DSP56304

Advance Information
24-BIT DIGITAL SIGNAL PROCESSOR

Motorola designed the ROM-based DSP56304 to support multifunction wireless and embedded DSP applications. In addition to the large on-chip ROM spaces, the DSP56304 also has a ROM patch feature that facilitates updates to the on-chip mask Program ROM-based on-chip software. The DSP56304 includes a triple timer module, Host Interface (HI08), an Enhanced Synchronous Serial Interface (ESSI), and a Serial Communications Interface (SCI). The DSP56300 core family includes a Phase Lock Loop (PLL), External Memory Interface (EMI), Data Arithmetic Logic Unit (Data ALU), 24-bit addressing, instruction cache, and DMA. The DSP56304 offers 66/80 MIPS using an internal 66/80 MHz clock at 3.0–3.6 volts.

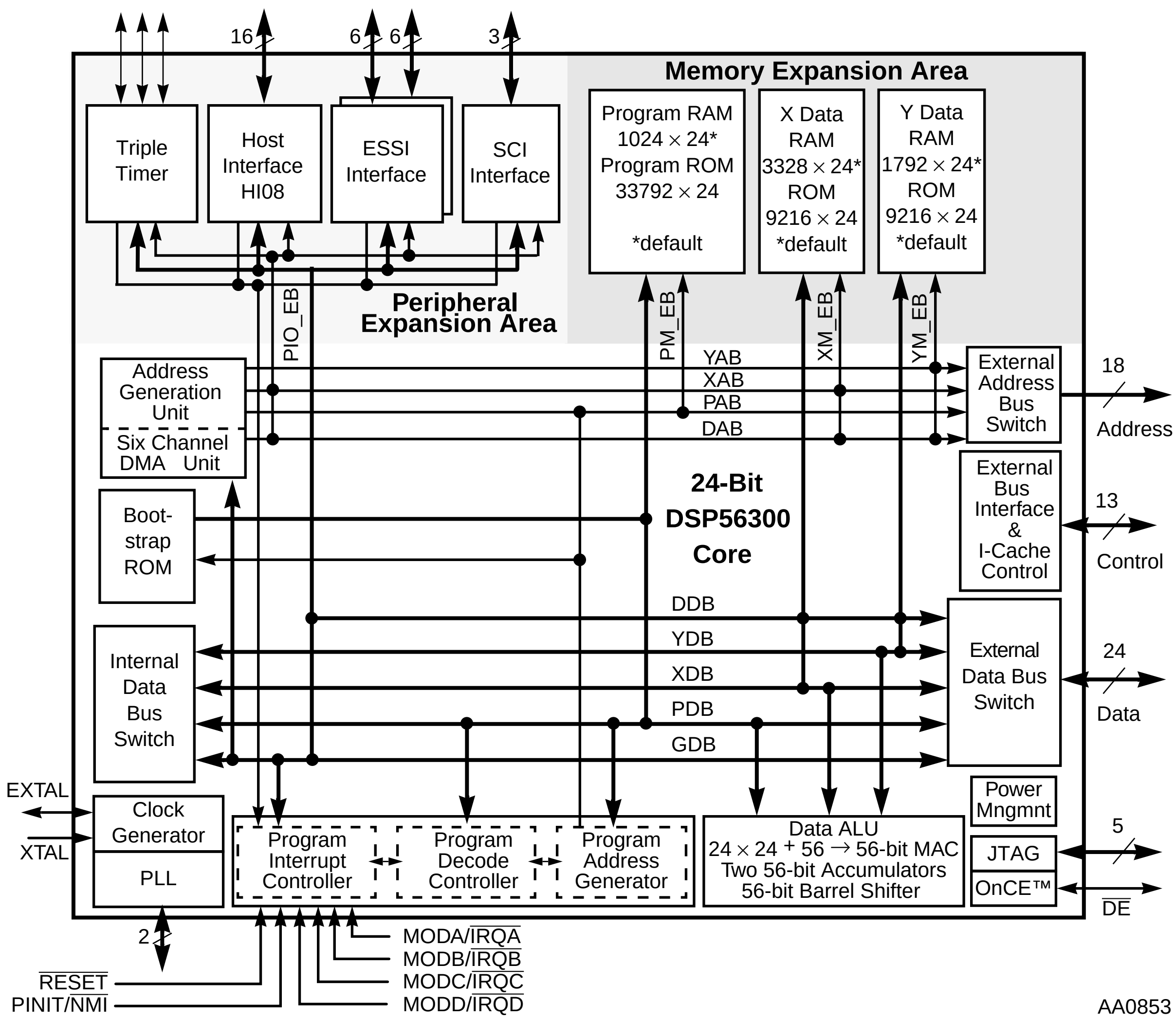

Figure 1 DSP56304 Block Diagram

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

Preliminary Data

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Data Sheet Conventions

This data sheet uses the following conventions:

$\overline{\text{OVERBAR}}$	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_{IL}/V_{OL}
$\overline{\text{PIN}}$	False	Deasserted	V_{IH}/V_{OH}
PIN	True	Asserted	V_{IH}/V_{OH}
PIN	False	Deasserted	V_{IL}/V_{OL}

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

FEATURES

DSP56304 FEATURES

High Performance DSP56300 Core

- 66/80 Million Instructions Per Second (MIPS) with a 66/80 MHz clock
- Object code compatible with the DSP56000 core
- Highly parallel instruction set
- Fully pipelined 24 × 24-bit parallel Multiplier-Accumulator (MAC)
- 56-bit parallel barrel shifter
- 24-bit or 16-bit arithmetic support under software control
- Position independent code support
- Addressing modes optimized for DSP applications
- On-chip instruction cache controller
- On-chip memory-expandable hardware stack
- Nested hardware DO loops
- Fast auto-return interrupts
- On-chip concurrent six-channel DMA controller
- On-chip Phase Lock Loop (PLL) and clock generator
- On-Chip Emulation (OnCE™) module
- JTAG Test Access Port (TAP)
- Address Tracing mode reflects internal accesses at the external port

On-chip Memories

- Program RAM, Instruction Cache, X data RAM, and Y data RAM size is programmable:

Instruction Cache	Switch Mode	Program RAM Size	Instruction Cache Size	X Data RAM Size	Y Data RAM Size
disabled	disabled	1024 × 24-bit	0	3328 × 24-bit	1792 × 24-bit
enabled	disabled	0	1024 × 24-bit	3328 × 24-bit	1792 × 24-bit
disabled	enabled	3584 × 24-bit	0	2048 × 24-bit	512 × 24-bit
enabled	enabled	2560 × 24-bit	1024 × 24-bit	2048 × 24-bit	512 × 24-bit

- 33, 792 × 24-bit Program ROM with Patch mode update capability using instruction cache memory space
- 9,216 × 24-bit X data ROM and 9,216 × 24-bit Y data ROM
- 192 × 24-bit bootstrap ROM

Off-chip Memory Expansion

- Data memory expansion to two 256 K × 24-bit word memory spaces (the usage of address attribute pins and/or DRAM interface may further extend the data memory expansion up to two 16 M × 24-bit words memory space)
- Program memory expansion to one 256 K × 24-bit word memory space (the usage of address attribute pins and/or DRAM interface may further extend the program memory expansion up to two 16 M × 24-bit words memory space)
- External memory expansion port
- Chip select logic requires no additional circuitry to interface to SRAMs and SSRAMs
- On-chip DRAM controller requires no additional circuitry to interface to DRAMs

On-chip Peripherals

- 8-bit parallel Host Interface (HI08), ISA-compatible bus interface, providing a cost-effective solution for applications not requiring the PCI bus
- Two Enhanced Synchronous Serial Interfaces (ESSI0 and ESSI1)
- Serial Communications Interface (SCI) with baud rate generator
- Triple timer module
- Up to thirty-four programmable General Purpose I/O pins (GPIO), depending on which peripherals are enabled

Reduced Power Dissipation

- Very low power CMOS design
- Wait and Stop low power standby modes
- Fully-static logic, operation frequency down to DC
- Optimized power management circuitry

TARGET APPLICATIONS

The DSP56304 is intended for use in embedded multifunction DSP applications requiring large on-board ROM spaces, such as wireless products that combine standard cellular phone operation with options such as two-way digital paging and fax capability in one unit.

PRODUCT DOCUMENTATION

The three manuals listed in **Table 1** are required for a complete description of the DSP56304 and are necessary to design with the part properly. Documentation is available from a local Motorola distributor, a Motorola semiconductor sales office, a Motorola Literature Distribution Center, or the World Wide Web.

Table 1 DSP56304 Documentation

Document Name	Description of Contents	Order Number
DSP56300 Family Manual	Detailed description of the DSP56300 family architecture and the 24-bit core processor and instruction set	DSP56300FM/AD
DSP56304 User's Manual	Detailed description of DSP56304 memory, peripherals, and interfaces	DSP56304UM/AD
DSP56304 Technical Data	DSP56304 pin and package descriptions, and electrical and timing specifications	DSP56304/D

SECTION 1

SIGNAL/CONNECTION DESCRIPTIONS

SIGNAL GROUPINGS

The input and output signals of the DSP56304 are organized into functional groups, as shown in **Table 1-1** and as illustrated in **Figure 1-1**.

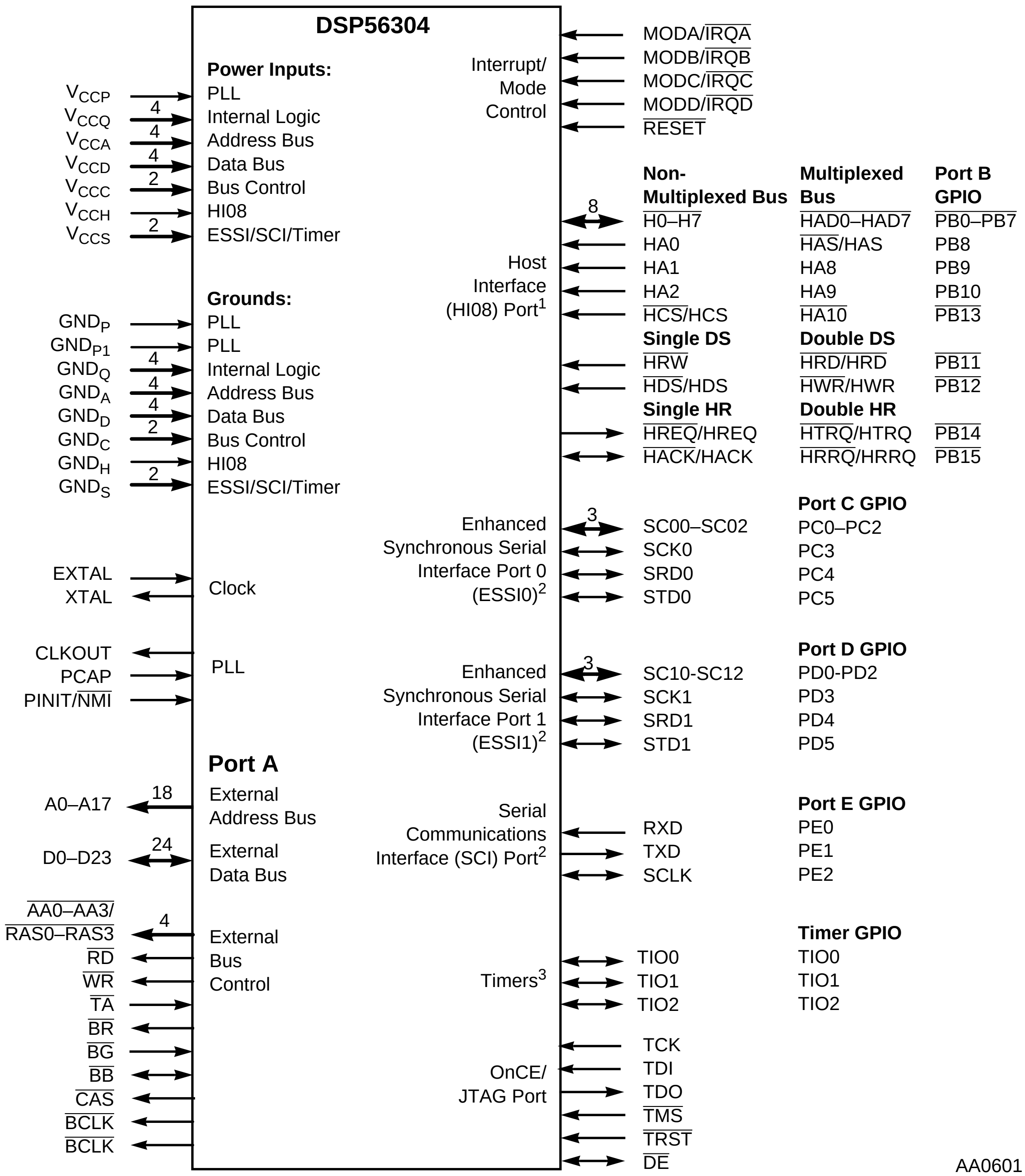
The DSP56304 is operated from a 3 V supply; however, some of the inputs can tolerate 5 V. A special notice for this feature is added to the signal descriptions of those inputs.

