2F |
| dc | \$40753C |
| dc | \$8262C5 |

```

dc      $CA641A
dc      $EB3B4B
dc      $2DA928
dc      $AB6641
dc      $28A7E6
dc      $4E2127
dc      $482FD4
dc      $7257D
dc      $E53C72
dc      $1A8C3
dc      $E27540

```

XDAT\_END

YDAT\_START

```

;      org      y:0
dc      $5B6DA
dc      $C3F70B
dc      $6A39E8
dc      $81E801
dc      $C666A6
dc      $46F8E7
dc      $AAEC94
dc      $24233D
dc      $802732
dc      $2E3C83
dc      $A43E00
dc      $C2B639
dc      $85A47E
dc      $ABFDDF
dc      $F3A2C
dc      $2D7CF5
dc      $E16A8A
dc      $ECB8FB
dc      $4BED18
dc      $43F371
dc      $83A556
dc      $E1E9D7
dc      $ACA2C4
dc      $8135AD
dc      $2CE0E2
dc      $8F2C73
dc      $432730
dc      $A87FA9
dc      $4A292E
dc      $A63CCF
dc      $6BA65C
dc      $E06D65
dc      $1AA3A
dc      $A1B6EB
dc      $48AC48
dc      $EF7AE1
dc      $6E3006
dc      $62F6C7

```

|    |          |
|----|----------|
| dc | \$6064F4 |
| dc | \$87E41D |
| dc | \$CB2692 |
| dc | \$2C3863 |
| dc | \$C6BC60 |
| dc | \$43A519 |
| dc | \$6139DE |
| dc | \$ADF7BF |
| dc | \$4B3E8C |
| dc | \$6079D5 |
| dc | \$E0F5EA |
| dc | \$8230DB |
| dc | \$A3B778 |
| dc | \$2BFE51 |
| dc | \$E0A6B6 |
| dc | \$68FFB7 |
| dc | \$28F324 |
| dc | \$8F2E8D |
| dc | \$667842 |
| dc | \$83E053 |
| dc | \$A1FD90 |
| dc | \$6B2689 |
| dc | \$85B68E |
| dc | \$622EAF |
| dc | \$6162BC |
| dc | \$E4A245 |

YDAT\_END



# APPENDIX B

## IBIS MODEL

```

[IBIS ver]      2.1
[File name]     56366.ibs
[File Rev]      0.0
[Date]          29/6/2000
[Component]     56366
[Manufacturer]  Motorola
[Package]
|variable      typ          min          max
R_pkg          45m          22m          75m
L_pkg          2.5nH        1.1nH        4.3nH
C_pkg          1.3pF        1.2pF        1.4pF

```

```

[Pin]signal_name model_name
1 sck            ip5b_io
2 ss_            ip5b_io
3 hreq_          ip5b_io
4 sdo0           ip5b_io
5 sdo1           ip5b_io
6 sdoi23         ip5b_io
7 sdoi32         ip5b_io
8 svcc           power
9 sgnd           gnd
10 sdoi41        ip5b_io
11 sdoi50        ip5b_io
12 fst           ip5b_io
13 fsr           ip5b_io
14 sckt          ip5b_io
15 sckr          ip5b_io
16 hsckt         ip5b_io
17 hsckr         ip5b_io
18 qvcc1         power
19 gnd           gnd
20 qvcch         power
21 hp12          ip5b_io
22 hp11          ip5b_io
23 hp15          ip5b_io
24 hp14          ip5b_io
25 svcc          power
26 sgnd          gnd
27 ado           ip5b_io
28 aci           ip5b_io
29 tio           ip5b_io
30 hp13          ip5b_io
31 hp10          ip5b_io

```

|    |         |         |
|----|---------|---------|
| 32 | hp9     | ip5b_io |
| 33 | hp8     | ip5b_io |
| 34 | hp7     | ip5b_io |
| 35 | hp6     | ip5b_io |
| 36 | hp5     | ip5b_io |
| 37 | hp4     | ip5b_io |
| 38 | svcc    | power   |
| 39 | sgnd    | gnd     |
| 40 | hp3     | ip5b_io |
| 41 | hp2     | ip5b_io |
| 42 | hp1     | ip5b_io |
| 43 | hp0     | ip5b_io |
| 44 | ires_   | ip5b_i  |
| 45 | pvcc    | power   |
| 46 | pcap    | power   |
| 47 | pgnd    | gnd     |
| 48 | sdo5    | ipbw_io |
| 49 | qvcch   | power   |
| 50 | fst_1   | ipbw_io |
| 51 | aa2     | icbc_o  |
| 52 | cas_    | icbc_o  |
| 53 | sck_1   | ipbw_io |
| 54 | qgnd    | gnd     |
| 55 | cxtdis_ | iexlh_i |
| 56 | qvcc1   | power   |
| 57 | cvcc    | power   |
| 58 | cgnd    | gnd     |
| 59 | fsr_1   | ipbw_io |
| 60 | sckr1   | ipbw_io |
| 61 | nmi_    | ipbw_i  |
| 62 | ta_     | icbc_o  |
| 63 | br_     | icbc_o  |
| 64 | bb_     | icbc_o  |
| 65 | cvcc    | power   |
| 66 | cgnd    | gnd     |
| 67 | wr_     | icbc_o  |
| 68 | rd_     | icbc_o  |
| 69 | aa1     | icbc_o  |
| 70 | aa0     | icbc_o  |
| 71 | bg_     | icbc_o  |
| 72 | eab0    | icba_o  |
| 73 | eab1    | icba_o  |
| 74 | avcc    | power   |
| 75 | agnd    | gnd     |
| 76 | eab2    | icba_o  |
| 77 | eab3    | icba_o  |
| 78 | eab4    | icba_o  |
| 79 | eab5    | icba_o  |
| 80 | avcc    | power   |
| 81 | agnd    | gnd     |
| 82 | eab6    | icba_o  |
| 83 | eab7    | icba_o  |
| 84 | eab8    | icba_o  |

|           |         |
|-----------|---------|
| 85 eab9   | icba_o  |
| 86 avcc   | power   |
| 87 agnd   | gnd     |
| 88 eab10  | icba_o  |
| 89 eab11  | icba_o  |
| 90 qgnd   | gnd     |
| 91 qvcc   | power   |
| 92 eab12  | icba_o  |
| 93 eab13  | icba_o  |
| 94 eab14  | icba_o  |
| 95 qvcch  | power   |
| 96 agnd   | gnd     |
| 97 eab15  | icba_o  |
| 98 eab16  | icba_o  |
| 99 eab17  | icba_o  |
| 100 edb0  | icba_io |
| 101 edb1  | icba_io |
| 102 edb2  | icba_io |
| 103 dvcc  | power   |
| 104 dgnd  | gnd     |
| 105 edb3  | icba_io |
| 106 edb4  | icba_io |
| 107 edb5  | icba_io |
| 108 edb6  | icba_io |
| 109 edb7  | icba_io |
| 110 edb8  | icba_io |
| 111 dvcc  | power   |
| 112 dgnd  | gnd     |
| 113 edb9  | icba_io |
| 114 edb10 | icba_io |
| 115 edb11 | icba_io |
| 116 edb12 | icba_io |
| 117 edb13 | icba_io |
| 118 edb14 | icba_io |
| 119 dvcc  | power   |
| 120 dgnd  | gnd     |
| 121 edb15 | icba_io |
| 122 edb16 | icba_io |
| 123 edb17 | icba_io |
| 124 edb18 | icba_io |
| 125 edb19 | icba_io |
| 126 qvccl | power   |
| 127 qgnd  | gnd     |
| 128 edb20 | icba_io |
| 129 dvcc  | power   |
| 130 dgnd  | gnd     |
| 131 edb21 | icba_io |
| 132 edb22 | icba_io |
| 133 edb23 | icba_io |
| 134 irqd_ | ip5b_i  |
| 135 irqc_ | ip5b_i  |
| 136 irqb_ | ip5b_i  |
| 137 irqa_ | ip5b_i  |

```

138 sdo4_1          ip5b_io
139 tdo             ip5b_o
140 tdi             ip5b_i
141 tck             ip5b_i
142 tms             ip5b_i
143 mosi            ip5b_io
144 sda             ip5b_io
|
[Model]            ip5b_i
Model_type          Input
Polarity            Non-Inverting
Vinl= 0.8000v
Vinh= 2.000v
C_comp             5.00pF          5.00pF          5.00pF
|
|
[Voltage Range]     3.3v          3v          3.6v
[GND_clamp]
|voltage            I(typ)          I(min)          I(max)
|
-3.30e+00  -5.21e+02  -3.65e+02  -5.18e+02
-3.10e+00  -4.69e+02  -3.30e+02  -4.67e+02
-2.90e+00  -4.18e+02  -2.94e+02  -4.16e+02
-2.70e+00  -3.67e+02  -2.59e+02  -3.65e+02
-2.50e+00  -3.16e+02  -2.23e+02  -3.14e+02
-2.30e+00  -2.65e+02  -1.88e+02  -2.63e+02
-2.10e+00  -2.14e+02  -1.52e+02  -2.12e+02
-1.90e+00  -1.63e+02  -1.17e+02  -1.61e+02
-1.70e+00  -1.13e+02  -9.25e+01  -1.10e+02
-1.50e+00  -7.83e+01  -6.88e+01  -7.58e+01
-1.30e+00  -4.43e+01  -4.52e+01  -4.17e+01
-1.10e+00  -1.02e+01  -2.15e+01  -7.67e+00
-9.00e-01  -9.69e-03  -1.18e+00  -7.81e-03
-7.00e-01  -2.83e-04  -5.70e-03  -8.42e-04
-5.00e-01  -1.35e-06  -4.53e-05  -1.00e-05
-3.00e-01  -1.31e-09  -3.74e-07  -8.58e-09
-1.00e-01  -2.92e-11  -3.00e-09  -3.64e-11
0.000e+00  -2.44e-11  -5.14e-10  -2.79e-11
|
|
[Model]            ip5b_io
Model_type          I/O
Polarity            Non-Inverting
Vinl= 0.8000v
Vinh= 2.000v
C_comp             5.00pF          5.00pF          5.00pF
|
|
[Voltage Range]     3.3v          3v          3.6v
[Pulldown]
|voltage            I(typ)          I(min)          I(max)
|
-3.30e+00  -5.21e+02  -3.65e+02  -5.18e+02

```

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -3.10e+00 | -4.69e+02 | -3.30e+02 | -4.67e+02 |
| -2.90e+00 | -4.18e+02 | -2.94e+02 | -4.16e+02 |
| -2.70e+00 | -3.67e+02 | -2.59e+02 | -3.65e+02 |
| -2.50e+00 | -3.16e+02 | -2.23e+02 | -3.14e+02 |
| -2.30e+00 | -2.65e+02 | -1.88e+02 | -2.63e+02 |
| -2.10e+00 | -2.14e+02 | -1.52e+02 | -2.12e+02 |
| -1.90e+00 | -1.63e+02 | -1.17e+02 | -1.61e+02 |
| -1.70e+00 | -1.13e+02 | -9.25e+01 | -1.10e+02 |
| -1.50e+00 | -7.83e+01 | -6.88e+01 | -7.58e+01 |
| -1.30e+00 | -4.43e+01 | -4.52e+01 | -4.17e+01 |
| -1.10e+00 | -1.02e+01 | -2.15e+01 | -7.69e+00 |
| -9.00e-01 | -5.10e-02 | -1.18e+00 | -5.63e-02 |
| -7.00e-01 | -3.65e-02 | -2.25e-02 | -4.28e-02 |
| -5.00e-01 | -2.65e-02 | -1.38e-02 | -3.12e-02 |
| -3.00e-01 | -1.62e-02 | -8.35e-03 | -1.91e-02 |
| -1.00e-01 | -5.49e-03 | -2.80e-03 | -6.52e-03 |
| 1.000e-01 | 5.377e-03 | 2.744e-03 | 6.427e-03 |
| 3.000e-01 | 1.516e-02 | 7.871e-03 | 1.823e-02 |
| 5.000e-01 | 2.370e-02 | 1.252e-02 | 2.869e-02 |
| 7.000e-01 | 3.098e-02 | 1.667e-02 | 3.776e-02 |
| 9.000e-01 | 3.700e-02 | 2.026e-02 | 4.544e-02 |
| 1.100e+00 | 4.175e-02 | 2.324e-02 | 5.171e-02 |
| 1.300e+00 | 4.531e-02 | 2.553e-02 | 5.660e-02 |
| 1.500e+00 | 4.779e-02 | 2.709e-02 | 6.023e-02 |
| 1.700e+00 | 4.935e-02 | 2.803e-02 | 6.271e-02 |
| 1.900e+00 | 5.013e-02 | 2.851e-02 | 6.419e-02 |
| 2.100e+00 | 5.046e-02 | 2.876e-02 | 6.494e-02 |
| 2.300e+00 | 5.063e-02 | 2.892e-02 | 6.525e-02 |
| 2.500e+00 | 5.075e-02 | 2.904e-02 | 6.540e-02 |
| 2.700e+00 | 5.085e-02 | 2.912e-02 | 6.549e-02 |
| 2.900e+00 | 5.090e-02 | 2.876e-02 | 6.555e-02 |
| 3.100e+00 | 4.771e-02 | 2.994e-02 | 6.561e-02 |
| 3.300e+00 | 4.525e-02 | 3.321e-02 | 6.182e-02 |
| 3.500e+00 | 4.657e-02 | 3.570e-02 | 6.049e-02 |
| 3.700e+00 | 4.904e-02 | 3.801e-02 | 6.178e-02 |
| 3.900e+00 | 5.221e-02 | 4.029e-02 | 6.450e-02 |
| 4.100e+00 | 5.524e-02 | 4.253e-02 | 6.659e-02 |
| 4.300e+00 | 5.634e-02 | 4.463e-02 | 6.867e-02 |
| 4.500e+00 | 5.751e-02 | 4.645e-02 | 6.970e-02 |
| 4.700e+00 | 5.634e-02 | 4.786e-02 | 6.938e-02 |
| 4.900e+00 | 5.648e-02 | 4.881e-02 | 6.960e-02 |
| 5.100e+00 | 5.664e-02 | 4.912e-02 | 6.983e-02 |
| 5.300e+00 | 5.679e-02 | 4.795e-02 | 7.005e-02 |
| 5.500e+00 | 5.693e-02 | 4.679e-02 | 7.026e-02 |
| 5.700e+00 | 5.707e-02 | 4.688e-02 | 7.049e-02 |
| 5.900e+00 | 5.722e-02 | 4.700e-02 | 7.074e-02 |
| 6.100e+00 | 5.741e-02 | 4.712e-02 | 7.105e-02 |
| 6.300e+00 | 5.766e-02 | 4.723e-02 | 7.147e-02 |
| 6.500e+00 | 5.801e-02 | 4.733e-02 | 7.205e-02 |
| 6.600e+00 | 5.824e-02 | 4.737e-02 | 7.242e-02 |
|           |           |           |           |
| [Pullup]  |           |           |           |
| voltage   | I(typ)    | I(min)    | I(max)    |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
|           |           |           |           |
| -3.30e+00 | 2.922e-04 | 2.177e-04 | 4.123e-04 |
| -3.10e+00 | 2.881e-04 | 2.175e-04 | 4.021e-04 |
| -2.90e+00 | 2.853e-04 | 2.173e-04 | 3.946e-04 |
| -2.70e+00 | 2.836e-04 | 2.172e-04 | 3.893e-04 |
| -2.50e+00 | 2.825e-04 | 2.171e-04 | 3.857e-04 |
| -2.30e+00 | 2.819e-04 | 2.170e-04 | 3.834e-04 |
| -2.10e+00 | 2.815e-04 | 2.169e-04 | 3.820e-04 |
| -1.90e+00 | 2.813e-04 | 2.167e-04 | 3.812e-04 |
| -1.70e+00 | 2.812e-04 | 2.520e-04 | 3.808e-04 |
| -1.50e+00 | 2.811e-04 | 3.078e-02 | 3.806e-04 |
| -1.30e+00 | 2.810e-04 | 2.684e-02 | 3.804e-04 |
| -1.10e+00 | 2.809e-04 | 2.277e-02 | 3.802e-04 |
| -9.00e-01 | 2.808e-04 | 1.864e-02 | 3.801e-04 |
| -7.00e-01 | 2.997e-04 | 1.447e-02 | 3.799e-04 |
| -5.00e-01 | 1.750e-02 | 1.031e-02 | 3.797e-04 |
| -3.00e-01 | 1.048e-02 | 6.181e-03 | 3.776e-04 |
| -1.00e-01 | 3.487e-03 | 2.084e-03 | 4.568e-03 |
| 1.000e-01 | -3.40e-03 | -2.03e-03 | -4.22e-03 |
| 3.000e-01 | -9.69e-03 | -5.71e-03 | -1.24e-02 |
| 5.000e-01 | -1.52e-02 | -8.99e-03 | -1.95e-02 |
| 7.000e-01 | -2.02e-02 | -1.19e-02 | -2.61e-02 |
| 9.000e-01 | -2.46e-02 | -1.43e-02 | -3.21e-02 |
| 1.100e+00 | -2.84e-02 | -1.62e-02 | -3.73e-02 |
| 1.300e+00 | -3.14e-02 | -1.77e-02 | -4.18e-02 |
| 1.500e+00 | -3.37e-02 | -1.88e-02 | -4.55e-02 |
| 1.700e+00 | -3.55e-02 | -1.95e-02 | -4.85e-02 |
| 1.900e+00 | -3.68e-02 | -2.00e-02 | -5.09e-02 |
| 2.100e+00 | -3.78e-02 | -2.04e-02 | -5.27e-02 |
| 2.300e+00 | -3.85e-02 | -2.07e-02 | -5.41e-02 |
| 2.500e+00 | -3.91e-02 | -2.10e-02 | -5.51e-02 |
| 2.700e+00 | -3.96e-02 | -2.12e-02 | -5.60e-02 |
| 2.900e+00 | -4.01e-02 | -2.15e-02 | -5.67e-02 |
| 3.100e+00 | -4.04e-02 | -2.17e-02 | -5.74e-02 |
| 3.300e+00 | -4.08e-02 | -2.18e-02 | -5.79e-02 |
| 3.500e+00 | -4.11e-02 | -2.20e-02 | -5.84e-02 |
| 3.700e+00 | -4.14e-02 | -2.78e-02 | -5.89e-02 |
| 3.900e+00 | -4.17e-02 | -1.20e+00 | -5.94e-02 |
| 4.100e+00 | -4.32e-02 | -2.15e+01 | -5.98e-02 |
| 4.300e+00 | -4.08e-01 | -4.52e+01 | -6.10e-02 |
| 4.500e+00 | -2.73e+01 | -6.89e+01 | -6.84e-02 |
| 4.700e+00 | -6.13e+01 | -9.25e+01 | -7.73e+00 |
| 4.900e+00 | -9.54e+01 | -1.17e+02 | -4.18e+01 |
| 5.100e+00 | -1.38e+02 | -1.52e+02 | -7.59e+01 |
| 5.300e+00 | -1.89e+02 | -1.88e+02 | -1.11e+02 |
| 5.500e+00 | -2.40e+02 | -2.23e+02 | -1.61e+02 |
| 5.700e+00 | -2.91e+02 | -2.59e+02 | -2.12e+02 |
| 5.900e+00 | -3.42e+02 | -2.94e+02 | -2.63e+02 |
| 6.100e+00 | -3.93e+02 | -3.30e+02 | -3.14e+02 |
| 6.300e+00 | -4.44e+02 | -3.65e+02 | -3.65e+02 |
| 6.500e+00 | -4.95e+02 | -4.01e+02 | -4.16e+02 |
| 6.600e+00 | -5.21e+02 | -4.18e+02 | -4.41e+02 |
|           |           |           |           |

```

[GND_clamp]
|voltage          I(typ)          I(min)          I(max)
|
-3.30e+00 -5.21e+02 -3.65e+02 -5.18e+02
-3.10e+00 -4.69e+02 -3.30e+02 -4.67e+02
-2.90e+00 -4.18e+02 -2.94e+02 -4.16e+02
-2.70e+00 -3.67e+02 -2.59e+02 -3.65e+02
-2.50e+00 -3.16e+02 -2.23e+02 -3.14e+02
-2.30e+00 -2.65e+02 -1.88e+02 -2.63e+02
-2.10e+00 -2.14e+02 -1.52e+02 -2.12e+02
-1.90e+00 -1.63e+02 -1.17e+02 -1.61e+02
-1.70e+00 -1.13e+02 -9.25e+01 -1.10e+02
-1.50e+00 -7.83e+01 -6.88e+01 -7.58e+01
-1.30e+00 -4.43e+01 -4.52e+01 -4.17e+01
-1.10e+00 -1.02e+01 -2.15e+01 -7.67e+00
-9.00e-01 -9.69e-03 -1.18e+00 -7.81e-03
-7.00e-01 -2.83e-04 -5.70e-03 -8.42e-04
-5.00e-01 -1.35e-06 -4.53e-05 -1.00e-05
-3.00e-01 -1.31e-09 -3.74e-07 -8.58e-09
-1.00e-01 -2.92e-11 -3.00e-09 -3.64e-11
0.000e+00 -2.44e-11 -5.14e-10 -2.79e-11
|
[Ramp]
R_load = 50.00
|voltage          I(typ)          I(min)          I(max)
|
|
dV/dt_r          1.030/0.465      0.605/0.676      1.320/0.366
|
|
dV/dt_f          1.290/0.671      0.829/0.122      1.520/0.431
|
|
[Model]          ip5b_o
Model_type        3-state
Polarity          Non-Inverting
C_comp            5.00pF          5.00pF          5.00pF
|
|
[Voltage Range]   3.3v          3v          3.6v
[Pulldown]
|voltage          I(typ)          I(min)          I(max)
|
-3.30e+00 -5.21e+02 -3.65e+02 -5.18e+02
-3.10e+00 -4.69e+02 -3.30e+02 -4.67e+02
-2.90e+00 -4.18e+02 -2.94e+02 -4.16e+02
-2.70e+00 -3.67e+02 -2.59e+02 -3.65e+02
-2.50e+00 -3.16e+02 -2.23e+02 -3.14e+02
-2.30e+00 -2.65e+02 -1.88e+02 -2.63e+02
-2.10e+00 -2.14e+02 -1.52e+02 -2.12e+02
-1.90e+00 -1.63e+02 -1.17e+02 -1.61e+02
-1.70e+00 -1.13e+02 -9.25e+01 -1.10e+02
-1.50e+00 -7.83e+01 -6.88e+01 -7.58e+01