Table 1-1 DSP56304 Functional Signal Groupings

Functional Group		Number of Signals	Detailed Description
Power (V_{CC})		18	**Table 1-2**
Ground (GND)		19	**Table 1-3**
Clock		2	**Table 1-4**
PLL		3	**Table 1-5**
Address Bus	Port A[1]	18	**Table 1-6**
Data Bus		24	**Table 1-7**
Bus Control		13	**Table 1-8**
Interrupt and Mode Control		5	**Table 1-9**
Host Interface (HI08)	Port B[2]	16	**Table 1-11**
Enhanced Synchronous Serial Interface (ESSI)	Ports C and D[3]	12	**Table 1-12** and **Table 1-13**
Serial Communication Interface (SCI)	Port E[4]	3	**Table 1-14**
Timer		3	**Table 1-15**
OnCE/JTAG Port		6	**Table 1-16**

Note:
1. Port A signals define the External Memory Interface port, including the external address bus, data bus, and control signals.
2. Port B signals are the HI08 port signals multiplexed with the GPIO signals.
3. Port C and D signals are the two ESSI port signals multiplexed with the GPIO signals.
4. Port E signals are the SCI port signals multiplexed with the GPIO signals.

Figure 1-1 is a diagram of DSP56304 signals by functional group.



Note:
1. The HI08 port supports a non-multiplexed or a multiplexed bus, single or double Data Strobe (DS), and single or double Host Request (HR) configurations. Since each these modes is configured independently, any combination of these modes is possible. These HI08 signals can also be configured alternately as GPIO signals (PB0–PB15). Signals with dual designations (e.g., HAS/HAS) have configurable polarity.
2. The ESSI0, ESSI1, and SCI signals are multiplexed with the Port C GPIO signals (PC0–PC5), Port D GPIO signals (PD0–PD5), and Port E GPIO signals (PE0–PE2), respectively.
3. TIO0–TIO2 can be configured as GPIO signals.

Figure 1-1 Signals Identified by Functional Group

POWER

Table 1-2 Power Inputs

Power Name	Description
V_{CCP}	**PLL Power—**V_{CCP} is V_{CC} dedicated for Phase Lock Loop (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_{CCQ} (4)	**Quiet Power—**V_{CCQ} 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_{CCQ} inputs.
V_{CCA} (4)	**Address Bus Power—**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 four V_{CCA} inputs.
V_{CCD} (4)	**Data Bus Power—**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)	**Bus Control Power—**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}	**Host Power—**V_{CCH} is an isolated power for the HI08 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)	**ESSI, SCI, and Timer Power—**V_{CCS} is an isolated power for the ESSI, SCI, and timer 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_{CCS} inputs.
Note: These designations are package-dependent. Some packages connect all V_{CC} inputs except V_{CCP} to each other internally. On those packages, all power input, except V_{CCP}, are labeled V_{CC}. The numbers of connections indicated in this table are minimum values; the total V_{CC} connections are package-dependent.	

GROUND

Table 1-3 Grounds

Ground Name	Description
GND_P	**PLL Ground—**GND_P is 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 µF capacitor located as close as possible to the chip package. There is one GND_P connection.
GND_{P1}	**PLL Ground 1—**GND_{P1} is ground dedicated for PLL use. The connection should be provided with an extremely low-impedance path to ground. There is one GND_{P1} connection.
GND_Q (4)	**Quiet Ground—**GND_Q 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_Q connections.
GND_A (4)	**Address Bus Ground—**GND_A 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_A connections.
GND_D (4)	**Data Bus Ground—**GND_D 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_D connections.
GND_C (2)	**Bus Control Ground—**GND_C 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_C connections.
GND_H	**Host Ground—**GND_H is an isolated ground for the HI08 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_H connection.
GND_S (2)	**ESSI, SCI, and Timer Ground—**GND_S is an isolated ground for the ESSI, SCI, and timer 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_S connections.
Note: These designations are package-dependent. Some packages connect all GND inputs, except GND_P and GND_{P1}, to each other internally. On those packages, all ground connections, except GND_P and GND_{P1}, are labeled GND. The numbers of connections indicated in this table are minimum values; the total GND connections are package-dependent.	

CLOCK

Table 1-4 Clock Signals

Signal Name	Type	State During Reset	Signal Description
EXTAL	Input	Input	**External Clock/Crystal Input—**EXTAL interfaces the internal crystal oscillator input to an external crystal or an external clock.
XTAL	Output	Chip Driven	**Crystal Output—**XTAL connects the internal crystal oscillator output to an external crystal. If an external clock is used, leave XTAL unconnected.

PHASE LOCK LOOP (PLL)

Table 1-5 Phase Lock Loop Signals

Signal Name	Type	State During Reset	Signal Description
PCAP	Input	Input	**PLL Capacitor—**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_{CCP}. If the PLL is not used, PCAP may be tied to V_{CC}, GND, or left floating.
CLKOUT	Output	Chip-driven	**Clock Output—**CLKOUT provides an output clock synchronized to the internal core clock phase. If the PLL is enabled and both the multiplication and division factors equal one, then CLKOUT is also synchronized to EXTAL. If the PLL is disabled, the CLKOUT frequency is half the frequency of EXTAL.

Table 1-5 Phase Lock Loop Signals (Continued)

Signal Name	Type	State During Reset	Signal Description
PINIT/ $\overline{\text{NMI}}$	Input	Input	**PLL Initial/Non-Maskable Interrupt—**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 Non-Maskable Interrupt (NMI) request internally synchronized to CLKOUT. PINIT/$\overline{\text{NMI}}$ can tolerate 5 V.

EXTERNAL MEMORY EXPANSION PORT (PORT A)

Note: When the DSP56304 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/$\overline{\text{RAS0}}$–AA3/$\overline{\text{RAS3}}$, $\overline{\text{RD}}$, $\overline{\text{WR}}$, $\overline{\text{BB}}$, $\overline{\text{CAS}}$, BCLK, $\overline{\text{BCLK}}$.

Note: If the hardware refresh of external DRAM is enabled, the Port A pins exit Wait state to perform the refresh, and then return to the Wait state again.

EXTERNAL ADDRESS BUS

Table 1-6 External Address Bus Signals

Signal Name	Type	State During Reset, Stop, or Wait	Signal Description
A0–A17	Output	Tri-stated	**Address Bus—**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 1-7 External Data Bus Signals

Signal Name	Type	State During Reset, Stop, or Wait	Signal Description
D0–D23	Input/ Output	Tri-stated	**Data Bus—**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 1-8 External Bus Control Signals

Signal Name	Type	State During Reset, Stop, or Wait	Signal Description
AA0–AA3/ $\overline{RAS0}$–$\overline{RAS3}$	Output	Tri-stated	**Address Attribute or Row Address Strobe—**When defined as AA, these signals can be used as chip selects or additional address lines. When defined as $\overline{RAS}$, these signals can be used as $\overline{RAS}$ for Dynamic Random Access Memory (DRAM) interface. These signals are tri-statable outputs with programmable polarity.
$\overline{RD}$	Output	Tri-stated	**Read Enable—**When the DSP is the bus master, $\overline{RD}$ is an active-low output that is asserted to read external memory on the data bus (D0–D23). Otherwise, $\overline{RD}$ is tri-stated.
$\overline{WR}$	Output	Tri-stated	**Write Enable—**When the DSP is the bus master, $\overline{WR}$ is an active-low output that is asserted to write external memory on the data bus (D0–D23). Otherwise, the signals are tri-stated.

Table 1-8 External Bus Control Signals (Continued)

Signal Name	Type	State During Reset, Stop, or Wait	Signal Description
$\overline{TA}$	Input	Ignored Input	**Transfer Acknowledge**—If the DSP56304 is the bus master and there is no external bus activity, or the DSP56304 is not the bus master, the $\overline{TA}$ input is ignored. The $\overline{TA}$ 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 $\overline{TA}$ deasserted. In typical operation, $\overline{TA}$ 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 $\overline{TA}$ is asserted synchronous to CLKOUT. The number of wait states is determined by the $\overline{TA}$ 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. In order to use the $\overline{TA}$ functionality, the BCR must be programmed to at least one wait state. A zero wait state access can not be extended by $\overline{TA}$ deassertion, otherwise improper operation may result. $\overline{TA}$ can operate synchronously or asynchronously depending on the setting of the TAS bit in the Operating Mode Register (OMR). $\overline{TA}$ functionality may not be used while performing DRAM type accesses, otherwise improper operation may result.
$\overline{BR}$	Output	Output (driven high/ deasserted)	**Bus Request—**$\overline{BR}$ is an active-low output, never tri-stated. $\overline{BR}$ is asserted when the DSP requests bus mastership. $\overline{BR}$ is deasserted when the DSP no longer needs the bus. $\overline{BR}$ may be asserted or deasserted independent of whether the DSP56304 is a bus master or a bus slave. Bus “parking” allows $\overline{BR}$ to be deasserted even though the DSP56304 is the bus master (see the description of bus “parking” in the $\overline{BB}$ signal description). The Bus Request Hole (BRH) bit in the BCR allows $\overline{BR}$ to be asserted under software control even though the DSP does not need the bus. $\overline{BR}$ is typically sent to an external bus arbitrator that controls the priority, parking and tenure of each master on the same external bus. $\overline{BR}$ is only affected by DSP requests for the external bus, never for the internal bus. During hardware reset, $\overline{BR}$ is deasserted and the arbitration is reset to the bus slave state.

Table 1-8 External Bus Control Signals (Continued)

Signal Name	Type	State During Reset, Stop, or Wait	Signal Description
$\overline{BG}$	Input	Ignored Input	**Bus Grant—**$\overline{BG}$ is an active-low input. $\overline{BG}$ must be asserted/deasserted synchronous to CLKOUT for proper operation. $\overline{BG}$ is asserted by an external bus arbitration circuit when the DSP56304 becomes the next bus master. When $\overline{BG}$ is asserted, the DSP56304 must wait until $\overline{BB}$ is deasserted before taking bus mastership. When $\overline{BG}$ 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.
$\overline{BB}$	Input/ Output	Input	**Bus Busy—**$\overline{BB}$ is a bidirectional active-low input/output and must be asserted and deasserted synchronous to CLKOUT. $\overline{BB}$ indicates that the bus is active. Only after $\overline{BB}$ is deasserted can the pending bus master become the bus master (and then assert the signal again). The bus master may keep $\overline{BB}$ asserted after ceasing bus activity regardless of whether $\overline{BR}$ 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 $\overline{BB}$ is done by an “active pull-up” method (i.e., $\overline{BB}$ is driven high and then released and held high by an external pull-up resistor). $\overline{BB}$ requires an external pull-up resistor.
$\overline{CAS}$	Output	Tri-stated	**Column Address Strobe—**When the DSP is the bus master, $\overline{CAS}$ 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.
BCLK	Output	Tri-stated	**Bus Clock—**When the DSP is the bus master, BCLK is an active-high output used by Synchronous Static Random Access Memory (SSRAM) to sample address, data, and control signals. BCLK is active either during SSRAM accesses or as a sampling signal when the program Address Tracing mode is enabled (by setting the ATE bit in the OMR). When BCLK is active and synchronized to CLKOUT by the internal PLL, BCLK precedes CLKOUT by one-fourth of a clock cycle. The BCLK rising edge may be used to sample the internal program memory access on the A0–A23 address lines.
$\overline{BCLK}$	Output	Tri-stated	**Bus Clock Not—**When the DSP is the bus master, $\overline{BCLK}$ is an active-low output and is the inverse of the BCLK signal. Otherwise, the signal is tri-stated.

INTERRUPT AND MODE CONTROL

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

Table 1-9 Interrupt and Mode Control

Signal Name	Type	State During Reset	Signal Description
$\overline{\text{RESET}}$	Input	Input	**Reset—**$\overline{\text{RESET}}$ is an active-low, Schmitt-trigger input. Deassertion of $\overline{\text{RESET}}$ is internally synchronized to the clock out (CLKOUT). 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. If $\overline{\text{RESET}}$ is deasserted synchronous to CLKOUT, exact start-up timing is guaranteed, allowing multiple processors to start synchronously and operate together in "lock-step". When the $\overline{\text{RESET}}$ signal is deasserted, the initial chip operating mode is latched from the MODA, MODB, MODC, and MODD inputs. The $\overline{\text{RESET}}$ signal must be asserted after power up. $\overline{\text{RESET}}$ can tolerate 5 V.
MODA/$\overline{\text{IRQA}}$	Input	Input	**Mode Select A/External Interrupt Request A—**MODA/$\overline{\text{IRQA}}$ is an active-low Schmitt-trigger input, internally synchronized to CLKOUT. MODA/$\overline{\text{IRQA}}$ 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. MODA, MODB, MODC, and MODD select one of sixteen initial chip operating modes, latched into the OMR when the $\overline{\text{RESET}}$ signal is deasserted. If $\overline{\text{IRQA}}$ is asserted synchronous to CLKOUT, multiple processors can be re-synchronized using the WAIT instruction and asserting $\overline{\text{IRQA}}$ to exit the Wait state. If the processor is in the Stop standby state and $\overline{\text{IRQA}}$ is asserted, the processor will exit the Stop state. MODA/$\overline{\text{IRQA}}$ can tolerate 5 V.

Table 1-9 Interrupt and Mode Control (Continued)

Signal Name	Type	State During Reset	Signal Description
MODB/$\overline{\text{IRQB}}$	Input	Input	**Mode Select B/External Interrupt Request B—**MODB/$\overline{\text{IRQB}}$ is an active-low Schmitt-trigger input, internally synchronized to CLKOUT. MODB/$\overline{\text{IRQB}}$ 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. MODA, MODB, MODC, and MODD select one of sixteen initial chip operating modes, latched into OMR when the $\overline{\text{RESET}}$ signal is deasserted. If $\overline{\text{IRQB}}$ is asserted synchronous to CLKOUT, multiple processors can be re-synchronized using the WAIT instruction and asserting $\overline{\text{IRQB}}$ to exit the Wait state. MODB/$\overline{\text{IRQB}}$ can tolerate 5 V.
MODC/$\overline{\text{IRQC}}$	Input	Input	**Mode Select C/External Interrupt Request C—**MODC/$\overline{\text{IRQC}}$ is an active-low Schmitt-trigger input, internally synchronized to CLKOUT. MODC/$\overline{\text{IRQC}}$ 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. MODA, MODB, MODC, and MODD select one of sixteen initial chip operating modes, latched into OMR when the $\overline{\text{RESET}}$ signal is deasserted. If $\overline{\text{IRQC}}$ is asserted synchronous to CLKOUT, multiple processors can be re-synchronized using the WAIT instruction and asserting $\overline{\text{IRQC}}$ to exit the Wait state. MODC/$\overline{\text{IRQC}}$ can tolerate 5 V.
MODD/$\overline{\text{IRQD}}$	Input	Input	**Mode Select D/External Interrupt Request D—**MODD/$\overline{\text{IRQD}}$ is an active-low Schmitt-trigger input, internally synchronized to CLKOUT. MODD/$\overline{\text{IRQD}}$ 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. MODA, MODB, MODC, and MODD select one of sixteen initial chip operating modes, latched into OMR when the $\overline{\text{RESET}}$ signal is deasserted. If $\overline{\text{IRQD}}$ is asserted synchronous to CLKOUT, multiple processors can be re-synchronized using the WAIT instruction and asserting $\overline{\text{IRQD}}$ to exit the Wait state. MODD/$\overline{\text{IRQD}}$ can tolerate 5 V.

HOST INTERFACE (HI08)

The HI08 provides a fast parallel data to 8-bit port, which may be connected directly to the host bus.

The HI08 supports a variety of standard buses, and can be directly connected to a number of industry standard microcomputers, microprocessors, DSPs, and DMA hardware.

Host Port Usage Considerations

Careful synchronization is required when reading multiple-bit registers that are written by another asynchronous system. This is a common problem when two asynchronous systems are connected (as they are in the Host port). The considerations for proper operation are discussed in the following table:

Table 1-10 Host Port Usage Considerations

Action	Description
Asynchronous read 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 which indicates that data is available. This assures that the data in the receive byte registers will be valid.
Asynchronous write to 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 guarantees that the transmit byte registers will transfer valid data to the Host Receive (HRX) register.
Asynchronous write to host vector	The host interface programmer should change the Host Vector (HV) register only when the Host Command bit (HC) is clear. This will guarantee that the DSP interrupt control logic will receive a stable vector.

Host Port Configuration

The functions of the signals associated with the HI08 vary according to the programmed configuration of the interface as determined by the 16 bits in the HI08 Port Control Register (HPCR). Refer to the DSP56304 User's Manual for detailed descriptions of this and the other configuration registers used with the HI08.

Table 1-11 Host Interface

Signal Name	Type	State During Reset or Stop[1]	Signal Description
H0–H7	Input/ Output	Disconnected	**Host Data**—When the HI08 is programmed to interface a non-multiplexed host bus and the HI function is selected, these signals are lines 0–7 of the Data bidirectional, tri-state bus.
HAD0–HAD7	Input/ Output		**Host Address—**When HI08 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 or Output		**Port B 0–7**—When the HI08 is configured as GPIO through the HPCR, these signals are individually programmed as inputs or outputs through the HI08 Data Direction Register (HDDR). This input is 5 V tolerant.
HA0	Input	Disconnected	**Host Address Input 0**—When the HI08 is programmed to interface a non-multiplexed host bus and the HI function is selected, this signal is line 0 of the Host Address input bus.
$\overline{\text{HAS}}$/HAS	Input		**Host Address Strobe—**When HI08 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 ($\overline{\text{HAS}}$) following reset.
PB8	Input or Output		**Port B 8—**When the HI08 is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.

Table 1-11 Host Interface (Continued)

Signal Name	Type	State During Reset or Stop[1]	Signal Description
HA1 HA8 PB9	Input Input Input or Output	Disconnected	**Host Address Input 1—**When the HI08 is programmed to interface a non-multiplexed host bus and the HI function is selected, this signal is line 1 of the Host Address (HA1) input bus. **Host Address 8—**When HI08 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. **Port B 9—**When the HI08 is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.
HA2 HA9 PB10	Input Input Input or Output	Disconnected	**Host Address Input 2—**When the HI08 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. **Host Address 9—**When HI08 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. **Port B 10—**When the HI08 is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.

Table 1-11 Host Interface (Continued)

Signal Name	Type	State During Reset or Stop[1]	Signal Description
HRW	Input	Disconnected	**Host Read/Write—**When HI08 is programmed to interface a single-data-strobe host bus and the HI function is selected, this signal is the Host Read/$\overline{\text{Write}}$ (HRW) input.
$\overline{\text{HRD}}$/HRD	Input		**Host Read Data—**When HI08 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 or Output		**Port B 11—**When the HI08 is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.
$\overline{\text{HDS}}$/HDS	Input	Disconnected	**Host Data Strobe—**When HI08 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.
$\overline{\text{HWR}}$/HWR	Input		**Host Write Data—**When HI08 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 or Output		**Port B 12—**When the HI08 is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.

Table 1-11 Host Interface (Continued)

Signal Name	Type	State During Reset or Stop[1]	Signal Description
HCS	Input	Disconnected	**Host Chip Select—**When HI08 is programmed to interface a non-multiplexed 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 ($\overline{HCS}$) after reset.
HA10	Input		**Host Address 10—**When HI08 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.
PB13	Input or Output		**Port B 13—**When the HI08 is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.
$\overline{HREQ}$/ HREQ	Output	Disconnected	**Host Request—**When HI08 is programmed to interface a single host request host bus and the HI function is selected, this signal is the Host Request (HREQ) output. The polarity of the host request is programmable, but is configured as active-low ($\overline{HREQ}$) following reset. The host request may be programmed as a driven or open-drain output.
$\overline{HTRQ}$/ HTRQ	Output		**Transmit Host Request—**When HI08 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 ($\overline{HTRQ}$) following reset. The host request may be programmed as a driven or open-drain output.
PB14	Input or Output		**Port B 14—**When the HI08 is programmed to interface a multiplexed host bus and the signal is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.

Table 1-11 Host Interface (Continued)

Signal Name	Type	State During Reset or Stop[1]	Signal Description
$\overline{\text{HACK}}$/ HACK	Input	Disconnected	**Host Acknowledge—**When HI08 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.
$\overline{\text{HRRQ}}$/ HRRQ	Output		**Receive Host Request—**When HI08 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 or Output		**Port B 15—**When the HI08 is configured as GPIO through the HPCR, this signal is individually programmed as an input or output through the HDDR. This input is 5 V tolerant.

Note: 1. Wait state does not affect signal state.

ENHANCED SYNCHRONOUS SERIAL INTERFACE 0 (ESSI0)

There are two synchronous serial interfaces (ESSI0 and ESSI1) that provide a full-duplex serial port for serial communication with a variety of serial devices, including one or more industry-standard codecs, other DSPs, microprocessors, and peripherals which implement the Motorola Serial Peripheral Interface (SPI).

Table 1-12 Enhanced Synchronous Serial Interface 0 (ESSI0)

Signal Name	Type	State During[1]		Signal Description
		Reset	Stop	
SC00 PC0	Input or Output	Input	Disconnected	**Serial Control 0**—The function of SC00 is determined by the selection of either Synchronous or Asynchronous mode. For Asynchronous mode, this signal will be used for the receive clock I/O (Schmitt-trigger input). For Synchronous mode, this signal is used either for Transmitter 1 output or for Serial I/O Flag 0. **Port C 0**—The default configuration following reset is GPIO input PC0. When configured as PC0, signal direction is controlled through the Port Directions Register (PRR0). The signal can be configured as ESSI signal SC00 through the Port Control Register (PCR0). This input is 5 V tolerant.
SC01 PC1	Input/ Output Input or Output	Input	Disconnected	**Serial Control 1**—The function of this signal is determined by the selection of either Synchronous or Asynchronous mode. For Asynchronous mode, this signal is the receiver frame sync I/O. For Synchronous mode, this signal is used either for Transmitter 2 output or for Serial I/O Flag 1. **Port C 1**—The default configuration following reset is GPIO input PC1. When configured as PC1, signal direction is controlled through PRR0. The signal can be configured as an ESSI signal SC01 through PCR0. This input is 5 V tolerant.

Table 1-12 Enhanced Synchronous Serial Interface 0 (ESSI0) (Continued)

Signal Name	Type	State During[1]		Signal Description
		Reset	Stop	
SC02 PC2	Input/ Output Input or Output	Input	Disconnected	**Serial Control Signal 2—**SC02 is used for frame sync I/O. SC02 is the frame sync for both the transmitter and receiver in Synchronous mode, and for the transmitter only in Asynchronous mode. When configured as an output, this signal is the internally generated frame sync signal. When configured as an input, this signal receives an external frame sync signal for the transmitter (and the receiver in synchronous operation). **Port C 2—**The default configuration following reset is GPIO input PC2. When configured as PC2, signal direction is controlled through PRR0. The signal can be configured as an ESSI signal SC02 through PCR0. This input is 5 V tolerant.
SCK0 PC3	Input/ Output Input or Output	Input	Disconnected	**Serial Clock—**SCK0 is a bidirectional Schmitt-trigger input signal providing the serial bit rate clock for the ESSI interface. The SCK0 is a clock input or output used by both the transmitter and receiver in Synchronous modes, or by the transmitter in Asynchronous modes. Although an external serial clock can be independent of and asynchronous to the DSP system clock, it must exceed the minimum clock cycle time of 6 T (i.e., the system clock frequency must be at least three times the external ESSI clock frequency). The ESSI needs at least three DSP phases inside each half of the serial clock. **Port C 3—**The default configuration following reset is GPIO input PC3. When configured as PC3, signal direction is controlled through PRR0. The signal can be configured as an ESSI signal SCK0 through PCR0. This input is 5 V tolerant.

Table 1-12 Enhanced Synchronous Serial Interface 0 (ESSI0) (Continued)

Signal Name	Type	State During[1]		Signal Description
		Reset	Stop	
SRD0 PC4	Input/ Output Input or Output	Input	Disconnected	**Serial Receive Data**—SRD0 receives serial data and transfers the data to the ESSI receive shift register. SRD0 is an input when data is being received. **Port C 4**—The default configuration following reset is GPIO input PC4. When configured as PC4, signal direction is controlled through PRR0. The signal can be configured as an ESSI signal SRD0 through PCR0. This input is 5 V tolerant.
STD0 PC5	Input/ Output Input or Output	Input	Disconnected	**Serial Transmit Data**—STD0 is used for transmitting data from the serial transmit shift register. STD0 is an output when data is being transmitted. **Port C 5**—The default configuration following reset is GPIO input PC5. When configured as PC5, signal direction is controlled through PRR0. The signal can be configured as an ESSI signal STD0 through PCR0. This input is 5 V tolerant.

Note: 1. Wait state does not affect signal state.