```

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -1.30e+00 | -4.43e+01 | -4.52e+01 | -4.17e+01 |
| -1.10e+00 | -1.02e+01 | -2.15e+01 | -7.69e+00 |
| -9.00e-01 | -5.10e-02 | -1.18e+00 | -5.63e-02 |
| -7.00e-01 | -3.65e-02 | -2.25e-02 | -4.28e-02 |
| -5.00e-01 | -2.65e-02 | -1.38e-02 | -3.12e-02 |
| -3.00e-01 | -1.62e-02 | -8.35e-03 | -1.91e-02 |
| -1.00e-01 | -5.49e-03 | -2.80e-03 | -6.52e-03 |
| 1.000e-01 | 5.377e-03 | 2.744e-03 | 6.427e-03 |
| 3.000e-01 | 1.516e-02 | 7.871e-03 | 1.823e-02 |
| 5.000e-01 | 2.370e-02 | 1.252e-02 | 2.869e-02 |
| 7.000e-01 | 3.098e-02 | 1.667e-02 | 3.776e-02 |
| 9.000e-01 | 3.700e-02 | 2.026e-02 | 4.544e-02 |
| 1.100e+00 | 4.175e-02 | 2.324e-02 | 5.171e-02 |
| 1.300e+00 | 4.531e-02 | 2.553e-02 | 5.660e-02 |
| 1.500e+00 | 4.779e-02 | 2.709e-02 | 6.023e-02 |
| 1.700e+00 | 4.935e-02 | 2.803e-02 | 6.271e-02 |
| 1.900e+00 | 5.013e-02 | 2.851e-02 | 6.419e-02 |
| 2.100e+00 | 5.046e-02 | 2.876e-02 | 6.494e-02 |
| 2.300e+00 | 5.063e-02 | 2.892e-02 | 6.525e-02 |
| 2.500e+00 | 5.075e-02 | 2.904e-02 | 6.540e-02 |
| 2.700e+00 | 5.085e-02 | 2.912e-02 | 6.549e-02 |
| 2.900e+00 | 5.090e-02 | 2.876e-02 | 6.555e-02 |
| 3.100e+00 | 4.771e-02 | 2.994e-02 | 6.561e-02 |
| 3.300e+00 | 4.525e-02 | 3.321e-02 | 6.182e-02 |
| 3.500e+00 | 4.657e-02 | 3.570e-02 | 6.049e-02 |
| 3.700e+00 | 4.904e-02 | 3.801e-02 | 6.178e-02 |
| 3.900e+00 | 5.221e-02 | 4.029e-02 | 6.450e-02 |
| 4.100e+00 | 5.524e-02 | 4.253e-02 | 6.659e-02 |
| 4.300e+00 | 5.634e-02 | 4.463e-02 | 6.867e-02 |
| 4.500e+00 | 5.751e-02 | 4.645e-02 | 6.970e-02 |
| 4.700e+00 | 5.634e-02 | 4.786e-02 | 6.938e-02 |
| 4.900e+00 | 5.648e-02 | 4.881e-02 | 6.960e-02 |
| 5.100e+00 | 5.664e-02 | 4.912e-02 | 6.983e-02 |
| 5.300e+00 | 5.679e-02 | 4.795e-02 | 7.005e-02 |
| 5.500e+00 | 5.693e-02 | 4.679e-02 | 7.026e-02 |
| 5.700e+00 | 5.707e-02 | 4.688e-02 | 7.049e-02 |
| 5.900e+00 | 5.722e-02 | 4.700e-02 | 7.074e-02 |
| 6.100e+00 | 5.741e-02 | 4.712e-02 | 7.105e-02 |
| 6.300e+00 | 5.766e-02 | 4.723e-02 | 7.147e-02 |
| 6.500e+00 | 5.801e-02 | 4.733e-02 | 7.205e-02 |
| 6.600e+00 | 5.824e-02 | 4.737e-02 | 7.242e-02 |
|           |           |           |           |
| [Pullup]  |           |           |           |
| voltage   | I(typ)    | I(min)    | I(max)    |
|           |           |           |           |
| -3.30e+00 | 2.922e-04 | 2.177e-04 | 4.123e-04 |
| -3.10e+00 | 2.881e-04 | 2.175e-04 | 4.021e-04 |
| -2.90e+00 | 2.853e-04 | 2.173e-04 | 3.946e-04 |
| -2.70e+00 | 2.836e-04 | 2.172e-04 | 3.893e-04 |
| -2.50e+00 | 2.825e-04 | 2.171e-04 | 3.857e-04 |
| -2.30e+00 | 2.819e-04 | 2.170e-04 | 3.834e-04 |
| -2.10e+00 | 2.815e-04 | 2.169e-04 | 3.820e-04 |
| -1.90e+00 | 2.813e-04 | 2.167e-04 | 3.812e-04 |

|             |           |           |           |
|-------------|-----------|-----------|-----------|
| -1.70e+00   | 2.812e-04 | 2.520e-04 | 3.808e-04 |
| -1.50e+00   | 2.811e-04 | 3.078e-02 | 3.806e-04 |
| -1.30e+00   | 2.810e-04 | 2.684e-02 | 3.804e-04 |
| -1.10e+00   | 2.809e-04 | 2.277e-02 | 3.802e-04 |
| -9.00e-01   | 2.808e-04 | 1.864e-02 | 3.801e-04 |
| -7.00e-01   | 2.997e-04 | 1.447e-02 | 3.799e-04 |
| -5.00e-01   | 1.750e-02 | 1.031e-02 | 3.797e-04 |
| -3.00e-01   | 1.048e-02 | 6.181e-03 | 3.776e-04 |
| -1.00e-01   | 3.487e-03 | 2.084e-03 | 4.568e-03 |
| 1.000e-01   | -3.40e-03 | -2.03e-03 | -4.22e-03 |
| 3.000e-01   | -9.69e-03 | -5.71e-03 | -1.24e-02 |
| 5.000e-01   | -1.52e-02 | -8.99e-03 | -1.95e-02 |
| 7.000e-01   | -2.02e-02 | -1.19e-02 | -2.61e-02 |
| 9.000e-01   | -2.46e-02 | -1.43e-02 | -3.21e-02 |
| 1.100e+00   | -2.84e-02 | -1.62e-02 | -3.73e-02 |
| 1.300e+00   | -3.14e-02 | -1.77e-02 | -4.18e-02 |
| 1.500e+00   | -3.37e-02 | -1.88e-02 | -4.55e-02 |
| 1.700e+00   | -3.55e-02 | -1.95e-02 | -4.85e-02 |
| 1.900e+00   | -3.68e-02 | -2.00e-02 | -5.09e-02 |
| 2.100e+00   | -3.78e-02 | -2.04e-02 | -5.27e-02 |
| 2.300e+00   | -3.85e-02 | -2.07e-02 | -5.41e-02 |
| 2.500e+00   | -3.91e-02 | -2.10e-02 | -5.51e-02 |
| 2.700e+00   | -3.96e-02 | -2.12e-02 | -5.60e-02 |
| 2.900e+00   | -4.01e-02 | -2.15e-02 | -5.67e-02 |
| 3.100e+00   | -4.04e-02 | -2.17e-02 | -5.74e-02 |
| 3.300e+00   | -4.08e-02 | -2.18e-02 | -5.79e-02 |
| 3.500e+00   | -4.11e-02 | -2.20e-02 | -5.84e-02 |
| 3.700e+00   | -4.14e-02 | -2.78e-02 | -5.89e-02 |
| 3.900e+00   | -4.17e-02 | -1.20e+00 | -5.94e-02 |
| 4.100e+00   | -4.32e-02 | -2.15e+01 | -5.98e-02 |
| 4.300e+00   | -4.08e-01 | -4.52e+01 | -6.10e-02 |
| 4.500e+00   | -2.73e+01 | -6.89e+01 | -6.84e-02 |
| 4.700e+00   | -6.13e+01 | -9.25e+01 | -7.73e+00 |
| 4.900e+00   | -9.54e+01 | -1.17e+02 | -4.18e+01 |
| 5.100e+00   | -1.38e+02 | -1.52e+02 | -7.59e+01 |
| 5.300e+00   | -1.89e+02 | -1.88e+02 | -1.11e+02 |
| 5.500e+00   | -2.40e+02 | -2.23e+02 | -1.61e+02 |
| 5.700e+00   | -2.91e+02 | -2.59e+02 | -2.12e+02 |
| 5.900e+00   | -3.42e+02 | -2.94e+02 | -2.63e+02 |
| 6.100e+00   | -3.93e+02 | -3.30e+02 | -3.14e+02 |
| 6.300e+00   | -4.44e+02 | -3.65e+02 | -3.65e+02 |
| 6.500e+00   | -4.95e+02 | -4.01e+02 | -4.16e+02 |
| 6.600e+00   | -5.21e+02 | -4.18e+02 | -4.41e+02 |
|             |           |           |           |
| [GND_clamp] |           |           |           |
| voltage     | I(typ)    | I(min)    | I(max)    |
|             |           |           |           |
| -3.30e+00   | -5.21e+02 | -3.65e+02 | -5.18e+02 |
| -3.10e+00   | -4.69e+02 | -3.30e+02 | -4.67e+02 |
| -2.90e+00   | -4.18e+02 | -2.94e+02 | -4.16e+02 |
| -2.70e+00   | -3.67e+02 | -2.59e+02 | -3.65e+02 |
| -2.50e+00   | -3.16e+02 | -2.23e+02 | -3.14e+02 |
| -2.30e+00   | -2.65e+02 | -1.88e+02 | -2.63e+02 |

|                 |               |             |             |
|-----------------|---------------|-------------|-------------|
| -2.10e+00       | -2.14e+02     | -1.52e+02   | -2.12e+02   |
| -1.90e+00       | -1.63e+02     | -1.17e+02   | -1.61e+02   |
| -1.70e+00       | -1.13e+02     | -9.25e+01   | -1.10e+02   |
| -1.50e+00       | -7.83e+01     | -6.88e+01   | -7.58e+01   |
| -1.30e+00       | -4.43e+01     | -4.52e+01   | -4.17e+01   |
| -1.10e+00       | -1.02e+01     | -2.15e+01   | -7.67e+00   |
| -9.00e-01       | -9.69e-03     | -1.18e+00   | -7.81e-03   |
| -7.00e-01       | -2.83e-04     | -5.70e-03   | -8.42e-04   |
| -5.00e-01       | -1.35e-06     | -4.53e-05   | -1.00e-05   |
| -3.00e-01       | -1.31e-09     | -3.74e-07   | -8.58e-09   |
| -1.00e-01       | -2.92e-11     | -3.00e-09   | -3.64e-11   |
| 0.000e+00       | -2.44e-11     | -5.14e-10   | -2.79e-11   |
|                 |               |             |             |
| [Ramp]          |               |             |             |
| R_load = 50.00  |               |             |             |
| voltage         | I(typ)        | I(min)      | I(max)      |
|                 |               |             |             |
| dV/dt_r         | 1.030/0.465   | 0.605/0.676 | 1.320/0.366 |
|                 |               |             |             |
| dV/dt_f         | 1.290/0.671   | 0.829/0.122 | 1.520/0.431 |
|                 |               |             |             |
| [Model]         | icba_io       |             |             |
| Model_type      | I/O           |             |             |
| Polarity        | Non-Inverting |             |             |
| Vinl=           | 0.8000v       |             |             |
| Vinh=           | 2.000v        |             |             |
| C_comp          | 5.00pF        | 5.00pF      | 5.00pF      |
|                 |               |             |             |
| [Voltage Range] | 3.3v          | 3v          | 3.6v        |
| [Pulldown]      |               |             |             |
| voltage         | I(typ)        | I(min)      | I(max)      |
|                 |               |             |             |
| -3.30e+00       | -5.20e+02     | -3.65e+02   | -5.18e+02   |
| -3.10e+00       | -4.69e+02     | -3.30e+02   | -4.67e+02   |
| -2.90e+00       | -4.18e+02     | -2.94e+02   | -4.16e+02   |
| -2.70e+00       | -3.67e+02     | -2.59e+02   | -3.65e+02   |
| -2.50e+00       | -3.16e+02     | -2.23e+02   | -3.14e+02   |
| -2.30e+00       | -2.65e+02     | -1.88e+02   | -2.63e+02   |
| -2.10e+00       | -2.14e+02     | -1.52e+02   | -2.12e+02   |
| -1.90e+00       | -1.63e+02     | -1.17e+02   | -1.60e+02   |
| -1.70e+00       | -1.13e+02     | -9.25e+01   | -1.10e+02   |
| -1.50e+00       | -7.83e+01     | -6.88e+01   | -7.58e+01   |
| -1.30e+00       | -4.43e+01     | -4.52e+01   | -4.17e+01   |
| -1.10e+00       | -1.02e+01     | -2.15e+01   | -7.68e+00   |
| -9.00e-01       | -2.70e-02     | -1.19e+00   | -2.90e-02   |
| -7.00e-01       | -1.32e-02     | -1.25e-02   | -1.63e-02   |
| -5.00e-01       | -9.33e-03     | -4.69e-03   | -1.10e-02   |
| -3.00e-01       | -5.75e-03     | -2.81e-03   | -6.76e-03   |
| -1.00e-01       | -1.97e-03     | -9.48e-04   | -2.32e-03   |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| 1.000e-01 | 1.945e-03 | 9.285e-04 | 2.307e-03 |
| 3.000e-01 | 5.507e-03 | 2.640e-03 | 6.599e-03 |
| 5.000e-01 | 8.649e-03 | 4.168e-03 | 1.048e-02 |
| 7.000e-01 | 1.136e-02 | 5.504e-03 | 1.393e-02 |
| 9.000e-01 | 1.364e-02 | 6.636e-03 | 1.693e-02 |
| 1.100e+00 | 1.547e-02 | 7.551e-03 | 1.950e-02 |
| 1.300e+00 | 1.688e-02 | 8.240e-03 | 2.162e-02 |
| 1.500e+00 | 1.299e-01 | 6.458e-02 | 2.331e-02 |
| 1.700e+00 | 1.366e-01 | 6.746e-02 | 1.755e-01 |
| 1.900e+00 | 1.404e-01 | 6.916e-02 | 1.847e-01 |
| 2.100e+00 | 1.423e-01 | 7.006e-02 | 1.907e-01 |
| 2.300e+00 | 1.433e-01 | 7.059e-02 | 1.940e-01 |
| 2.500e+00 | 1.440e-01 | 7.098e-02 | 1.958e-01 |
| 2.700e+00 | 1.445e-01 | 7.128e-02 | 1.970e-01 |
| 2.900e+00 | 1.450e-01 | 7.154e-02 | 1.979e-01 |
| 3.100e+00 | 1.454e-01 | 7.176e-02 | 1.986e-01 |
| 3.300e+00 | 1.458e-01 | 7.196e-02 | 1.993e-01 |
| 3.500e+00 | 1.461e-01 | 7.223e-02 | 1.999e-01 |
| 3.700e+00 | 1.464e-01 | 8.810e-02 | 2.004e-01 |
| 3.900e+00 | 1.469e-01 | 2.589e+00 | 2.009e-01 |
| 4.100e+00 | 1.490e-01 | 1.451e+01 | 2.015e-01 |
| 4.300e+00 | 1.501e+00 | 2.658e+01 | 2.030e-01 |
| 4.500e+00 | 1.813e+01 | 3.866e+01 | 2.385e-01 |
| 4.700e+00 | 3.540e+01 | 5.076e+01 | 9.563e+00 |
| 4.900e+00 | 5.269e+01 | 6.461e+01 | 2.682e+01 |
| 5.100e+00 | 7.541e+01 | 8.261e+01 | 4.409e+01 |
| 5.300e+00 | 1.012e+02 | 1.006e+02 | 6.258e+01 |
| 5.500e+00 | 1.270e+02 | 1.186e+02 | 8.836e+01 |
| 5.700e+00 | 1.527e+02 | 1.366e+02 | 1.141e+02 |
| 5.900e+00 | 1.785e+02 | 1.546e+02 | 1.399e+02 |
| 6.100e+00 | 2.043e+02 | 1.726e+02 | 1.657e+02 |
| 6.300e+00 | 2.301e+02 | 1.906e+02 | 1.915e+02 |
| 6.500e+00 | 2.559e+02 | 2.086e+02 | 2.173e+02 |
| 6.600e+00 | 2.688e+02 | 2.176e+02 | 2.302e+02 |
|           |           |           |           |
| [Pullup]  |           |           |           |
| voltage   | I(typ)    | I(min)    | I(max)    |
|           |           |           |           |
| -3.30e+00 | 2.686e+02 | 1.905e+02 | 2.686e+02 |
| -3.10e+00 | 2.428e+02 | 1.725e+02 | 2.428e+02 |
| -2.90e+00 | 2.170e+02 | 1.545e+02 | 2.170e+02 |
| -2.70e+00 | 1.912e+02 | 1.365e+02 | 1.912e+02 |
| -2.50e+00 | 1.655e+02 | 1.185e+02 | 1.655e+02 |
| -2.30e+00 | 1.397e+02 | 1.005e+02 | 1.397e+02 |
| -2.10e+00 | 1.139e+02 | 8.253e+01 | 1.139e+02 |
| -1.90e+00 | 8.814e+01 | 6.454e+01 | 8.814e+01 |
| -1.70e+00 | 6.237e+01 | 5.068e+01 | 6.237e+01 |
| -1.50e+00 | 4.389e+01 | 3.859e+01 | 4.389e+01 |
| -1.30e+00 | 2.662e+01 | 2.651e+01 | 2.662e+01 |
| -1.10e+00 | 9.360e+00 | 1.444e+01 | 9.362e+00 |
| -9.00e-01 | 4.275e-02 | 2.518e+00 | 4.663e-02 |
| -7.00e-01 | 8.208e-03 | 2.012e-02 | 1.070e-02 |
| -5.00e-01 | 5.635e-03 | 3.518e-03 | 7.068e-03 |

|             |           |           |           |
|-------------|-----------|-----------|-----------|
| -3.00e-01   | 3.370e-03 | 2.053e-03 | 4.233e-03 |
| -1.00e-01   | 1.118e-03 | 6.789e-04 | 1.410e-03 |
| 1.000e-01   | -1.09e-03 | -6.56e-04 | -1.38e-03 |
| 3.000e-01   | -3.12e-03 | -1.86e-03 | -3.99e-03 |
| 5.000e-01   | -4.96e-03 | -2.93e-03 | -6.39e-03 |
| 7.000e-01   | -6.60e-03 | -3.87e-03 | -8.59e-03 |
| 9.000e-01   | -8.04e-03 | -4.66e-03 | -1.06e-02 |
| 1.100e+00   | -9.26e-03 | -5.30e-03 | -1.23e-02 |
| 1.300e+00   | -1.03e-02 | -6.55e-02 | -1.38e-02 |
| 1.500e+00   | -1.25e-01 | -6.93e-02 | -1.70e-01 |
| 1.700e+00   | -1.31e-01 | -7.19e-02 | -1.82e-01 |
| 1.900e+00   | -1.36e-01 | -7.38e-02 | -1.91e-01 |
| 2.100e+00   | -1.40e-01 | -7.53e-02 | -1.97e-01 |
| 2.300e+00   | -1.42e-01 | -7.65e-02 | -2.03e-01 |
| 2.500e+00   | -1.44e-01 | -7.76e-02 | -2.07e-01 |
| 2.700e+00   | -1.46e-01 | -7.85e-02 | -2.10e-01 |
| 2.900e+00   | -1.48e-01 | -7.93e-02 | -2.13e-01 |
| 3.100e+00   | -1.49e-01 | -8.00e-02 | -2.15e-01 |
| 3.300e+00   | -1.50e-01 | -8.06e-02 | -2.17e-01 |
| 3.500e+00   | -1.52e-01 | -8.13e-02 | -2.19e-01 |
| 3.700e+00   | -1.53e-01 | -8.84e-02 | -2.21e-01 |
| 3.900e+00   | -1.54e-01 | -1.26e+00 | -2.22e-01 |
| 4.100e+00   | -1.57e-01 | -2.16e+01 | -2.24e-01 |
| 4.300e+00   | -5.25e-01 | -4.53e+01 | -2.27e-01 |
| 4.500e+00   | -2.74e+01 | -6.89e+01 | -2.38e-01 |
| 4.700e+00   | -6.14e+01 | -9.26e+01 | -7.90e+00 |
| 4.900e+00   | -9.55e+01 | -1.17e+02 | -4.20e+01 |
| 5.100e+00   | -1.38e+02 | -1.52e+02 | -7.60e+01 |
| 5.300e+00   | -1.89e+02 | -1.88e+02 | -1.11e+02 |
| 5.500e+00   | -2.40e+02 | -2.23e+02 | -1.61e+02 |
| 5.700e+00   | -2.91e+02 | -2.59e+02 | -2.12e+02 |
| 5.900e+00   | -3.42e+02 | -2.94e+02 | -2.63e+02 |
| 6.100e+00   | -3.93e+02 | -3.30e+02 | -3.14e+02 |
| 6.300e+00   | -4.44e+02 | -3.65e+02 | -3.65e+02 |
| 6.500e+00   | -4.95e+02 | -4.01e+02 | -4.16e+02 |
| 6.600e+00   | -5.21e+02 | -4.19e+02 | -4.42e+02 |
|             |           |           |           |
| [GND_clamp] |           |           |           |
| voltage     | I(typ)    | I(min)    | I(max)    |
|             |           |           |           |
| -3.30e+00   | -5.20e+02 | -3.65e+02 | -5.18e+02 |
| -3.10e+00   | -4.69e+02 | -3.30e+02 | -4.67e+02 |
| -2.90e+00   | -4.18e+02 | -2.94e+02 | -4.16e+02 |
| -2.70e+00   | -3.67e+02 | -2.59e+02 | -3.65e+02 |
| -2.50e+00   | -3.16e+02 | -2.23e+02 | -3.14e+02 |
| -2.30e+00   | -2.65e+02 | -1.88e+02 | -2.63e+02 |
| -2.10e+00   | -2.14e+02 | -1.52e+02 | -2.12e+02 |
| -1.90e+00   | -1.63e+02 | -1.17e+02 | -1.60e+02 |
| -1.70e+00   | -1.13e+02 | -9.25e+01 | -1.10e+02 |
| -1.50e+00   | -7.83e+01 | -6.88e+01 | -7.58e+01 |
| -1.30e+00   | -4.43e+01 | -4.52e+01 | -4.17e+01 |
| -1.10e+00   | -1.02e+01 | -2.15e+01 | -7.67e+00 |
| -9.00e-01   | -1.22e-02 | -1.18e+00 | -1.17e-02 |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -7.00e-01 | -5.18e-04 | -6.62e-03 | -1.56e-03 |
| -5.00e-01 | -2.43e-06 | -6.64e-05 | -1.80e-05 |
| -3.00e-01 | -2.33e-09 | -6.35e-07 | -1.54e-08 |
| -1.00e-01 | -2.10e-11 | -6.31e-09 | -2.99e-11 |
| 0.000e+00 | -1.70e-11 | -1.95e-09 | -1.91e-11 |

|

[POWER\_clamp]

| voltage   | I(typ)    | I(min)    | I(max)    |
|-----------|-----------|-----------|-----------|
|           |           |           |           |
| -3.30e+00 | 2.686e+02 | 1.905e+02 | 2.686e+02 |
| -3.10e+00 | 2.428e+02 | 1.725e+02 | 2.428e+02 |
| -2.90e+00 | 2.170e+02 | 1.545e+02 | 2.170e+02 |
| -2.70e+00 | 1.912e+02 | 1.365e+02 | 1.912e+02 |
| -2.50e+00 | 1.655e+02 | 1.185e+02 | 1.655e+02 |
| -2.30e+00 | 1.397e+02 | 1.005e+02 | 1.397e+02 |
| -2.10e+00 | 1.139e+02 | 8.253e+01 | 1.139e+02 |
| -1.90e+00 | 8.814e+01 | 6.454e+01 | 8.814e+01 |
| -1.70e+00 | 6.236e+01 | 5.068e+01 | 6.237e+01 |
| -1.50e+00 | 4.389e+01 | 3.859e+01 | 4.389e+01 |
| -1.30e+00 | 2.662e+01 | 2.651e+01 | 2.662e+01 |
| -1.10e+00 | 9.358e+00 | 1.444e+01 | 9.359e+00 |
| -9.00e-01 | 3.399e-02 | 2.517e+00 | 3.554e-02 |
| -7.00e-01 | 3.426e-04 | 1.577e-02 | 9.211e-04 |
| -5.00e-01 | 2.840e-06 | 7.857e-05 | 1.655e-05 |
| -3.00e-01 | 3.401e-09 | 6.836e-07 | 1.946e-08 |
| -1.00e-01 | 6.162e-11 | 7.379e-09 | 7.622e-11 |
| 0.000e+00 | 5.758e-11 | 2.438e-09 | 6.240e-11 |

|

[Ramp]

R\_load = 50.00

| voltage | I(typ)      | I(min)      | I(max)      |
|---------|-------------|-------------|-------------|
|         |             |             |             |
|         |             |             |             |
| dV/dt_r | 1.680/0.164 | 1.360/0.329 | 1.900/0.124 |
|         |             |             |             |
| dV/dt_f | 1.690/0.219 | 1.310/0.442 | 1.880/0.155 |
|         |             |             |             |
|         |             |             |             |