ENHANCED SYNCHRONOUS SERIAL INTERFACE 1 (ESSI1)

Table 1-13 Enhanced Synchronous Serial Interface 1 (ESSI1)

Signal Name	Type	State During[1]		Signal Description
		Reset	Stop	
SC10 PD0	Input or Output	Input	Disconnected	**Serial Control 0—**The function of SC10 is determined by the selection of either Synchronous or Asynchronous mode. For Asynchronous mode, this signal will be used for the receive clock I/O (Schmitt-trigger input). For Synchronous mode, this signal is used either for Transmitter 1 output or for Serial I/O Flag 0. **Port D 0—**The default configuration following reset is GPIO input PD0. When configured as PD0, signal direction is controlled through the Port Directions Register (PRR1). The signal can be configured as an ESSI signal SC10 through the Port Control Register (PCR1). This input is 5 V tolerant.
SC11 PD1	Input/ Output Input or Output	Input	Disconnected	**Serial Control 1—**The function of this signal is determined by the selection of either Synchronous or Asynchronous mode. For Asynchronous mode, this signal is the receiver frame sync I/O. For Synchronous mode, this signal is used either for Transmitter 2 output or for Serial I/O Flag 1. **Port D 1—**The default configuration following reset is GPIO input PD1. When configured as PD1, signal direction is controlled through PRR1. The signal can be configured as an ESSI signal SC11 through PCR1. This input is 5 V tolerant.

Table 1-13 Enhanced Synchronous Serial Interface 1 (ESSI1) (Continued)

Signal Name	Type	State During[1]		Signal Description
		Reset	Stop	
SC12 PD2	Input/ Output Input or Output	Input	Disconnected	**Serial Control Signal 2**—SC12 is used for frame sync I/O. SC12 is the frame sync for both the transmitter and receiver in Synchronous mode, and for the transmitter only in Asynchronous mode. When configured as an output, this signal is the internally generated frame sync signal. When configured as an input, this signal receives an external frame sync signal for the transmitter (and the receiver in Synchronous operation). **Port D 2**—The default configuration following reset is GPIO input PD2. When configured as PD2, signal direction is controlled through PRR1. The signal can be configured as an ESSI signal SC12 through PCR1. This input is 5 V tolerant.
SCK1 PD3	Input/ Output Input or Output	Input	Disconnected	**Serial Clock**—SCK1 is a bidirectional Schmitt-trigger input signal providing the serial bit rate clock for the ESSI interface. The SCK1 is a clock input or output used by both the transmitter and receiver in Synchronous modes, or by the transmitter in Asynchronous modes. Although an external serial clock can be independent of and asynchronous to the DSP system clock, it must exceed the minimum clock cycle time of 6T (i.e., the system clock frequency must be at least three times the external ESSI clock frequency). The ESSI needs at least three DSP phases inside each half of the serial clock. **Port D 3**—The default configuration following reset is GPIO input PD3. When configured as PD3, signal direction is controlled through PRR1. The signal can be configured as an ESSI signal SCK1 through PCR1. This input is 5 V tolerant.

Table 1-13 Enhanced Synchronous Serial Interface 1 (ESSI1) (Continued)

Signal Name	Type	State During[1]		Signal Description
		Reset	Stop	
SRD1 PD4	Input/Output Input or Output	Input	Disconnected	**Serial Receive Data**—SRD1 receives serial data and transfers the data to the ESSI receive shift register. SRD1 is an input when data is being received. **Port D 4**—The default configuration following reset is GPIO input PD4. When configured as PD4, signal direction is controlled through PRR1. The signal can be configured as an ESSI signal SRD1 through PCR1. This input is 5 V tolerant.
STD1 PD5	Input/Output Input or Output	Input	Disconnected	**Serial Transmit Data**—STD1 is used for transmitting data from the serial transmit shift register. STD1 is an output when data is being transmitted. **Port D 5**—The default configuration following reset is GPIO input PD5. When configured as PD5, signal direction is controlled through PRR1. The signal can be configured as an ESSI signal STD1 through PCR1. This input is 5 V tolerant.

Note: 1. Wait state does not affect signal state.

SERIAL COMMUNICATION INTERFACE (SCI)

The Serial Communication interface (SCI) provides a full duplex port for serial communication to other DSPs, microprocessors, or peripherals such as modems.

Table 1-14 Serial Communication Interface (SCI)

Signal Name	Type	State During[1] Reset	State During[1] Stop	Signal Description
RXD PE0	Input Input or Output	Input	Disconnected	**Serial Receive Data—**This input receives byte oriented serial data and transfers it to the SCI receive shift register. **Port E 0—**The default configuration following reset is GPIO input PE0. When configured as PE0, signal direction is controlled through the SCI Port Directions Register (PRR). The signal can be configured as an SCI signal RXD through the SCI Port Control Register (PCR). This input is 5 V tolerant.
TXD PE1	Output (may be open drain) Input or Output	Input	Disconnected	**Serial Transmit Data—**This signal transmits data from SCI transmit data register. **Port E 1—**The default configuration following reset is GPIO input PE1. When configured as PE1, signal direction is controlled through the SCI PRR. The signal can be configured as an SCI signal TXD through the SCI PCR. This input is 5 V tolerant.
SCLK PE2	Input/ Output Input or Output	Input	Disconnected	**Serial Clock—**This is the bidirectional Schmitt-trigger input signal providing the input or output clock used by the transmitter and/or the receiver. **Port E 2—**The default configuration following reset is GPIO input PE2. When configured as PE2, signal direction is controlled through the SCI PRR. The signal can be configured as an SCI signal SCLK through the SCI PCR. This input is 5 V tolerant.

Note: 1. Wait state does not affect signal state.

TIMERS

Three identical and independent timers are implemented in the DSP56304. Each timer can use internal or external clocking, and can interrupt the DSP56304 after a specified number of events (clocks), or can signal an external device after counting a specific number of internal events.

Table 1-15 Triple Timer Signals

Signal Name	Type	State During[1]		Signal Description
		Reset	Stop	
TIO0	Input or Output	Input	Disconnected	**Timer 0 Schmitt-Trigger Input/Output—**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. 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). This input is 5 V tolerant.
TIO1	Input or Output	Input	Disconnected	**Timer 1 Schmitt-Trigger Input/Output—**When Timer 1 functions as an external event counter or in Measurement mode, TIO1 is used as input. When Timer 1 functions in Watchdog, Timer, or Pulse Modulation mode, TIO1 is used as output. The default mode after reset is GPIO input. This can be changed to output or configured as a Timer Input/Output through the Timer 1 Control/Status Register (TCSR1). This input is 5 V tolerant.
TIO2	Input or Output	Input	Disconnected	**Timer 2 Schmitt-Trigger Input/Output—**When Timer 2 functions as an external event counter or in Measurement mode, TIO2 is used as input. When Timer 2 functions in Watchdog, Timer, or Pulse Modulation mode, TIO2 is used as output. The default mode after reset is GPIO input. This can be changed to output or configured as a Timer Input/Output through the Timer 2 Control/Status Register (TCSR2). This input is 5 V tolerant.

Note: 1. Wait state does not affect signal state.

OnCE/JTAG INTERFACE

Table 1-16 OnCE/JTAG Interface

Signal Name	Type	State During Reset	Signal Description
TCK	Input	Input	**Test Clock—**TCK is a test clock input signal used to synchronize the JTAG test logic. This input is 5 V tolerant.
TDI	Input	Input	**Test Data Input—**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. This input is 5 V tolerant.
TDO	Output	Tri-stated	**Test Data Output—**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.
TMS	Input	Input	**Test Mode Select—**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. This input is 5 V tolerant.
$\overline{\text{TRST}}$	Input	Input	**Test Reset—**$\overline{\text{TRST}}$ is an active-low Schmitt-trigger input signal used to asynchronously initialize the test controller. $\overline{\text{TRST}}$ has an internal pull-up resistor. $\overline{\text{TRST}}$ must be asserted after power up. This input is 5 V tolerant.

Table 1-16 OnCE/JTAG Interface (Continued)

Signal Name	Type	State During Reset	Signal Description
$\overline{DE}$	Input/ Output	Input	**Debug Event—**$\overline{DE}$ is an open-drain, bidirectional, active-low signal providing, as an input, a means of entering the Debug mode of operation from an external command controller, and, as an output, a means of acknowledging that the chip has entered the Debug mode. This signal, when asserted as an input, causes the DSP56300 core to finish the current instruction being executed, save the instruction pipeline information, enter the Debug mode, and wait for commands to be entered from the debug serial input line. This signal is asserted as an output for three clock cycles when the chip enters the Debug mode as a result of a debug request or as a result of meeting a breakpoint condition. The $\overline{DE}$ has an internal pull-up resistor. This is not a standard part of the JTAG Test Access Port (TAP) Controller. The signal connects directly to the OnCE module to initiate Debug mode directly or to provide a direct external indication that the chip has entered the Debug mode. All other interface with the OnCE module must occur through the JTAG port. This input is 5 V tolerant.

SECTION 2

SPECIFICATIONS

INTRODUCTION

The DSP56304 is fabricated in high density CMOS with Transistor-Transistor Logic (TTL) compatible inputs and outputs. The DSP56304 specifications are preliminary and are from design simulations, and may not be fully tested or guaranteed at this early stage of the product life cycle. 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 is enhanced if unused inputs are tied to an appropriate logic voltage level (e.g., either GND or V_{CC}).

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.

Table 2-1 Maximum Ratings

Rating[1]	Symbol	Value[1, 2]	Unit
Supply Voltage	V_{CC}	−0.3 to +4.0	V
All input voltages excluding "5 V tolerant" inputs[3]	V_{IN}	GND − 0.3 to V_{CC} + 0.3	V
All "5 V tolerant" input voltages[3]	V_{IN5}	GND − 0.3 to V_{CC} + 3.95	V
Current drain per pin excluding V_{CC} and GND	I	10	mA
Operating temperature range	T_J	−40 to +100	°C
Storage temperature	T_{STG}	−55 to +150	°C

Note:
1. GND = 0 V, V_{CC} = 3.3 V ± 0.3 V, T_J = –40°C to +100°C, CL = 50 pF + 2 TTL Loads
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.
3. **CAUTION**: All "5 V Tolerant" input voltages cannot 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 can not 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	PBGA[3] Value	PBGA[4] Value	Unit
Junction-to-ambient thermal resistance	$R_{\theta JA}$ or θ_{JA}	55.7	57	28	°C/W
Junction-to-case thermal resistance	$R_{\theta JC}$ or θ_{JC}	11.4	15	—	°C/W
Thermal characterization parameter	Ψ_{JT}	6.8	8	—	°C/W

Note:
1. Junction-to-ambient thermal resistance is based on measurements on a horizontal single-sided printed circuit board per SEMI G38-87 in natural convection.(SEMI is Semiconductor Equipment and Materials International, 805 East Middlefield Rd., Mountain View, CA 94043, (415) 964-5111)
2. Junction-to-case thermal resistance is based on measurements using a cold plate per SEMI G30-88, with the exception that the cold plate temperature is used for the case temperature.
3. These are simulated values; testing is not complete. See note 1 for test board conditions.
4. These are simulated values; testing is not complete. The test board has two, 2-ounce signal layers and two 1-ounce solid ground planes internal to the test board.

DC ELECTRICAL CHARACTERISTICS

Table 2-3 DC Electrical Characteristics[6]

Characteristics	Symbol	Min	Typ	Max	Unit
Supply voltage	V_{CC}	3.0	3.3	3.6	V
Input high voltage • D(0:23), $\overline{BG}$, $\overline{BB}$, $\overline{TA}$ • MOD[1]/$\overline{IRQ}$[1], $\overline{RESET}$, PINIT/$\overline{NMI}$ and all JTAG/ESSI/SCI/Timer/HI08 pins • EXTAL[8]	 V_{IH} V_{IHP} V_{IHX}	 2.0 2.0 0.8	 — — —	 V_{CC} V_{CC} + 3.95 V_{CC}	 V V V
Input low voltage • D(0:23), $\overline{BG}$, $\overline{BB}$, $\overline{TA}$, MOD[1]/$\overline{IRQ}$[1], $\overline{RESET}$, PINIT • All JTAG/ESSI/SCI/Timer/HI08 pins • EXTAL[8]	 V_{IL} V_{ILP} V_{ILX}	 –0.3 –0.3 –0.3	 — — —	 0.8 0.8 0.2	 V V V
Input leakage current	I_{IN}	–10	—	10	µA
High impedance (off-state) input current (@ 2.4 V / 0.4 V)	I_{TSI}	–10	—	10	µA
Output high voltage • TTL (I_{OH} = –0.4 mA)[5,7] • CMOS (I_{OH} = –10 µA)[5]	V_{OH}	 V_{CC} – 0.4 V_{CC} – 0.01	 — —	 — —	 V V
Output low voltage • TTL (I_{OL} = 3.0 mA, open-drain pins I_{OL} = 6.7 mA)[5,7] • CMOS (I_{OL} = 10 µA)[5]	V_{OL}	 — —	 — —	 0.4 0.01	 V V
Internal supply current[2]: • In Normal mode • In Wait mode[3] • In Stop mode[4]	 I_{CCI} I_{CCW} I_{CCS}	 — — —	 **66 MHz**: 84 **80 MHz**: 102 **66 MHz**: 5 **80 MHz**: 6 **66 MHz**: 100 **80 MHz**: 100	 **66 MHz**: 120 **80 MHz**: 145 **66 MHz**: 7 **80 MHz**: 9 **66 MHz**: 150 **80 MHz**: 150	 mA mA mA mA µA µA
PLL supply current in Stop mode[5]		—	1	2.5	mA
Input capacitance[5]	C_{IN}	—	—	10	pF

Table 2-3 DC Electrical Characteristics[6] (Continued)

Characteristics	Symbol	Min	Typ	Max	Unit

Note:
1. Refers to MODA/$\overline{IRQA}$, MODB/$\overline{IRQB}$, MODC/$\overline{IRQC}$, and MODD/$\overline{IRQD}$ pins
2. **Power Consumption Considerations** 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 (see **Appendix A**). 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 V_{CC} = 3.0 V at T_J = 100°C. Maximum internal supply current is measured with V_{CC} = 3.6 V at T_J = 100°C.
3. In order to obtain these results, all inputs must be terminated (i.e., not allowed to float). PLL and XTAL signals are disabled during Stop state.
4. In order to obtain these results, all inputs, which are not disconnected at Stop mode, must be terminated (i.e., not allowed to float).
5. Periodically sampled and not 100% tested
6. V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100 °C, C_L = 50 pF + 2 TTL Loads
7. This characteristic does not apply to XTAL and PCAP.
8. Driving EXTAL to the extreme values for V_{IHX} (0.8 V_{CC}) or V_{ILX} (0.2 V_{CC}) may cause increased DC current. To achieve the lowest current, maintain the minimum V_{IHX} above 0.9 V_{CC} and the maximum V_{ILX} below 0.1 V_{CC}.