[Model]

icba\_o

Model\_type 3-state

Polarity Non-Inverting

C\_comp 5.00pF 5.00pF 5.00pF

|

[Voltage Range] 3.3v 3v 3.6v

[Pulldown]

| voltage   | I(typ)    | I(min)    | I(max)    |
|-----------|-----------|-----------|-----------|
|           |           |           |           |
| -3.30e+00 | -5.20e+02 | -3.65e+02 | -5.18e+02 |
| -3.10e+00 | -4.69e+02 | -3.30e+02 | -4.67e+02 |
| -2.90e+00 | -4.18e+02 | -2.94e+02 | -4.16e+02 |
| -2.70e+00 | -3.67e+02 | -2.59e+02 | -3.65e+02 |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -2.50e+00 | -3.16e+02 | -2.23e+02 | -3.14e+02 |
| -2.30e+00 | -2.65e+02 | -1.88e+02 | -2.63e+02 |
| -2.10e+00 | -2.14e+02 | -1.52e+02 | -2.12e+02 |
| -1.90e+00 | -1.63e+02 | -1.17e+02 | -1.60e+02 |
| -1.70e+00 | -1.13e+02 | -9.25e+01 | -1.10e+02 |
| -1.50e+00 | -7.83e+01 | -6.88e+01 | -7.58e+01 |
| -1.30e+00 | -4.43e+01 | -4.52e+01 | -4.17e+01 |
| -1.10e+00 | -1.02e+01 | -2.15e+01 | -7.68e+00 |
| -9.00e-01 | -2.70e-02 | -1.19e+00 | -2.90e-02 |
| -7.00e-01 | -1.32e-02 | -1.25e-02 | -1.63e-02 |
| -5.00e-01 | -9.33e-03 | -4.69e-03 | -1.10e-02 |
| -3.00e-01 | -5.75e-03 | -2.81e-03 | -6.76e-03 |
| -1.00e-01 | -1.97e-03 | -9.48e-04 | -2.32e-03 |
| 1.000e-01 | 1.945e-03 | 9.285e-04 | 2.307e-03 |
| 3.000e-01 | 5.507e-03 | 2.640e-03 | 6.599e-03 |
| 5.000e-01 | 8.649e-03 | 4.168e-03 | 1.048e-02 |
| 7.000e-01 | 1.136e-02 | 5.504e-03 | 1.393e-02 |
| 9.000e-01 | 1.364e-02 | 6.636e-03 | 1.693e-02 |
| 1.100e+00 | 1.547e-02 | 7.551e-03 | 1.950e-02 |
| 1.300e+00 | 1.688e-02 | 8.240e-03 | 2.162e-02 |
| 1.500e+00 | 1.299e-01 | 6.458e-02 | 2.331e-02 |
| 1.700e+00 | 1.366e-01 | 6.746e-02 | 1.755e-01 |
| 1.900e+00 | 1.404e-01 | 6.916e-02 | 1.847e-01 |
| 2.100e+00 | 1.423e-01 | 7.006e-02 | 1.907e-01 |
| 2.300e+00 | 1.433e-01 | 7.059e-02 | 1.940e-01 |
| 2.500e+00 | 1.440e-01 | 7.098e-02 | 1.958e-01 |
| 2.700e+00 | 1.445e-01 | 7.128e-02 | 1.970e-01 |
| 2.900e+00 | 1.450e-01 | 7.154e-02 | 1.979e-01 |
| 3.100e+00 | 1.454e-01 | 7.176e-02 | 1.986e-01 |
| 3.300e+00 | 1.458e-01 | 7.196e-02 | 1.993e-01 |
| 3.500e+00 | 1.461e-01 | 7.223e-02 | 1.999e-01 |
| 3.700e+00 | 1.464e-01 | 8.810e-02 | 2.004e-01 |
| 3.900e+00 | 1.469e-01 | 2.589e+00 | 2.009e-01 |
| 4.100e+00 | 1.490e-01 | 1.451e+01 | 2.015e-01 |
| 4.300e+00 | 1.501e+00 | 2.658e+01 | 2.030e-01 |
| 4.500e+00 | 1.813e+01 | 3.866e+01 | 2.385e-01 |
| 4.700e+00 | 3.540e+01 | 5.076e+01 | 9.563e+00 |
| 4.900e+00 | 5.269e+01 | 6.461e+01 | 2.682e+01 |
| 5.100e+00 | 7.541e+01 | 8.261e+01 | 4.409e+01 |
| 5.300e+00 | 1.012e+02 | 1.006e+02 | 6.258e+01 |
| 5.500e+00 | 1.270e+02 | 1.186e+02 | 8.836e+01 |
| 5.700e+00 | 1.527e+02 | 1.366e+02 | 1.141e+02 |
| 5.900e+00 | 1.785e+02 | 1.546e+02 | 1.399e+02 |
| 6.100e+00 | 2.043e+02 | 1.726e+02 | 1.657e+02 |
| 6.300e+00 | 2.301e+02 | 1.906e+02 | 1.915e+02 |
| 6.500e+00 | 2.559e+02 | 2.086e+02 | 2.173e+02 |
| 6.600e+00 | 2.688e+02 | 2.176e+02 | 2.302e+02 |
|           |           |           |           |
| [Pullup]  |           |           |           |
| voltage   | I(typ)    | I(min)    | I(max)    |
|           |           |           |           |
| -3.30e+00 | 2.686e+02 | 1.905e+02 | 2.686e+02 |
| -3.10e+00 | 2.428e+02 | 1.725e+02 | 2.428e+02 |

|             |           |           |           |
|-------------|-----------|-----------|-----------|
| -2.90e+00   | 2.170e+02 | 1.545e+02 | 2.170e+02 |
| -2.70e+00   | 1.912e+02 | 1.365e+02 | 1.912e+02 |
| -2.50e+00   | 1.655e+02 | 1.185e+02 | 1.655e+02 |
| -2.30e+00   | 1.397e+02 | 1.005e+02 | 1.397e+02 |
| -2.10e+00   | 1.139e+02 | 8.253e+01 | 1.139e+02 |
| -1.90e+00   | 8.814e+01 | 6.454e+01 | 8.814e+01 |
| -1.70e+00   | 6.237e+01 | 5.068e+01 | 6.237e+01 |
| -1.50e+00   | 4.389e+01 | 3.859e+01 | 4.389e+01 |
| -1.30e+00   | 2.662e+01 | 2.651e+01 | 2.662e+01 |
| -1.10e+00   | 9.360e+00 | 1.444e+01 | 9.362e+00 |
| -9.00e-01   | 4.275e-02 | 2.518e+00 | 4.663e-02 |
| -7.00e-01   | 8.208e-03 | 2.012e-02 | 1.070e-02 |
| -5.00e-01   | 5.635e-03 | 3.518e-03 | 7.068e-03 |
| -3.00e-01   | 3.370e-03 | 2.053e-03 | 4.233e-03 |
| -1.00e-01   | 1.118e-03 | 6.789e-04 | 1.410e-03 |
| 1.000e-01   | -1.09e-03 | -6.56e-04 | -1.38e-03 |
| 3.000e-01   | -3.12e-03 | -1.86e-03 | -3.99e-03 |
| 5.000e-01   | -4.96e-03 | -2.93e-03 | -6.39e-03 |
| 7.000e-01   | -6.60e-03 | -3.87e-03 | -8.59e-03 |
| 9.000e-01   | -8.04e-03 | -4.66e-03 | -1.06e-02 |
| 1.100e+00   | -9.26e-03 | -5.30e-03 | -1.23e-02 |
| 1.300e+00   | -1.03e-02 | -6.55e-02 | -1.38e-02 |
| 1.500e+00   | -1.25e-01 | -6.93e-02 | -1.70e-01 |
| 1.700e+00   | -1.31e-01 | -7.19e-02 | -1.82e-01 |
| 1.900e+00   | -1.36e-01 | -7.38e-02 | -1.91e-01 |
| 2.100e+00   | -1.40e-01 | -7.53e-02 | -1.97e-01 |
| 2.300e+00   | -1.42e-01 | -7.65e-02 | -2.03e-01 |
| 2.500e+00   | -1.44e-01 | -7.76e-02 | -2.07e-01 |
| 2.700e+00   | -1.46e-01 | -7.85e-02 | -2.10e-01 |
| 2.900e+00   | -1.48e-01 | -7.93e-02 | -2.13e-01 |
| 3.100e+00   | -1.49e-01 | -8.00e-02 | -2.15e-01 |
| 3.300e+00   | -1.50e-01 | -8.06e-02 | -2.17e-01 |
| 3.500e+00   | -1.52e-01 | -8.13e-02 | -2.19e-01 |
| 3.700e+00   | -1.53e-01 | -8.84e-02 | -2.21e-01 |
| 3.900e+00   | -1.54e-01 | -1.26e+00 | -2.22e-01 |
| 4.100e+00   | -1.57e-01 | -2.16e+01 | -2.24e-01 |
| 4.300e+00   | -5.25e-01 | -4.53e+01 | -2.27e-01 |
| 4.500e+00   | -2.74e+01 | -6.89e+01 | -2.38e-01 |
| 4.700e+00   | -6.14e+01 | -9.26e+01 | -7.90e+00 |
| 4.900e+00   | -9.55e+01 | -1.17e+02 | -4.20e+01 |
| 5.100e+00   | -1.38e+02 | -1.52e+02 | -7.60e+01 |
| 5.300e+00   | -1.89e+02 | -1.88e+02 | -1.11e+02 |
| 5.500e+00   | -2.40e+02 | -2.23e+02 | -1.61e+02 |
| 5.700e+00   | -2.91e+02 | -2.59e+02 | -2.12e+02 |
| 5.900e+00   | -3.42e+02 | -2.94e+02 | -2.63e+02 |
| 6.100e+00   | -3.93e+02 | -3.30e+02 | -3.14e+02 |
| 6.300e+00   | -4.44e+02 | -3.65e+02 | -3.65e+02 |
| 6.500e+00   | -4.95e+02 | -4.01e+02 | -4.16e+02 |
| 6.600e+00   | -5.21e+02 | -4.19e+02 | -4.42e+02 |
|             |           |           |           |
| [GND_clamp] |           |           |           |
| voltage     | I(typ)    | I(min)    | I(max)    |
|             |           |           |           |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -3.30e+00 | -5.20e+02 | -3.65e+02 | -5.18e+02 |
| -3.10e+00 | -4.69e+02 | -3.30e+02 | -4.67e+02 |
| -2.90e+00 | -4.18e+02 | -2.94e+02 | -4.16e+02 |
| -2.70e+00 | -3.67e+02 | -2.59e+02 | -3.65e+02 |
| -2.50e+00 | -3.16e+02 | -2.23e+02 | -3.14e+02 |
| -2.30e+00 | -2.65e+02 | -1.88e+02 | -2.63e+02 |
| -2.10e+00 | -2.14e+02 | -1.52e+02 | -2.12e+02 |
| -1.90e+00 | -1.63e+02 | -1.17e+02 | -1.60e+02 |
| -1.70e+00 | -1.13e+02 | -9.25e+01 | -1.10e+02 |
| -1.50e+00 | -7.83e+01 | -6.88e+01 | -7.58e+01 |
| -1.30e+00 | -4.43e+01 | -4.52e+01 | -4.17e+01 |
| -1.10e+00 | -1.02e+01 | -2.15e+01 | -7.67e+00 |
| -9.00e-01 | -1.22e-02 | -1.18e+00 | -1.17e-02 |
| -7.00e-01 | -5.18e-04 | -6.62e-03 | -1.56e-03 |
| -5.00e-01 | -2.43e-06 | -6.64e-05 | -1.80e-05 |
| -3.00e-01 | -2.33e-09 | -6.35e-07 | -1.54e-08 |
| -1.00e-01 | -2.10e-11 | -6.31e-09 | -2.99e-11 |
| 0.000e+00 | -1.70e-11 | -1.95e-09 | -1.91e-11 |

|  
[POWER\_clamp]  
|voltage            I(typ)            I(min)            I(max)  
|

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -3.30e+00 | 2.686e+02 | 1.905e+02 | 2.686e+02 |
| -3.10e+00 | 2.428e+02 | 1.725e+02 | 2.428e+02 |
| -2.90e+00 | 2.170e+02 | 1.545e+02 | 2.170e+02 |
| -2.70e+00 | 1.912e+02 | 1.365e+02 | 1.912e+02 |
| -2.50e+00 | 1.655e+02 | 1.185e+02 | 1.655e+02 |
| -2.30e+00 | 1.397e+02 | 1.005e+02 | 1.397e+02 |
| -2.10e+00 | 1.139e+02 | 8.253e+01 | 1.139e+02 |
| -1.90e+00 | 8.814e+01 | 6.454e+01 | 8.814e+01 |
| -1.70e+00 | 6.236e+01 | 5.068e+01 | 6.237e+01 |
| -1.50e+00 | 4.389e+01 | 3.859e+01 | 4.389e+01 |
| -1.30e+00 | 2.662e+01 | 2.651e+01 | 2.662e+01 |
| -1.10e+00 | 9.358e+00 | 1.444e+01 | 9.359e+00 |
| -9.00e-01 | 3.399e-02 | 2.517e+00 | 3.554e-02 |
| -7.00e-01 | 3.426e-04 | 1.577e-02 | 9.211e-04 |
| -5.00e-01 | 2.840e-06 | 7.857e-05 | 1.655e-05 |
| -3.00e-01 | 3.401e-09 | 6.836e-07 | 1.946e-08 |
| -1.00e-01 | 6.162e-11 | 7.379e-09 | 7.622e-11 |
| 0.000e+00 | 5.758e-11 | 2.438e-09 | 6.240e-11 |

|  
[Ramp]  
R\_load = 50.00  
|voltage            I(typ)            I(min)            I(max)  
|

|         |             |             |             |
|---------|-------------|-------------|-------------|
| dV/dt_r | 1.680/0.164 | 1.360/0.329 | 1.900/0.124 |
|---------|-------------|-------------|-------------|

|         |             |             |             |
|---------|-------------|-------------|-------------|
| dV/dt_f | 1.690/0.219 | 1.310/0.442 | 1.880/0.155 |
|---------|-------------|-------------|-------------|

|  
[Model]            icbc\_o

| Model_type      | 3-state       |           |           |
|-----------------|---------------|-----------|-----------|
| Polarity        | Non-Inverting |           |           |
| C_comp          | 5.00pF        | 5.00pF    | 5.00pF    |
|                 |               |           |           |
|                 |               |           |           |
| [Voltage Range] | 3.3v          | 3v        | 3.6v      |
| [Pulldown]      |               |           |           |
| voltage         | I(typ)        | I(min)    | I(max)    |
|                 |               |           |           |
| -3.30e+00       | -5.20e+02     | -3.65e+02 | -5.18e+02 |
| -3.10e+00       | -4.69e+02     | -3.30e+02 | -4.67e+02 |
| -2.90e+00       | -4.18e+02     | -2.94e+02 | -4.16e+02 |
| -2.70e+00       | -3.67e+02     | -2.59e+02 | -3.65e+02 |
| -2.50e+00       | -3.16e+02     | -2.23e+02 | -3.14e+02 |
| -2.30e+00       | -2.65e+02     | -1.88e+02 | -2.63e+02 |
| -2.10e+00       | -2.14e+02     | -1.52e+02 | -2.11e+02 |
| -1.90e+00       | -1.63e+02     | -1.17e+02 | -1.60e+02 |
| -1.70e+00       | -1.13e+02     | -9.25e+01 | -1.10e+02 |
| -1.50e+00       | -7.83e+01     | -6.88e+01 | -7.58e+01 |
| -1.30e+00       | -4.42e+01     | -4.51e+01 | -4.17e+01 |
| -1.10e+00       | -1.02e+01     | -2.15e+01 | -7.67e+00 |
| -9.00e-01       | -2.51e-02     | -1.18e+00 | -2.65e-02 |
| -7.00e-01       | -1.30e-02     | -1.16e-02 | -1.58e-02 |
| -5.00e-01       | -9.33e-03     | -4.67e-03 | -1.10e-02 |
| -3.00e-01       | -5.75e-03     | -2.81e-03 | -6.76e-03 |
| -1.00e-01       | -1.97e-03     | -9.48e-04 | -2.32e-03 |
| 1.000e-01       | 1.945e-03     | 9.285e-04 | 2.307e-03 |
| 3.000e-01       | 5.507e-03     | 2.640e-03 | 6.599e-03 |
| 5.000e-01       | 8.649e-03     | 4.168e-03 | 1.048e-02 |
| 7.000e-01       | 1.136e-02     | 5.504e-03 | 1.393e-02 |
| 9.000e-01       | 1.364e-02     | 6.636e-03 | 1.693e-02 |
| 1.100e+00       | 1.547e-02     | 7.551e-03 | 1.950e-02 |
| 1.300e+00       | 1.688e-02     | 8.240e-03 | 2.162e-02 |
| 1.500e+00       | 9.632e-02     | 4.783e-02 | 2.331e-02 |
| 1.700e+00       | 1.012e-01     | 4.994e-02 | 1.302e-01 |
| 1.900e+00       | 1.039e-01     | 5.118e-02 | 1.369e-01 |
| 2.100e+00       | 1.053e-01     | 5.184e-02 | 1.412e-01 |
| 2.300e+00       | 1.060e-01     | 5.223e-02 | 1.436e-01 |
| 2.500e+00       | 1.065e-01     | 5.251e-02 | 1.449e-01 |
| 2.700e+00       | 1.069e-01     | 5.274e-02 | 1.458e-01 |
| 2.900e+00       | 1.073e-01     | 5.293e-02 | 1.464e-01 |
| 3.100e+00       | 1.076e-01     | 5.309e-02 | 1.470e-01 |
| 3.300e+00       | 1.078e-01     | 5.324e-02 | 1.475e-01 |
| 3.500e+00       | 1.081e-01     | 5.344e-02 | 1.479e-01 |
| 3.700e+00       | 1.083e-01     | 6.705e-02 | 1.483e-01 |
| 3.900e+00       | 1.086e-01     | 2.529e+00 | 1.487e-01 |
| 4.100e+00       | 1.103e-01     | 1.438e+01 | 1.491e-01 |
| 4.300e+00       | 1.437e+00     | 2.638e+01 | 1.503e-01 |
| 4.500e+00       | 1.800e+01     | 3.839e+01 | 1.810e-01 |
| 4.700e+00       | 3.519e+01     | 5.041e+01 | 9.452e+00 |
| 4.900e+00       | 5.241e+01     | 6.419e+01 | 2.664e+01 |
| 5.100e+00       | 7.505e+01     | 8.210e+01 | 4.384e+01 |
| 5.300e+00       | 1.007e+02     | 1.000e+02 | 6.224e+01 |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| 5.500e+00 | 1.264e+02 | 1.179e+02 | 8.794e+01 |
| 5.700e+00 | 1.522e+02 | 1.359e+02 | 1.136e+02 |
| 5.900e+00 | 1.779e+02 | 1.538e+02 | 1.394e+02 |
| 6.100e+00 | 2.036e+02 | 1.717e+02 | 1.651e+02 |
| 6.300e+00 | 2.293e+02 | 1.896e+02 | 1.908e+02 |
| 6.500e+00 | 2.550e+02 | 2.075e+02 | 2.165e+02 |
| 6.600e+00 | 2.678e+02 | 2.165e+02 | 2.293e+02 |
|           |           |           |           |
| [Pullup]  |           |           |           |
| voltage   | I(typ)    | I(min)    | I(max)    |
|           |           |           |           |
| -3.30e+00 | 2.677e+02 | 1.896e+02 | 2.677e+02 |
| -3.10e+00 | 2.420e+02 | 1.716e+02 | 2.420e+02 |
| -2.90e+00 | 2.163e+02 | 1.537e+02 | 2.163e+02 |
| -2.70e+00 | 1.906e+02 | 1.358e+02 | 1.906e+02 |
| -2.50e+00 | 1.649e+02 | 1.179e+02 | 1.649e+02 |
| -2.30e+00 | 1.392e+02 | 9.996e+01 | 1.392e+02 |
| -2.10e+00 | 1.135e+02 | 8.205e+01 | 1.135e+02 |
| -1.90e+00 | 8.778e+01 | 6.413e+01 | 8.778e+01 |
| -1.70e+00 | 6.208e+01 | 5.035e+01 | 6.208e+01 |
| -1.50e+00 | 4.368e+01 | 3.834e+01 | 4.368e+01 |
| -1.30e+00 | 2.649e+01 | 2.633e+01 | 2.649e+01 |
| -1.10e+00 | 9.302e+00 | 1.433e+01 | 9.303e+00 |
| -9.00e-01 | 3.838e-02 | 2.477e+00 | 4.183e-02 |
| -7.00e-01 | 8.115e-03 | 1.789e-02 | 1.045e-02 |
| -5.00e-01 | 5.634e-03 | 3.503e-03 | 7.064e-03 |
| -3.00e-01 | 3.370e-03 | 2.053e-03 | 4.233e-03 |
| -1.00e-01 | 1.118e-03 | 6.789e-04 | 1.410e-03 |
| 1.000e-01 | -1.09e-03 | -6.56e-04 | -1.38e-03 |
| 3.000e-01 | -3.12e-03 | -1.86e-03 | -3.99e-03 |
| 5.000e-01 | -4.96e-03 | -2.93e-03 | -6.39e-03 |
| 7.000e-01 | -6.60e-03 | -3.87e-03 | -8.59e-03 |
| 9.000e-01 | -8.04e-03 | -4.66e-03 | -1.06e-02 |
| 1.100e+00 | -9.26e-03 | -5.30e-03 | -1.23e-02 |
| 1.300e+00 | -1.03e-02 | -4.75e-02 | -1.41e-02 |
| 1.500e+00 | -9.03e-02 | -5.02e-02 | -1.23e-01 |
| 1.700e+00 | -9.49e-02 | -5.21e-02 | -1.31e-01 |
| 1.900e+00 | -9.84e-02 | -5.34e-02 | -1.38e-01 |
| 2.100e+00 | -1.01e-01 | -5.45e-02 | -1.43e-01 |
| 2.300e+00 | -1.03e-01 | -5.54e-02 | -1.47e-01 |
| 2.500e+00 | -1.05e-01 | -5.62e-02 | -1.50e-01 |
| 2.700e+00 | -1.06e-01 | -5.68e-02 | -1.52e-01 |
| 2.900e+00 | -1.07e-01 | -5.74e-02 | -1.54e-01 |
| 3.100e+00 | -1.08e-01 | -5.79e-02 | -1.56e-01 |
| 3.300e+00 | -1.09e-01 | -5.84e-02 | -1.57e-01 |
| 3.500e+00 | -1.10e-01 | -5.89e-02 | -1.59e-01 |
| 3.700e+00 | -1.11e-01 | -6.49e-02 | -1.60e-01 |
| 3.900e+00 | -1.11e-01 | -1.23e+00 | -1.61e-01 |
| 4.100e+00 | -1.14e-01 | -2.16e+01 | -1.62e-01 |
| 4.300e+00 | -4.76e-01 | -4.52e+01 | -1.64e-01 |
| 4.500e+00 | -2.73e+01 | -6.89e+01 | -1.73e-01 |
| 4.700e+00 | -6.14e+01 | -9.25e+01 | -7.82e+00 |
| 4.900e+00 | -9.54e+01 | -1.17e+02 | -4.19e+01 |