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 6** 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. DSP56304 output levels are measured with the production test machine V_{OL} and V_{OH} reference levels set at 0.8 V and 2.0 V, respectively.

INTERNAL CLOCKS

Table 2-4 Internal Clocks, CLKOUT

Characteristics	Symbol	Expression[1, 2]		
		Min	Typ	Max
Internal operation frequency and CLKOUT with PLL enabled	f	—	(Ef × MF)/ (PDF × DF)	—

Preliminary Data

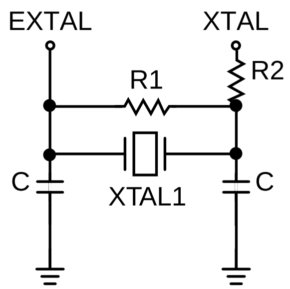
Table 2-4 Internal Clocks, CLKOUT

Characteristics	Symbol	Expression[1, 2]		
		Min	Typ	Max
Internal operation frequency and CLKOUT with PLL disabled	f	—	Ef/2	—
Internal clock and CLKOUT high period • With PLL disabled	T_H	—	ET_C	—
• With PLL enabled and $MF \le 4$		$0.49 \times ET_C \times PDF \times DF / MF$	—	$0.51 \times ET_C \times PDF \times DF / MF$
• 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 and CLKOUT low period • With PLL disabled	T_L	—	ET_C	—
• With PLL enabled and $MF \le 4$		$0.49 \times ET_C \times PDF \times DF / MF$	—	$0.51 \times ET_C \times PDF \times DF / MF$
• 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 and CLKOUT cycle time with PLL enabled	T_C	—	$ET_C \times PDF \times DF / MF$	—
Internal clock and CLKOUT cycle time with PLL disabled	T_C	—	$2 \times ET_C$	—
Instruction cycle time	I_{CYC}	—	T_C	—

Note:
1. DF = Division Factor
   Ef = External frequency
   ET_C = External clock cycle
   MF = Multiplication Factor
   PDF = Predivision Factor
   T_C = internal clock cycle
2. See the **PLL and Clock Generation** section in the DSP56300 Family Manual for a detailed discussion of the PLL.

EXTERNAL CLOCK OPERATION

The DSP56304 system clock may be derived from the on–chip crystal oscillator, as shown in **Figure 1** on the cover page, or it may be externally supplied. An externally supplied square wave voltage source should be connected to EXTAL, leaving XTAL physically not connected to the board or socket (see **Figure 2-2**).

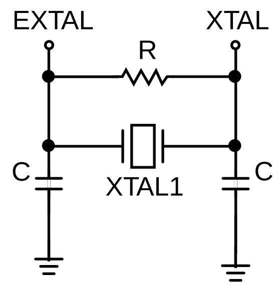


Fundamental Frequency
Fork Crystal Oscillator

Suggested Component Values:

f_{OSC} = 32.768 kHz
R1 = 3.9 MΩ ± 10%
C = 22 pF ± 20%
R2 = 200 kΩ ± 10%

Calculations were done for a 32.768 kHz crystal with the following parameters:
a load capacitance (C_L) of 12.5 pF,
a shunt capacitance (C_0) of 1.8 pF,
a series resistance of 40 kΩ, and
a drive level of 1 μW.



Fundamental Frequency
Crystal Oscillator

Suggested Component Values:

f_{OSC} = 4 MHz	f_{OSC} = 20 MHz
R = 680 kΩ ± 10%	R = 680 kΩ ± 10%
C = 56 pF ± 20%	C = 22 pF ± 20%

Calculations were done for a 4/20 MHz crystal with the following parameters:
a $C_L$of 30/20 pF,
a C_0 of 7/6 pF,
a series resistance of 100/20 Ω, and
a drive level of 2 mW.

Figure 2-1 Crystal Oscillator Circuits

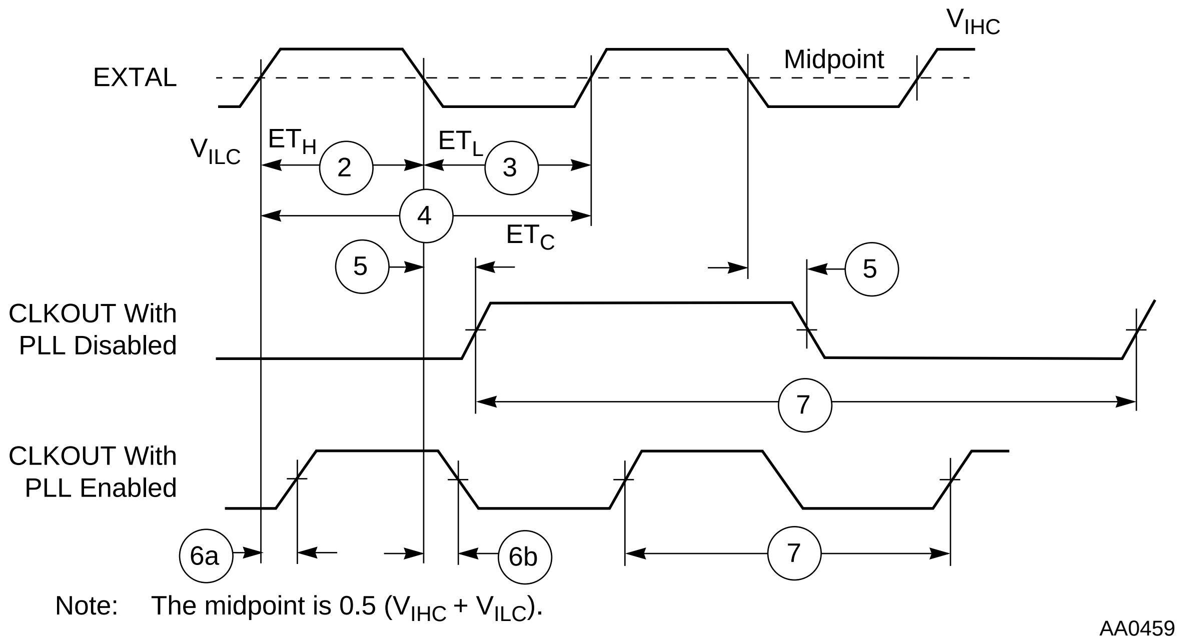


Figure 2-2 External Clock Timing

Table 2-5 Clock Operation

No.	Characteristics	Symbol	66 MHz		80 MHz	
			Min	Max	Min	Max
1	Frequency of EXTAL (EXTAL Pin Frequency) The rise and fall time of the external clock should be 3 ns maximum.	Ef	0	66.0	0	80.0
2	Clock input high[1, 2] • With PLL disabled (46.7%–53.3% duty cycle[6]) • With PLL enabled (42.5%–57.5% duty cycle[6])	ET_H	7.08 ns 6.44 ns	∞ 157.0 µs	5.84 ns 5.31 ns	∞ 157.0 µs
3	Clock input low[1, 2] • With PLL disabled (46.7%–53.3% duty cycle[6]) • With PLL enabled (42.5%–57.5% duty cycle[6])	ET_L	7.08 ns 6.44 ns	∞ 157.0 µs	5.84 ns 5.31 ns	∞ 157.0 µs
4	Clock cycle time[2] • With PLL disabled • With PLL enabled	ET_C	30.3 ns 15.15 ns	∞ 273.1 µs	25.0 ns 12.50 ns	∞ 273.1 µs
5	CLKOUT change from EXTAL fall with PLL disabled		4.3 ns	11.0 ns	4.3 ns	11.0 ns

Table 2-5 Clock Operation (Continued)

No.	Characteristics	Symbol	66 MHz		80 MHz	
			Min	Max	Min	Max
6	CLKOUT from EXTAL with PLL enabled[3,5] a. MF = 1, PDF = 1, Ef > 15 MHz b. MF = 2 or 4, PDF = 1, Ef > 15 MHz, or, MF ≤ 4, PDF ≠ 1, Ef / PDF > 15 MHz		 0.0 ns 0.0 ns	 1.8 ns 1.8 ns	 0.0 ns 0.0 ns	 1.8 ns 1.8 ns
7	Instruction cycle time = I_{CYC} = T_C[4] (See **Table 2-4**.) (46.7%–53.3% duty cycle) • With PLL disabled • With PLL enabled	I_{CYC}	 30.3 ns 15.15 ns	 ∞ 8.53 µs	 25.0 ns 12.50 ns	 ∞ 8.53 µs

Note:
1. Measured at 50% of the input transition
2. The maximum value for PLL enabled is given for minimum V_{CO} and maximum MF.
3. Periodically sampled and not 100% tested
4. The maximum value for PLL enabled is given for minimum V_{CO} and maximum DF.
5. The skew is not guaranteed for any other MF value.
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 correction 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	66 MHz		80 MHz		Unit
	Min	Max	Min	Max	
V_{CO} frequency when PLL enabled ($MF \times E_f \times 2/PDF$)	30	132	30	160	MHz
PLL external capacitor (PCAP pin to V_{CCP}) (C_{PCAP}[1])					
• @ MF ≤ 4	(MF × 425) – 125	(MF × 590) – 175	(MF × 425) – 125	(MF × 590) – 175	pF
• @ MF > 4	MF × 520	MF × 920	MF × 520	MF × 920	pF

Note: C_{PCAP} is the value of the PLL capacitor (connected between the PCAP pin and V_{CCP}). The recommended value in pF for C_{PCAP} can be computed from one of the following equations:

(500 × MF) – 150, for MF ≤ 4, or

690 × MF, for MF > 4.

RESET, STOP, MODE SELECT, AND INTERRUPT TIMING

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing[6]

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
8	Delay from $\overline{\text{RESET}}$ assertion to all pins at reset value[3]	—	—	26.0	—	26.0	ns
9	Required $\overline{\text{RESET}}$ duration[4]						
	• Power on, external clock generator, PLL disabled	$50 \times ET_C$	760.0	—	625.0	—	ns
	• Power on, external clock generator, PLL enabled	$1000 \times ET_C$	15.2	—	12.5	—	ms
	• Power on, internal oscillator	$75000 \times ET_C$	1.14	—	1.0	—	ms
	• During STOP, XTAL disabled (PCTL Bit 16 = 0)	$75000 \times ET_C$	1.14	—	1.0	—	ms
	• During STOP, XTAL enabled (PCTL Bit 16 = 1)	$2.5 \times T_C$	38.0	—	31.3	—	ns
	• During normal operation	$2.5 \times T_C$	38.0	—	31.3	—	ns
10	Delay from asynchronous $\overline{\text{RESET}}$ deassertion to first external address output (internal reset deassertion)[5]						
	• Minimum	**66 MHz**: $3.25 \times T_C + 2.0$	51.0	—	—	—	ns
		80 MHz: $3.25 \times T_C + 2.0$	—	—	42.6	—	ns
	• Maximum	**66 MHz**: $20.25\ T_C + 11.0$	—	318.0	—	—	ns
		80 MHz: $20.25\ T_C + 9.95$	—	—	—	263.1	ns
11	Synchronous reset setup time from $\overline{\text{RESET}}$ deassertion to CLKOUT Transition 1						
	• Minimum		9.0	—	7.4	—	ns
	• Maximum	T_C	—	15.2	—	12.5	ns
12	Synchronous reset deasserted, delay time from the CLKOUT Transition 1 to the first external address output						
	• Minimum	$3.25 \times T_C + 1.0$	50.0	—	41.6	—	ns
	• Maximum	$20.25\ T_C + 5.0$	—	312.0	—	258.1	ns
13	Mode select setup time		30.0	—	30.0	—	ns

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing[6] (Continued)

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
14	Mode select hold time		0.0	—	0.0	—	ns
15	Minimum edge-triggered interrupt request assertion width		10.0	—	8.25	—	ns
16	Minimum edge-triggered interrupt request deassertion width		10.0	—	8.25	—	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	$4.25 \times T_C + 2.0$	66.0	—	55.1	—	ns
	• Caused by first interrupt instruction execution	$7.25 \times T_C + 2.0$	112.0	—	92.6	—	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	$10 \times T_C + 5.0$	157.0	—	130.0	—	ns
19	Delay from address output valid caused by first interrupt instruction execute to interrupt request deassertion for level sensitive fast interrupts[1]	**66 MHz**[8]: $3.75 \times T_C + WS \times T_C - 14$ **80 MHz**[8]: $3.75 \times T_C + WS \times T_C - 12.4$	—		 —		ns ns
20	Delay from $\overline{\text{RD}}$ assertion to interrupt request deassertion for level sensitive fast interrupts[1]	**66 MHz**[8]: $3.25 \times T_C + WS \times T_C - 14$ **80 MHz**[8]: $3.25 \times T_C + WS \times T_C - 12.4$	—		 —		ns ns

Preliminary Data

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing[6] (Continued)

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
21	Delay from $\overline{WR}$ assertion to interrupt request deassertion for level sensitive fast interrupts[1]						
	• SSRAM for all WS	**66 MHz[8]**: $(3.75 + WS) \times T_C - 14$	—				ns
		80 MHz[8]: $(3.75 + WS) \times T_C - 12.4$			—		ns
	• DRAM for all WS	**66 MHz[8]**: $(3.5 + WS) \times T_C - 14$	—				ns
		80 MHz[8]: $(3.5 + WS) \times T_C - 12.4$			—		ns
	• SRAM WS = 1	**66 MHz[8]**: $(WS + 3.5) \times T_C - 14$	—				ns
		80 MHz[8]: $(WS + 3.5) \times T_C - 12.4$			—		ns
	• SRAM WS = 2, 3	**66 MHz[8]**: $(WS + 3) \times T_C - 14$	—				ns
		80 MHz[8]: $(WS + 3) \times T_C - 12.4$			—		ns
	• SRAM WS ≥ 4	**66 MHz[8]**: $(2.5 + WS) \times T_C - 14$	—				ns
		80 MHz[8]: $(2.5 + WS) \times T_C - 12.4$			—		ns
22	Synchronous interrupt setup time from $\overline{IRQA}$, $\overline{IRQB}$, $\overline{IRQC}$, $\overline{IRQD}$, $\overline{NMI}$ assertion to the CLKOUT Transition 2		9.0	T_C	7.4	T_C	ns

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing[6] (Continued)

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
23	Synchronous interrupt delay time from the CLKOUT Transition 2 to the first external address output valid caused by the first instruction fetch after coming out of Wait Processing state						
	• Minimum	$9.25 \times T_C + 1.0$	141.0	—	116.6	—	ns
	• Maximum	$24.75 \times T_C + 5.0$	—	380.0	—	314.4	ns
24	Duration for $\overline{IRQA}$ assertion to recover from Stop state		9.0	—	7.4	—	ns
25	Delay from $\overline{IRQA}$ assertion to fetch of first instruction (when exiting Stop)[2, 3]						
	• PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is enabled (OMR Bit 6 = 0)	$PLC \times ET_C \times PDF + (128\ K - PLC/2) \times T_C$	2.0	64.1	1.6	52.8	ms
	• PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is not enabled (OMR Bit 6 = 1)	$PLC \times ET_C \times PDF + (23.75 \pm 0.5) \times T_C$	352.3 ns	62.1 ms	290.6 ns	51.2 ms	
	• PLL is active during Stop (PCTL Bit 17 = 1) (Implies No Stop Delay)	$(8.25 \pm 0.5) \times T_C$	117.4	132.6	96.9	109.4	ns
26	Duration of level sensitive $\overline{IRQA}$ assertion to ensure interrupt service (when exiting Stop)[2, 3]						
	• PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is enabled (OMR Bit 6 = 0)	$PLC \times ET_C \times PDF + (128K - PLC/2) \times T_C$	64.1	—	52.8	—	ms
	• PLL is not active during Stop (PCTL Bit 17 = 0) and Stop delay is not enabled (OMR Bit 6 = 1)	$PLC \times ET_C \times PDF + (20.5 \pm 0.5) \times T_C$	62.1	—	51.2	—	ms
	• PLL is active during Stop (PCTL Bit 17 = 1) (implies no Stop delay)	$5.5 \times T_C$	83.4	—	68.8	—	ns

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing[6] (Continued)

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
27	Interrupt Requests Rate						
	• HI08, ESSI, SCI, Timer	$12T_C$	—	181.8	—	150.0	ns
	• DMA	$8T_C$	—	121.2	—	100.0	ns
	• $\overline{\text{IRQ}}$, $\overline{\text{NMI}}$ (edge trigger)	$8T_C$	—	121.2	—	100.0	ns
	• $\overline{\text{IRQ}}$, $\overline{\text{NMI}}$ (level trigger)	$12T_C$	—	181.8	—	150.0	ns
28	DMA Requests Rate						
	• Data read from HI08, ESSI, SCI	$6T_C$	—	90.9	—	75.0	ns
	• Data write to HI08, ESSI, SCI	$7T_C$	—	106.1	—	87.5	ns
	• Timer	$2T_C$	—	30.3	—	25.0	ns
	• $\overline{\text{IRQ}}$, $\overline{\text{NMI}}$ (edge trigger)	$3T_C$	—	45.5	—	37.5	ns
29	Delay from $\overline{\text{IRQA}}$, $\overline{\text{IRQB}}$, $\overline{\text{IRQC}}$, $\overline{\text{IRQD}}$, $\overline{\text{NMI}}$ assertion to external memory (DMA source) access address out valid	$4.25 \times T_C + 2.0$	66.0	—	55.1	—	ns

Note: 1. When using fast interrupts and $\overline{\text{IRQA}}$, $\overline{\text{IRQB}}$, $\overline{\text{IRQC}}$, and $\overline{\text{IRQD}}$ 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.

Table 2-7 Reset, Stop, Mode Select, and Interrupt Timing[6] (Continued)

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	

2. This timing depends on several settings:

   For PLL disable, using internal oscillator (PLL Control Register (PCTL) Bit 16 = 0) and oscillator disabled during Stop (PCTL Bit 17 = 0), a stabilization delay is required to assure the oscillator is stable before executing programs. In that case, resetting the Stop delay (OMR Bit 6 = 0) will provide the proper delay. While it is possible to set OMR Bit 6 = 1, it is not recommended and these specifications do not guarantee timings for that case.

   For PLL disable, using internal oscillator (PCTL Bit 16 = 0) and oscillator enabled during Stop (PCTL Bit 17=1), no stabilization delay is required and recovery time will be minimal (OMR Bit 6 setting is ignored).

   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.

   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.

   PLC value for PLL disable is 0.

   The maximum value for ET_C is 4096 (maximum MF) divided by the desired internal frequency (i.e., for 66 MHz it is 4096/66 MHz = 62 µs). During the stabilization period, T_C, $T_{H,}$ and T_L will not be constant, and their width may vary, so timing may vary as well.
3. Periodically sampled and not 100% tested
4. For an external clock generator, $\overline{RESET}$ duration is measured during the time in which $\overline{RESET}$ is asserted, V_{CC} is valid, and the EXTAL input is active and valid.

   For internal oscillator, $\overline{RESET}$ duration is measured during the time in which $\overline{RESET}$ is asserted and V_{CC} is valid. The specified timing reflects the crystal oscillator stabilization time after power-up. This number is affected both by the specifications of the crystal and other components connected to the oscillator and reflects worst case conditions.

   When the V_{CC} is valid, but the other “required $\overline{RESET}$ 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.
5. If PLL does not lose lock
6. V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100°C, C_L = 50 pF + 2 TTL Loads
7. WS = number of wait states (measured in clock cycles, number of T_C)
8. Use expression to compute maximum value.