|               |           |           |           |
|---------------|-----------|-----------|-----------|
| 5.100e+00     | -1.38e+02 | -1.52e+02 | -7.59e+01 |
| 5.300e+00     | -1.89e+02 | -1.88e+02 | -1.11e+02 |
| 5.500e+00     | -2.40e+02 | -2.23e+02 | -1.61e+02 |
| 5.700e+00     | -2.91e+02 | -2.59e+02 | -2.12e+02 |
| 5.900e+00     | -3.42e+02 | -2.94e+02 | -2.63e+02 |
| 6.100e+00     | -3.93e+02 | -3.30e+02 | -3.14e+02 |
| 6.300e+00     | -4.44e+02 | -3.65e+02 | -3.65e+02 |
| 6.500e+00     | -4.95e+02 | -4.01e+02 | -4.16e+02 |
| 6.600e+00     | -5.20e+02 | -4.18e+02 | -4.41e+02 |
|               |           |           |           |
| [GND_clamp]   |           |           |           |
| voltage       | I(typ)    | I(min)    | I(max)    |
|               |           |           |           |
| -3.30e+00     | -5.20e+02 | -3.65e+02 | -5.18e+02 |
| -3.10e+00     | -4.69e+02 | -3.30e+02 | -4.67e+02 |
| -2.90e+00     | -4.18e+02 | -2.94e+02 | -4.16e+02 |
| -2.70e+00     | -3.67e+02 | -2.59e+02 | -3.65e+02 |
| -2.50e+00     | -3.16e+02 | -2.23e+02 | -3.14e+02 |
| -2.30e+00     | -2.65e+02 | -1.88e+02 | -2.63e+02 |
| -2.10e+00     | -2.14e+02 | -1.52e+02 | -2.11e+02 |
| -1.90e+00     | -1.63e+02 | -1.17e+02 | -1.60e+02 |
| -1.70e+00     | -1.13e+02 | -9.25e+01 | -1.10e+02 |
| -1.50e+00     | -7.83e+01 | -6.88e+01 | -7.58e+01 |
| -1.30e+00     | -4.42e+01 | -4.51e+01 | -4.17e+01 |
| -1.10e+00     | -1.02e+01 | -2.15e+01 | -7.66e+00 |
| -9.00e-01     | -1.03e-02 | -1.17e+00 | -9.27e-03 |
| -7.00e-01     | -3.74e-04 | -5.73e-03 | -1.14e-03 |
| -5.00e-01     | -1.72e-06 | -5.06e-05 | -1.28e-05 |
| -3.00e-01     | -1.67e-09 | -4.65e-07 | -1.10e-08 |
| -1.00e-01     | -2.03e-11 | -4.80e-09 | -2.71e-11 |
| 0.000e+00     | -1.69e-11 | -1.61e-09 | -1.89e-11 |
|               |           |           |           |
| [POWER_clamp] |           |           |           |
| voltage       | I(typ)    | I(min)    | I(max)    |
|               |           |           |           |
| -3.30e+00     | 2.677e+02 | 1.896e+02 | 2.677e+02 |
| -3.10e+00     | 2.420e+02 | 1.716e+02 | 2.420e+02 |
| -2.90e+00     | 2.163e+02 | 1.537e+02 | 2.163e+02 |
| -2.70e+00     | 1.906e+02 | 1.358e+02 | 1.906e+02 |
| -2.50e+00     | 1.649e+02 | 1.179e+02 | 1.649e+02 |
| -2.30e+00     | 1.392e+02 | 9.996e+01 | 1.392e+02 |
| -2.10e+00     | 1.135e+02 | 8.205e+01 | 1.135e+02 |
| -1.90e+00     | 8.778e+01 | 6.413e+01 | 8.778e+01 |
| -1.70e+00     | 6.208e+01 | 5.035e+01 | 6.208e+01 |
| -1.50e+00     | 4.368e+01 | 3.834e+01 | 4.368e+01 |
| -1.30e+00     | 2.649e+01 | 2.633e+01 | 2.649e+01 |
| -1.10e+00     | 9.300e+00 | 1.433e+01 | 9.301e+00 |
| -9.00e-01     | 2.962e-02 | 2.475e+00 | 3.075e-02 |
| -7.00e-01     | 2.501e-04 | 1.354e-02 | 6.708e-04 |
| -5.00e-01     | 2.066e-06 | 6.280e-05 | 1.204e-05 |
| -3.00e-01     | 2.487e-09 | 5.128e-07 | 1.417e-08 |
| -1.00e-01     | 5.672e-11 | 5.639e-09 | 6.832e-11 |
| 0.000e+00     | 5.334e-11 | 1.992e-09 | 5.783e-11 |

```

|
[Ramp]
R_load = 50.00
|voltage          I(typ)          I(min)          I(max)
|
|
dV/dt_r          1.570/0.200      1.210/0.411      1.810/0.149
|
|
dV/dt_f          1.590/0.304      1.170/0.673      1.800/0.205
|
|
[Model]          ipbw_i
Model_type        Input
Polarity          Non-Inverting
Vinl= 0.8000v
Vinh= 2.000v
C_comp           5.00pF           5.00pF           5.00pF
|
|
[Voltage Range]   3.3v            3v              3.6v
[GND_clamp]
|voltage          I(typ)          I(min)          I(max)
|
-3.30e+00        -5.20e+02      -3.65e+02      -5.17e+02
-3.10e+00        -4.69e+02      -3.29e+02      -4.66e+02
-2.90e+00        -4.18e+02      -2.94e+02      -4.15e+02
-2.70e+00        -3.67e+02      -2.58e+02      -3.64e+02
-2.50e+00        -3.16e+02      -2.23e+02      -3.13e+02
-2.30e+00        -2.65e+02      -1.88e+02      -2.62e+02
-2.10e+00        -2.14e+02      -1.52e+02      -2.11e+02
-1.90e+00        -1.63e+02      -1.17e+02      -1.60e+02
-1.70e+00        -1.13e+02      -9.24e+01      -1.10e+02
-1.50e+00        -7.82e+01      -6.87e+01      -7.57e+01
-1.30e+00        -4.42e+01      -4.51e+01      -4.16e+01
-1.10e+00        -1.02e+01      -2.15e+01      -7.64e+00
-9.00e-01        -7.17e-03      -1.16e+00      -4.87e-03
-7.00e-01        -1.14e-04      -4.39e-03      -3.03e-04
-5.00e-01        -4.86e-07      -2.55e-05      -2.73e-06
-3.00e-01        -5.19e-10      -1.91e-07      -2.57e-09
-1.00e-01        -1.91e-11      -2.47e-09      -2.19e-11
0.000e+00        -1.68e-11      -1.17e-09      -1.84e-11
|
[POWER_clamp]
|voltage          I(typ)          I(min)          I(max)
|
-3.30e+00        2.667e+02      1.885e+02      2.667e+02
-3.10e+00        2.411e+02      1.707e+02      2.411e+02
-2.90e+00        2.155e+02      1.528e+02      2.155e+02
-2.70e+00        1.898e+02      1.350e+02      1.898e+02
-2.50e+00        1.642e+02      1.172e+02      1.642e+02
-2.30e+00        1.386e+02      9.935e+01      1.386e+02
-2.10e+00        1.130e+02      8.152e+01      1.130e+02

```

|                              |           |           |           |
|------------------------------|-----------|-----------|-----------|
| -1.90e+00                    | 8.739e+01 | 6.369e+01 | 8.739e+01 |
| -1.70e+00                    | 6.178e+01 | 4.999e+01 | 6.178e+01 |
| -1.50e+00                    | 4.346e+01 | 3.806e+01 | 4.346e+01 |
| -1.30e+00                    | 2.634e+01 | 2.613e+01 | 2.634e+01 |
| -1.10e+00                    | 9.237e+00 | 1.421e+01 | 9.237e+00 |
| -9.00e-01                    | 2.454e-02 | 2.430e+00 | 2.488e-02 |
| -7.00e-01                    | 8.741e-05 | 1.104e-02 | 2.050e-04 |
| -5.00e-01                    | 6.316e-07 | 4.079e-05 | 2.961e-06 |
| -3.00e-01                    | 8.479e-10 | 2.484e-07 | 3.721e-09 |
| -1.00e-01                    | 4.420e-11 | 3.001e-09 | 4.943e-11 |
| 0.000e+00                    | 4.215e-11 | 1.346e-09 | 4.543e-11 |
|                              |           |           |           |
|                              |           |           |           |
| [Model] ipbw_io              |           |           |           |
| Model_type I/O               |           |           |           |
| Polarity Non-Inverting       |           |           |           |
| Vinl= 0.8000v                |           |           |           |
| Vinh= 2.000v                 |           |           |           |
| C_comp                       | 5.00pF    | 5.00pF    | 5.00pF    |
|                              |           |           |           |
|                              |           |           |           |
| [Voltage Range] 3.3v 3v 3.6v |           |           |           |
| [Pulldown]                   |           |           |           |
| voltage                      | I(typ)    | I(min)    | I(max)    |
|                              |           |           |           |
| -3.30e+00                    | -5.20e+02 | -3.65e+02 | -5.17e+02 |
| -3.10e+00                    | -4.69e+02 | -3.29e+02 | -4.66e+02 |
| -2.90e+00                    | -4.18e+02 | -2.94e+02 | -4.15e+02 |
| -2.70e+00                    | -3.67e+02 | -2.58e+02 | -3.64e+02 |
| -2.50e+00                    | -3.16e+02 | -2.23e+02 | -3.13e+02 |
| -2.30e+00                    | -2.65e+02 | -1.88e+02 | -2.62e+02 |
| -2.10e+00                    | -2.14e+02 | -1.52e+02 | -2.11e+02 |
| -1.90e+00                    | -1.63e+02 | -1.17e+02 | -1.60e+02 |
| -1.70e+00                    | -1.13e+02 | -9.24e+01 | -1.10e+02 |
| -1.50e+00                    | -7.82e+01 | -6.87e+01 | -7.57e+01 |
| -1.30e+00                    | -4.42e+01 | -4.51e+01 | -4.17e+01 |
| -1.10e+00                    | -1.02e+01 | -2.15e+01 | -7.66e+00 |
| -9.00e-01                    | -3.69e-02 | -1.17e+00 | -3.79e-02 |
| -7.00e-01                    | -2.52e-02 | -1.67e-02 | -2.81e-02 |
| -5.00e-01                    | -1.83e-02 | -9.77e-03 | -2.04e-02 |
| -3.00e-01                    | -1.11e-02 | -5.89e-03 | -1.24e-02 |
| -1.00e-01                    | -3.77e-03 | -1.98e-03 | -4.20e-03 |
| 1.000e-01                    | 3.729e-03 | 1.940e-03 | 4.177e-03 |
| 3.000e-01                    | 1.076e-02 | 5.578e-03 | 1.216e-02 |
| 5.000e-01                    | 1.723e-02 | 8.907e-03 | 1.965e-02 |
| 7.000e-01                    | 2.311e-02 | 1.191e-02 | 2.663e-02 |
| 9.000e-01                    | 2.836e-02 | 1.455e-02 | 3.305e-02 |
| 1.100e+00                    | 3.292e-02 | 1.680e-02 | 3.887e-02 |
| 1.300e+00                    | 3.675e-02 | 1.862e-02 | 4.404e-02 |
| 1.500e+00                    | 3.979e-02 | 1.997e-02 | 4.850e-02 |
| 1.700e+00                    | 4.205e-02 | 2.085e-02 | 5.223e-02 |
| 1.900e+00                    | 4.347e-02 | 2.136e-02 | 5.518e-02 |
| 2.100e+00                    | 4.413e-02 | 2.162e-02 | 5.728e-02 |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| 2.300e+00 | 4.445e-02 | 2.176e-02 | 5.843e-02 |
| 2.500e+00 | 4.465e-02 | 2.186e-02 | 5.899e-02 |
| 2.700e+00 | 4.479e-02 | 2.194e-02 | 5.931e-02 |
| 2.900e+00 | 4.492e-02 | 2.200e-02 | 5.953e-02 |
| 3.100e+00 | 4.502e-02 | 2.206e-02 | 5.971e-02 |
| 3.300e+00 | 4.511e-02 | 2.211e-02 | 5.986e-02 |
| 3.500e+00 | 4.519e-02 | 2.219e-02 | 5.999e-02 |
| 3.700e+00 | 4.526e-02 | 3.324e-02 | 6.010e-02 |
| 3.900e+00 | 4.536e-02 | 2.452e+00 | 6.021e-02 |
| 4.100e+00 | 4.614e-02 | 1.423e+01 | 6.032e-02 |
| 4.300e+00 | 1.344e+00 | 2.615e+01 | 6.065e-02 |
| 4.500e+00 | 1.783e+01 | 3.808e+01 | 8.548e-02 |
| 4.700e+00 | 3.495e+01 | 5.001e+01 | 9.298e+00 |
| 4.900e+00 | 5.208e+01 | 6.371e+01 | 2.640e+01 |
| 5.100e+00 | 7.463e+01 | 8.154e+01 | 4.352e+01 |
| 5.300e+00 | 1.002e+02 | 9.937e+01 | 6.184e+01 |
| 5.500e+00 | 1.259e+02 | 1.172e+02 | 8.745e+01 |
| 5.700e+00 | 1.515e+02 | 1.350e+02 | 1.131e+02 |
| 5.900e+00 | 1.771e+02 | 1.529e+02 | 1.387e+02 |
| 6.100e+00 | 2.027e+02 | 1.707e+02 | 1.643e+02 |
| 6.300e+00 | 2.283e+02 | 1.885e+02 | 1.899e+02 |
| 6.500e+00 | 2.539e+02 | 2.064e+02 | 2.155e+02 |
| 6.600e+00 | 2.667e+02 | 2.153e+02 | 2.283e+02 |
|           |           |           |           |
| [Pullup]  |           |           |           |
| voltage   | I(typ)    | I(min)    | I(max)    |
|           |           |           |           |
| -3.30e+00 | 2.667e+02 | 1.885e+02 | 2.667e+02 |
| -3.10e+00 | 2.411e+02 | 1.707e+02 | 2.411e+02 |
| -2.90e+00 | 2.155e+02 | 1.528e+02 | 2.155e+02 |
| -2.70e+00 | 1.898e+02 | 1.350e+02 | 1.898e+02 |
| -2.50e+00 | 1.642e+02 | 1.172e+02 | 1.642e+02 |
| -2.30e+00 | 1.386e+02 | 9.935e+01 | 1.386e+02 |
| -2.10e+00 | 1.130e+02 | 8.152e+01 | 1.130e+02 |
| -1.90e+00 | 8.739e+01 | 6.369e+01 | 8.739e+01 |
| -1.70e+00 | 6.178e+01 | 4.999e+01 | 6.178e+01 |
| -1.50e+00 | 4.346e+01 | 3.806e+01 | 4.346e+01 |
| -1.30e+00 | 2.635e+01 | 2.613e+01 | 2.635e+01 |
| -1.10e+00 | 9.243e+00 | 1.421e+01 | 9.245e+00 |
| -9.00e-01 | 5.536e-02 | 2.435e+00 | 6.260e-02 |
| -7.00e-01 | 2.847e-02 | 2.689e-02 | 3.437e-02 |
| -5.00e-01 | 2.025e-02 | 1.265e-02 | 2.451e-02 |
| -3.00e-01 | 1.208e-02 | 7.503e-03 | 1.467e-02 |
| -1.00e-01 | 3.994e-03 | 2.474e-03 | 4.868e-03 |
| 1.000e-01 | -3.88e-03 | -2.38e-03 | -4.76e-03 |
| 3.000e-01 | -1.11e-02 | -6.76e-03 | -1.37e-02 |
| 5.000e-01 | -1.76e-02 | -1.06e-02 | -2.20e-02 |
| 7.000e-01 | -2.35e-02 | -1.40e-02 | -2.95e-02 |
| 9.000e-01 | -2.86e-02 | -1.69e-02 | -3.63e-02 |
| 1.100e+00 | -3.30e-02 | -1.93e-02 | -4.23e-02 |
| 1.300e+00 | -3.65e-02 | -2.10e-02 | -4.75e-02 |
| 1.500e+00 | -3.92e-02 | -2.22e-02 | -5.17e-02 |
| 1.700e+00 | -4.12e-02 | -2.29e-02 | -5.51e-02 |