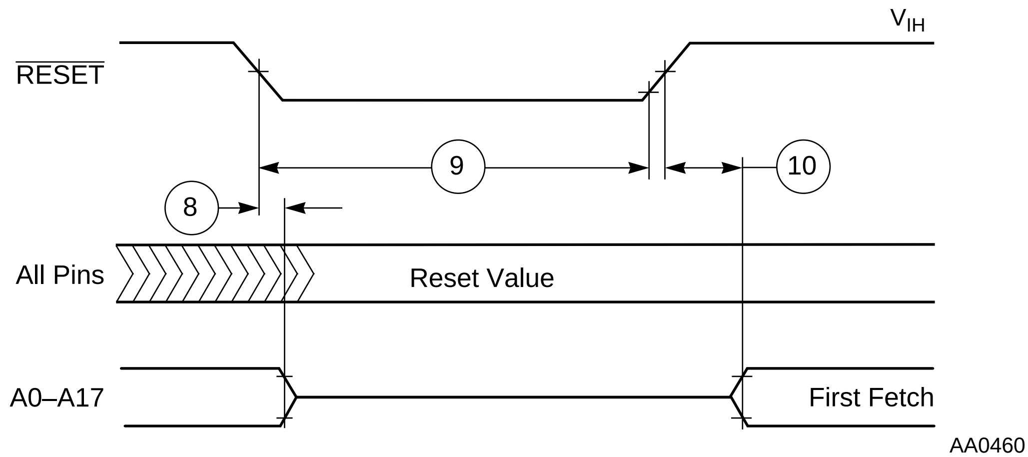


Figure 2-3 Reset Timing

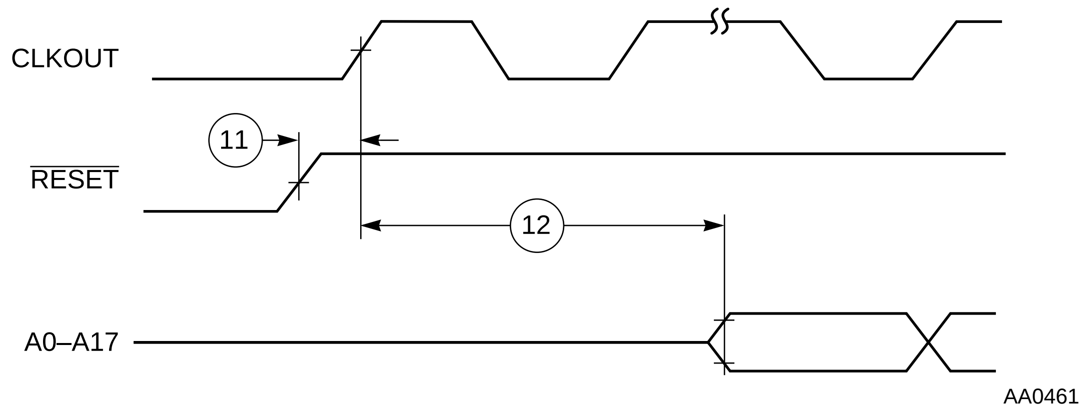


Figure 2-4 Synchronous Reset Timing

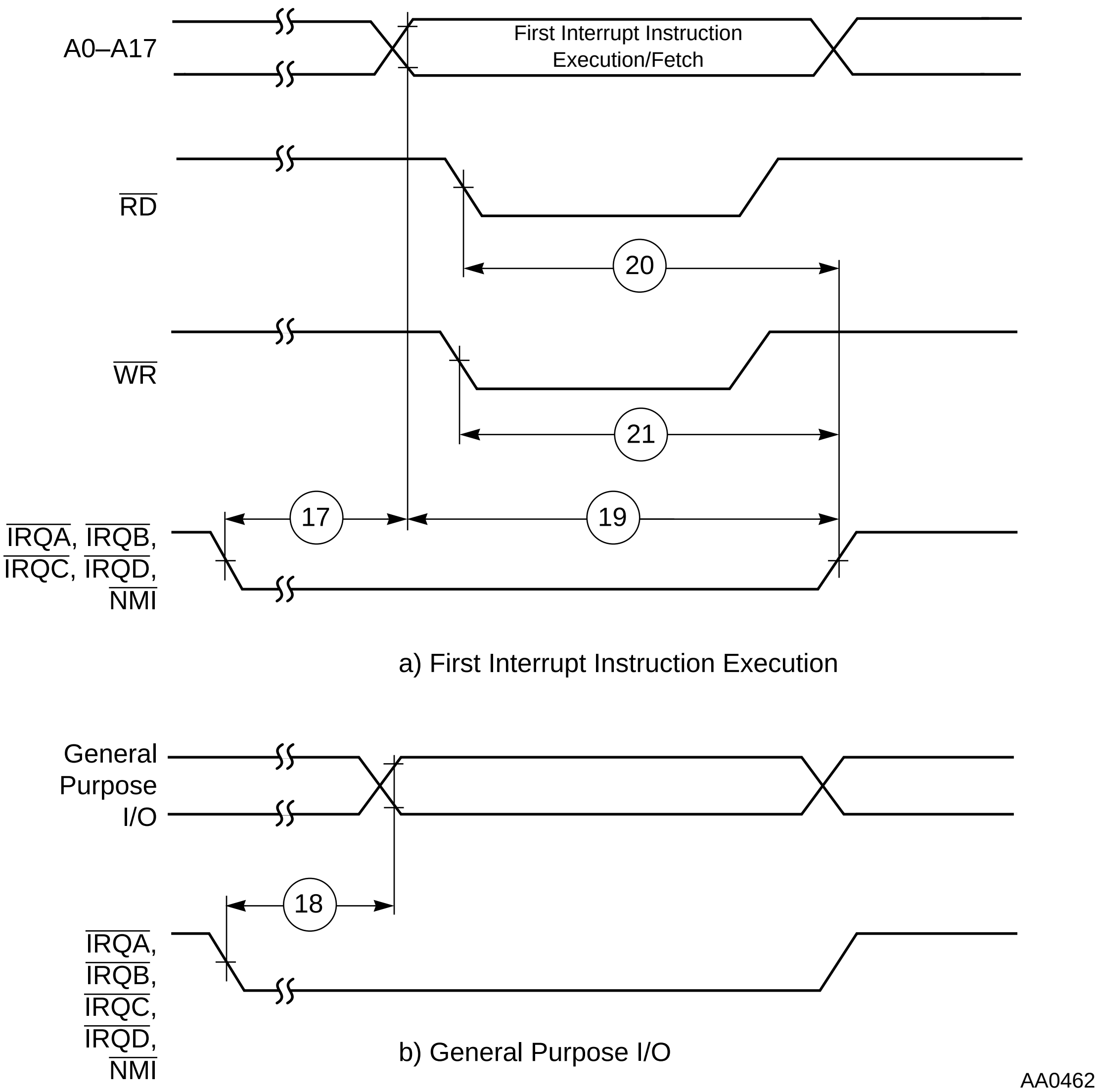


Figure 2-5 External Fast Interrupt Timing

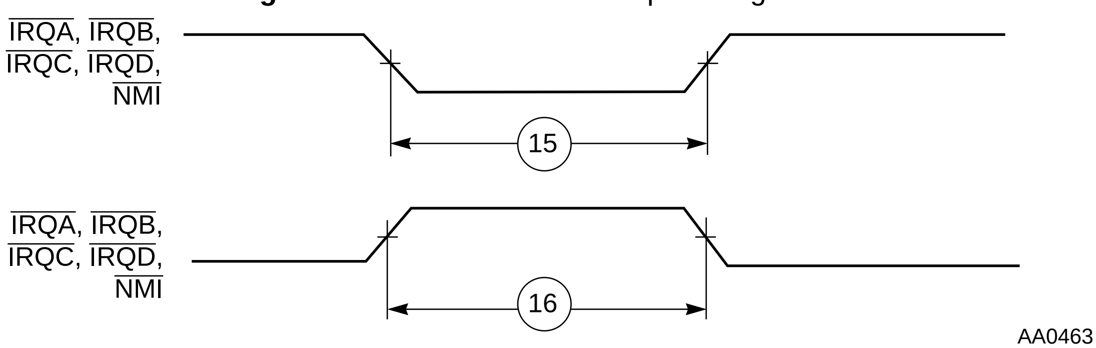


Figure 2-6 External Interrupt Timing (Negative Edge-Triggered)

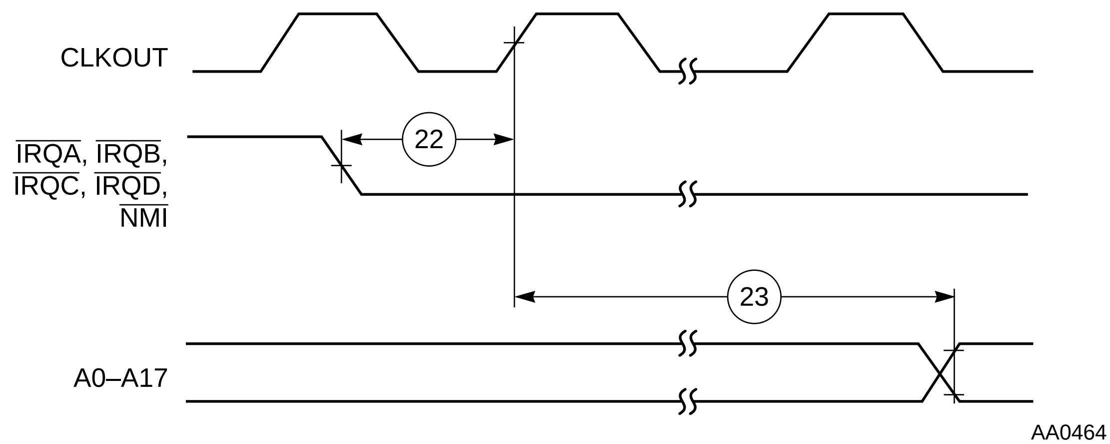


Figure 2-7 Synchronous Interrupt from Wait State Timing

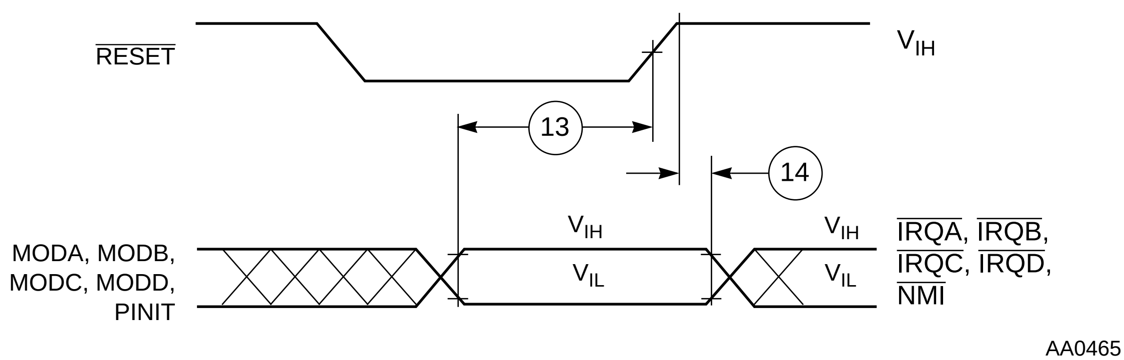


Figure 2-8 Operating Mode Select Timing

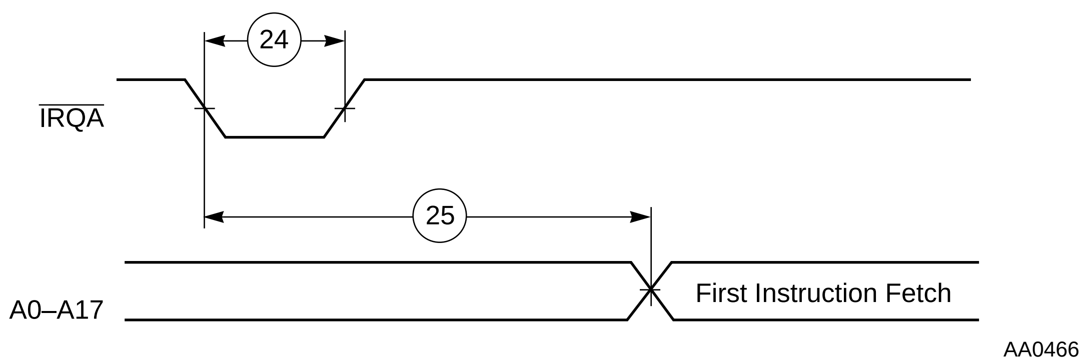


Figure 2-9 Recovery from Stop State Using $\overline{IRQA}$

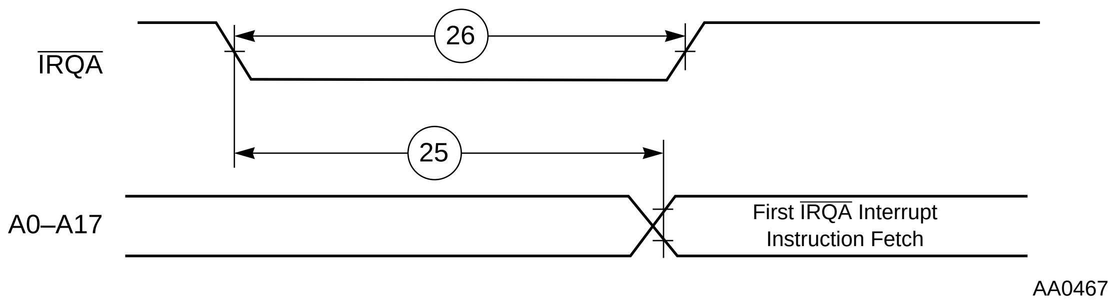
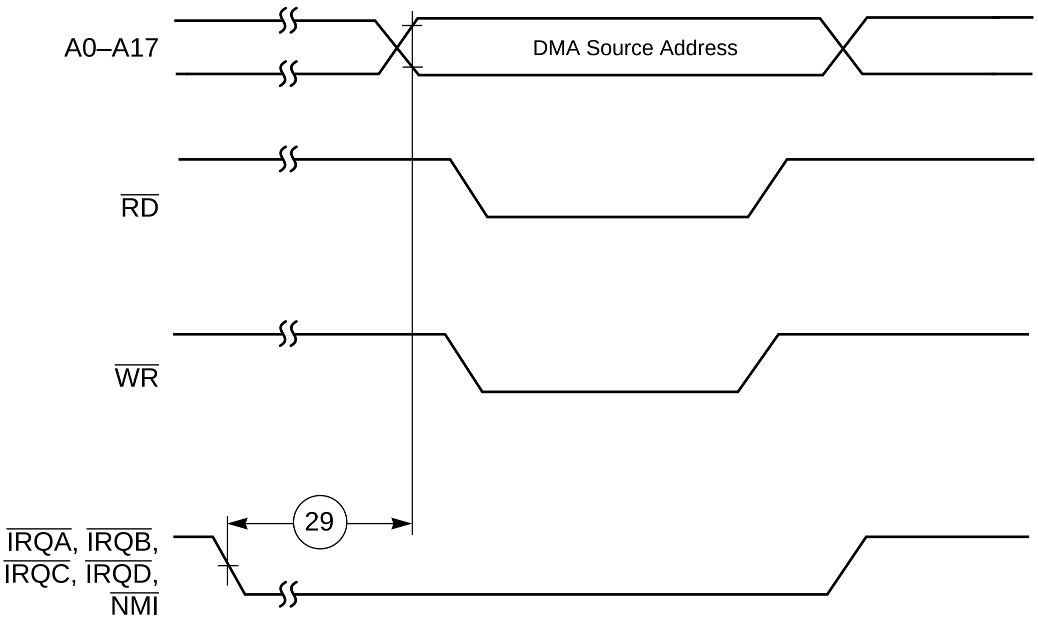


Figure 2-10 Recovery from Stop State Using IRQA Interrupt Service



a) First Interrupt Instruction Execution

Figure 2-11 External Memory Access (DMA Source) Timing

EXTERNAL MEMORY INTERFACE (PORT A)

Table 2-8 SRAM Read and Write Accesses

No.	Characteristics	Symbol	Expression[1]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
100	Address valid and AA assertion pulse width	t_{RC}, t_{WC}	$(WS + 1) \times T_C - 4.0$ [$1 \le WS \le 3$]	26.3	—	21.0	—	ns
			$(WS + 2) \times T_C - 4.0$ [$4 \le WS \le 7$]	86.9	—	71.0	—	ns
			$(WS + 3) \times T_C - 4.0$ [$WS \ge 8$]	162.7	—	133.5	—	ns
101	Address and AA valid to $\overline{WR}$ assertion	t_{AS}	**66 MHz:** $0.25 \times T_C - 3.7$ [$WS = 1$]	0.1	—	—	—	ns
			80 MHz: $0.25 \times T_C - 3.0$ [$WS = 1$]	—	—	0.1	—	ns
			$0.75 \times T_C - 4.0$ [$2 \le WS \le 3$]	7.4	—	5.4	—	ns
			$1.25 \times T_C - 4.0$ [$WS \ge 4$]	14.9	—	11.6	—	ns
102	$\overline{WR}$ assertion pulse width	t_{WP}	$1.5 \times T_C - 4.5$ [$WS = 1$]	18.2	—	14.8	—	ns
			$WS \times T_C - 4.0$ [$2 \le WS \le 3$]	26.3	—	21.0	—	ns
			$(WS - 0.5) \times T_C - 4.0$ [$WS \ge 4$]	49.0	—	39.8	—	ns
103	$\overline{WR}$ deassertion to address not valid	t_{WR}	**66 MHz:** $0.25 \times T_C - 3.8$ [$1 \le WS \le 3$]	0.1	—	—	—	ns
			80 MHz: $0.25 \times T_C - 3.0$ [$1 \le WS \le 3$]	—	—	0.0	—	ns
			$1.25 \times T_C - 4.0$ [$4 \le WS \le 7$]	14.9	—	11.6	—	ns
			$2.25 \times T_C - 4.0$ [$WS \ge 8$]	30.1	—	24.1	—	ns