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| 1.900e+00 | -4.26e-02 | -2.35e-02 | -5.77e-02 |
| 2.100e+00 | -4.36e-02 | -2.38e-02 | -5.97e-02 |
| 2.300e+00 | -4.43e-02 | -2.42e-02 | -6.11e-02 |
| 2.500e+00 | -4.49e-02 | -2.44e-02 | -6.22e-02 |
| 2.700e+00 | -4.54e-02 | -2.47e-02 | -6.31e-02 |
| 2.900e+00 | -4.58e-02 | -2.49e-02 | -6.38e-02 |
| 3.100e+00 | -4.61e-02 | -2.50e-02 | -6.44e-02 |
| 3.300e+00 | -4.65e-02 | -2.52e-02 | -6.49e-02 |
| 3.500e+00 | -4.68e-02 | -2.54e-02 | -6.54e-02 |
| 3.700e+00 | -4.70e-02 | -2.99e-02 | -6.58e-02 |
| 3.900e+00 | -4.73e-02 | -1.19e+00 | -6.62e-02 |
| 4.100e+00 | -4.81e-02 | -2.15e+01 | -6.66e-02 |
| 4.300e+00 | -4.00e-01 | -4.51e+01 | -6.72e-02 |
| 4.500e+00 | -2.72e+01 | -6.87e+01 | -7.21e-02 |
| 4.700e+00 | -6.12e+01 | -9.24e+01 | -7.70e+00 |
| 4.900e+00 | -9.52e+01 | -1.17e+02 | -4.17e+01 |
| 5.100e+00 | -1.37e+02 | -1.52e+02 | -7.57e+01 |
| 5.300e+00 | -1.88e+02 | -1.88e+02 | -1.10e+02 |
| 5.500e+00 | -2.39e+02 | -2.23e+02 | -1.60e+02 |
| 5.700e+00 | -2.90e+02 | -2.58e+02 | -2.11e+02 |
| 5.900e+00 | -3.41e+02 | -2.94e+02 | -2.62e+02 |
| 6.100e+00 | -3.92e+02 | -3.29e+02 | -3.13e+02 |
| 6.300e+00 | -4.43e+02 | -3.65e+02 | -3.64e+02 |
| 6.500e+00 | -4.94e+02 | -4.00e+02 | -4.15e+02 |
| 6.600e+00 | -5.20e+02 | -4.18e+02 | -4.41e+02 |

|

[GND\_clamp]

|voltage                      I(typ)                      I(min)                      I(max)

|

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -3.30e+00 | -5.20e+02 | -3.65e+02 | -5.17e+02 |
| -3.10e+00 | -4.69e+02 | -3.29e+02 | -4.66e+02 |
| -2.90e+00 | -4.18e+02 | -2.94e+02 | -4.15e+02 |
| -2.70e+00 | -3.67e+02 | -2.58e+02 | -3.64e+02 |
| -2.50e+00 | -3.16e+02 | -2.23e+02 | -3.13e+02 |
| -2.30e+00 | -2.65e+02 | -1.88e+02 | -2.62e+02 |
| -2.10e+00 | -2.14e+02 | -1.52e+02 | -2.11e+02 |
| -1.90e+00 | -1.63e+02 | -1.17e+02 | -1.60e+02 |
| -1.70e+00 | -1.13e+02 | -9.24e+01 | -1.10e+02 |
| -1.50e+00 | -7.82e+01 | -6.87e+01 | -7.57e+01 |
| -1.30e+00 | -4.42e+01 | -4.51e+01 | -4.16e+01 |
| -1.10e+00 | -1.02e+01 | -2.15e+01 | -7.64e+00 |
| -9.00e-01 | -7.17e-03 | -1.16e+00 | -4.87e-03 |
| -7.00e-01 | -1.14e-04 | -4.39e-03 | -3.03e-04 |
| -5.00e-01 | -4.86e-07 | -2.55e-05 | -2.73e-06 |
| -3.00e-01 | -5.19e-10 | -1.91e-07 | -2.57e-09 |
| -1.00e-01 | -1.91e-11 | -2.47e-09 | -2.19e-11 |
| 0.000e+00 | -1.68e-11 | -1.17e-09 | -1.84e-11 |

|

[POWER\_clamp]

|voltage                      I(typ)                      I(min)                      I(max)

|

|           |           |           |           |
|-----------|-----------|-----------|-----------|
| -3.30e+00 | 2.667e+02 | 1.885e+02 | 2.667e+02 |
| -3.10e+00 | 2.411e+02 | 1.707e+02 | 2.411e+02 |

|                 |               |             |             |
|-----------------|---------------|-------------|-------------|
| -2.90e+00       | 2.155e+02     | 1.528e+02   | 2.155e+02   |
| -2.70e+00       | 1.898e+02     | 1.350e+02   | 1.898e+02   |
| -2.50e+00       | 1.642e+02     | 1.172e+02   | 1.642e+02   |
| -2.30e+00       | 1.386e+02     | 9.935e+01   | 1.386e+02   |
| -2.10e+00       | 1.130e+02     | 8.152e+01   | 1.130e+02   |
| -1.90e+00       | 8.739e+01     | 6.369e+01   | 8.739e+01   |
| -1.70e+00       | 6.178e+01     | 4.999e+01   | 6.178e+01   |
| -1.50e+00       | 4.346e+01     | 3.806e+01   | 4.346e+01   |
| -1.30e+00       | 2.634e+01     | 2.613e+01   | 2.634e+01   |
| -1.10e+00       | 9.237e+00     | 1.421e+01   | 9.237e+00   |
| -9.00e-01       | 2.454e-02     | 2.430e+00   | 2.488e-02   |
| -7.00e-01       | 8.741e-05     | 1.104e-02   | 2.050e-04   |
| -5.00e-01       | 6.316e-07     | 4.079e-05   | 2.961e-06   |
| -3.00e-01       | 8.479e-10     | 2.484e-07   | 3.721e-09   |
| -1.00e-01       | 4.420e-11     | 3.001e-09   | 4.943e-11   |
| 0.000e+00       | 4.215e-11     | 1.346e-09   | 4.543e-11   |
|                 |               |             |             |
| [Ramp]          |               |             |             |
| R_load = 50.00  |               |             |             |
| voltage         | I(typ)        | I(min)      | I(max)      |
|                 |               |             |             |
| dV/dt_r         | 1.140/0.494   | 0.699/0.978 | 1.400/0.354 |
|                 |               |             |             |
| dV/dt_f         | 1.150/0.505   | 0.642/0.956 | 1.350/0.350 |
|                 |               |             |             |
| [Model]         | iexlh_i       |             |             |
| Model_type      | Input         |             |             |
| Polarity        | Non-Inverting |             |             |
| Vinl=           | 0.8000v       |             |             |
| Vinh=           | 2.000v        |             |             |
| C_comp          | 5.00pF        | 5.00pF      | 5.00pF      |
|                 |               |             |             |
| [Voltage Range] | 3.3v          | 3v          | 3.6v        |
| [GND_clamp]     |               |             |             |
| voltage         | I(typ)        | I(min)      | I(max)      |
|                 |               |             |             |
| -3.30e+00       | -5.21e+02     | -3.66e+02   | -5.18e+02   |
| -3.10e+00       | -4.70e+02     | -3.30e+02   | -4.67e+02   |
| -2.90e+00       | -4.19e+02     | -2.95e+02   | -4.16e+02   |
| -2.70e+00       | -3.68e+02     | -2.59e+02   | -3.65e+02   |
| -2.50e+00       | -3.17e+02     | -2.24e+02   | -3.14e+02   |
| -2.30e+00       | -2.66e+02     | -1.89e+02   | -2.63e+02   |
| -2.10e+00       | -2.15e+02     | -1.53e+02   | -2.12e+02   |
| -1.90e+00       | -1.64e+02     | -1.18e+02   | -1.61e+02   |
| -1.70e+00       | -1.14e+02     | -9.34e+01   | -1.11e+02   |
| -1.50e+00       | -7.93e+01     | -6.98e+01   | -7.68e+01   |
| -1.30e+00       | -4.53e+01     | -4.62e+01   | -4.28e+01   |
| -1.10e+00       | -1.13e+01     | -2.26e+01   | -8.78e+00   |
| -9.00e-01       | -7.94e-03     | -1.87e+00   | -3.77e-03   |

---

```

-7.00e-01  -1.62e-06  -5.11e-03  -7.69e-07
-5.00e-01  -3.45e-10  -1.40e-05  -1.72e-10
-3.00e-01  -1.29e-11  -3.90e-08  -1.38e-11
-1.00e-01  -1.10e-11  -8.67e-10  -1.19e-11
0.000e+00  -1.01e-11  -7.13e-10  -1.10e-11
|
[POWER_clamp]
|voltage      I(typ)      I(min)      I(max)
|
-3.30e+00    2.653e+02    1.870e+02    2.653e+02
-3.10e+00    2.398e+02    1.693e+02    2.398e+02
-2.90e+00    2.143e+02    1.516e+02    2.143e+02
-2.70e+00    1.888e+02    1.339e+02    1.888e+02
-2.50e+00    1.633e+02    1.162e+02    1.633e+02
-2.30e+00    1.378e+02    9.847e+01    1.378e+02
-2.10e+00    1.123e+02    8.076e+01    1.123e+02
-1.90e+00    8.682e+01    6.305e+01    8.682e+01
-1.70e+00    6.133e+01    4.947e+01    6.133e+01
-1.50e+00    4.313e+01    3.766e+01    4.313e+01
-1.30e+00    2.614e+01    2.585e+01    2.614e+01
-1.10e+00    9.145e+00    1.404e+01    9.145e+00
-9.00e-01    1.797e-02    2.364e+00    1.797e-02
-7.00e-01    3.667e-06    7.589e-03    3.667e-06
-5.00e-01    7.730e-10    2.072e-05    7.748e-10
-3.00e-01    2.293e-11    5.767e-08    2.476e-11
-1.00e-01    2.096e-11    1.163e-09    2.278e-11
0.000e+00    2.004e-11    9.618e-10    2.186e-11
|
[End]

```



Symphony and OnCE are registered trademarks of Motorola, Inc.

Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and  are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

How to reach us:

**USA/Europe/Locations Not Listed:**

Motorola Literature Distribution  
P.O. Box 5405

Denver, Colorado 80217

1 (800) 441-2447

1 (303) 675-2140

**Asia/Pacific:**

Motorola Semiconductors H.K. Ltd.

8B Tai Ping Industrial Park

51 Ting Kok Road

Tai Po, N.T., Hong Kong

852-26629298

**Technical Resource Center:**

1 (800) 521-6274

**DSP Helpline**

dsphelp@dsp.sps.mot.com

**Japan:**

Nippon Motorola Ltd.

SPD, Strategic Planning Office

4-32-1, Nishi-Gotanda

Shinagawa-ku, Tokyo 141, Japan

81-3-5487-8488

**Internet:**

<http://dspaudio.motorola.com>