Table 2-8 SRAM Read and Write Accesses (Continued)

No.	Characteristics	Symbol	Expression[1]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
104	Address and AA valid to input data valid	t_{AA}, t_{AC}	**66 MHz:** $(WS + 0.75) \times T_C - 10.0$ [WS ≥ 1]	—	16.5	—	—	ns
			80 MHz: $(WS + 0.75) \times T_C - 9.5$ [WS ≥ 1]	—	—	—	12.4	ns
105	$\overline{RD}$ assertion to input data valid	t_{OE}	**66 MHz:** $(WS + 0.25) \times T_C - 10.0$ [WS ≥ 1]	—	8.9	—	—	ns
			80 MHz: $(WS + 0.25) \times T_C - 9.5$ [WS ≥ 1]	—	—	—	6.1	ns
106	$\overline{RD}$ deassertion to data not valid (data hold time)	t_{OHZ}		0.0	—	0.0	—	ns
107	Address valid to $\overline{WR}$ deassertion	t_{AW}	$(WS + 0.75) \times T_C - 4.0$ [WS ≥ 1]	22.5	—	17.9	—	ns
108	Data valid to $\overline{WR}$ deassertion (data setup time)	t_{DS} (t_{DW})	**66 MHz:** $(WS - 0.25) \times T_C - 3.9$ [WS ≥ 1]	7.5	—	—	—	ns
			80 MHz: $(WS - 0.25) \times T_C - 3.3$ [WS ≥ 1]	—	—	6.1	—	ns
109	Data hold time from $\overline{WR}$ deassertion	t_{DH}	**66 MHz:** $0.25 \times T_C - 3.7$ [1 ≤ WS ≤ 3]	0.1	—	—	—	ns
			80 MHz: $0.25 \times T_C - 3.0$ [1 ≤ WS ≤ 3]	—	—	0.1	—	ns
			$1.25 \times T_C - 3.7$ [4 ≤ WS ≤ 7]	15.2	—	11.8	—	ns
			$2.25 \times T_C - 3.7$ [WS ≥ 8]	30.4	—	24.3	—	ns

Table 2-8 SRAM Read and Write Accesses (Continued)

No.	Characteristics	Symbol	Expression[1]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
110	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 3.7$ [WS = 1]	7.7	—	5.7	—	ns
			$0.25 \times T_C - 3.7$ [2 ≤ WS ≤ 3]	0.1	—	–0.6	—	ns
			$-0.25 \times T_C - 3.7$ [WS ≥ 4]	–7.5	—	–6.8	—	ns
111	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C + 0.2$ [1 ≤ WS ≤ 3]	—	4.0	—	3.3	ns
			$1.25 \times T_C + 0.2$ [4 ≤ WS ≤ 7]	—	19.1	—	15.8	ns
			$2.25 \times T_C + 0.2$ [WS ≥ 8]	—	34.3	—	28.3	ns
112	Previous $\overline{RD}$ deassertion to data active (write)		$1.25 \times T_C - 4.0$ [1 ≤ WS ≤ 3]	14.9	—	11.6	—	ns
			$2.25 \times T_C - 4.0$ [4 ≤ WS ≤ 7]	30.1	—	24.1	—	ns
			$3.25 \times T_C - 4.0$ [WS ≥ 8]	45.2	—	36.6	—	ns
113	$\overline{RD}$ deassertion time		$0.75 \times T_C - 4.0$ [1 ≤ WS ≤ 3]	7.4	—	5.4	—	ns
			$1.75 \times T_C - 4.0$ [4 ≤ WS ≤ 7]	22.5	—	17.9	—	ns
			$2.75 \times T_C - 4.0$ [WS ≥ 8]	37.7	—	30.4	—	ns
114	$\overline{WR}$ deassertion time		$0.5 \times T_C - 3.5$ [WS = 1]	4.1	—	2.8	—	ns
			$T_C - 3.5$ [2 ≤ WS ≤ 3]	11.7	—	9.0	—	ns
			$2.5 \times T_C - 3.5$ [4 ≤ WS ≤ 7]	34.4	—	27.8	—	ns
			$3.5 \times T_C - 3.5$ [WS ≥ 8]	49.5	—	40.3	—	ns
115	Address valid to $\overline{RD}$ assertion		$0.5 \times T_C - 4$	3.5	—	2.3	—	ns
116	$\overline{RD}$ assertion pulse width		$(WS + 0.25) \times T_C - 3.8$	15.1	—	11.8	—	ns

Table 2-8 SRAM Read and Write Accesses (Continued)

No.	Characteristics	Symbol	Expression[1]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
117	$\overline{RD}$ deassertion to address not valid		$0.25 \times T_C - 3.0$ [1 ≤ WS ≤ 3]	0.7	—	0.1	—	ns
			$1.25 \times T_C - 3.0$ [4 ≤ WS ≤ 7]	15.9	—	12.6	—	ns
			$2.25 \times T_C - 3.0$ [WS ≥ 8]	31.0	—	25.1	—	ns

Note: 1. WS is the number of wait states specified in the BCR.
2. V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100 °C, C_L = 50 pF + 2 TTL Loads

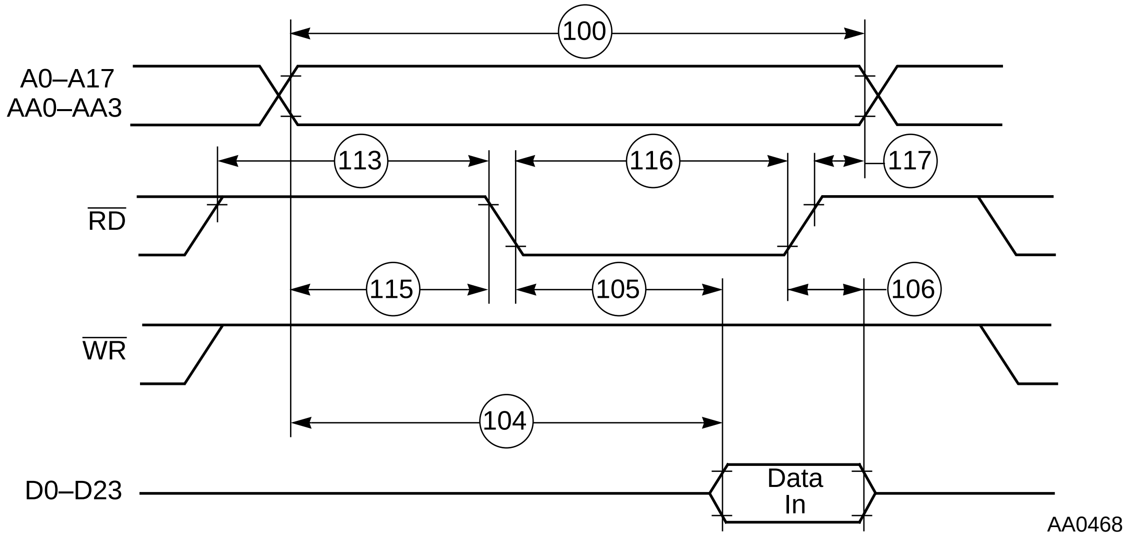


Figure 2-12 SRAM Read Access

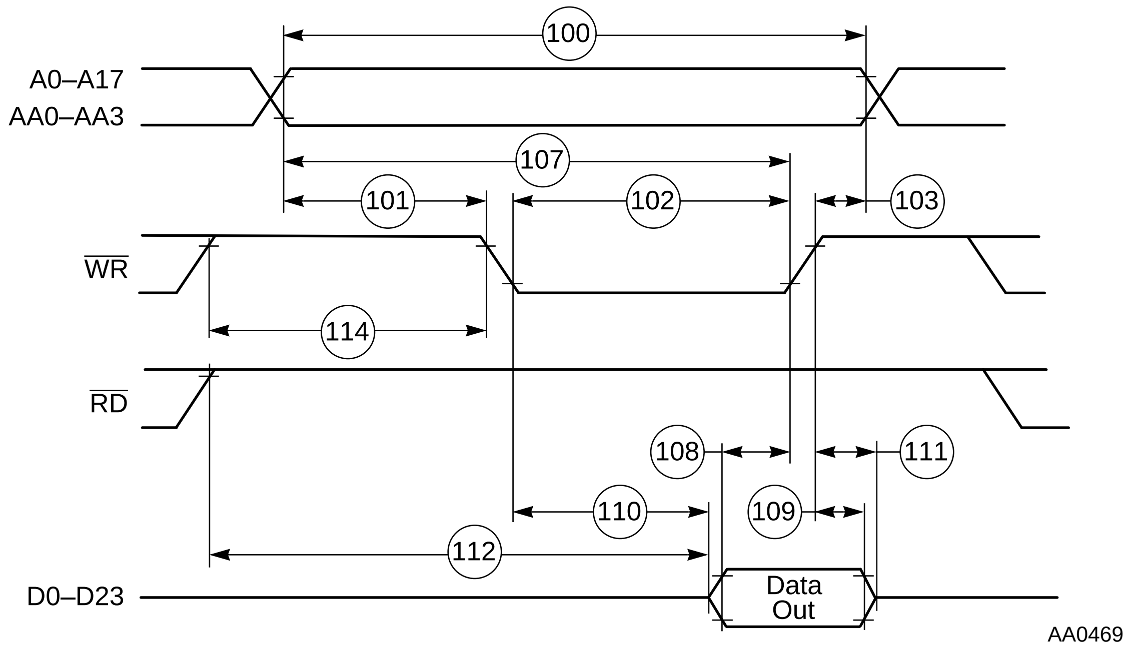


Figure 2-13 SRAM Write Access

Table 2-9 SSRAM Read and Write Access

No.	Characteristics	Symbol	Expression[2]	50 MHz[1]		66 MHz		80 MHz		Unit
				Min	Max	Min	Max	Min	Max	
118	BCLK high to BCLK high (cycle time)	t_{KHKH}	$(WS + 1) \times T_C$	20.0	—	15.1	—	12.5	—	ns
119	BCLK high time	t_{KHKL}	**50 MHz:** $0.5 \times T_C - 5.5$ **66 MHz:** $0.5 \times T_C - 4.8$ **80 MHz:** $0.5 \times T_C - 4.2$	4.5	—	2.8	—	1.5	—	ns ns ns
120	BCLK low time	t_{KLKH}	**50 MHz and 66 MHz:** $(WS + 0.5) \times T_C - 2.5$ **80 MHz:** $(WS + 0.5) \times T_C - 2.3$	7.5	—	5.1	—	4.0	—	ns ns
121	BCLK high to input data valid	t_{KHQV}	$(WS + 1) \times T_C - 7.5$	—	12.5	—	7.7	—	5.0	ns
122	$\overline{RD}$ assertion to input data valid	t_{GLQV}	$(WS + 1) \times T_C - 7.5$	—	12.5	—	7.7	—	5.0	ns

Table 2-9 SSRAM Read and Write Access (Continued)

No.	Characteristics	Symbol	Expression[2]	50 MHz[1]		66 MHz		80 MHz		Unit
				Min	Max	Min	Max	Min	Max	
123	$\overline{RD}$ deassertion to input data invalid	t_{GHQX}		0.0	—	0.0	—	0.0	—	ns
124	Address and AA setup time to clock high	t_{AVKH}	$0.5 \times T_C - 4.0$	6.0	—	3.6	—	2.8	—	ns
125	$\overline{WR}$ setup time to clock high	t_{SWVKH}	$0.5 \times T_C - 4.0$	6.0	—	3.6	—	2.8	—	ns
126	Data out setup time to clock high	t_{DVKH}	$(WS + 0.5) \times T_C - 4.0$	6.0	—	3.6	—	2.8	—	ns
127	BCLK high to address and AA invalid (hold time)	t_{KHAX}	$(WS + 0.5) \times T_C - 1.0$	9.0	—	6.6	—	5.3	—	ns
128	BCLK high to $\overline{WR}$ deassertion (hold time)	t_{KHSWX}	$(WS + 0.5) \times T_C - 1.0$	9.0	—	6.6	—	5.3	—	ns
129	BCLK high to input data invalid (data hold time)	t_{KHQX2}		0.0	—	0.0	—	0.0	—	ns
130	BCLK high to output data invalid (data hold time) BCLK high to data high impedance	t_{KHDX}	$0.5 \times T_C - 1.0$	9.0	—	6.6	—	5.3	—	ns

Note:
1. Using available SSRAM, the DSP56304 can be run at 50 MHz with zero wait states.
2. WS is the number of wait states specified in the BCR.

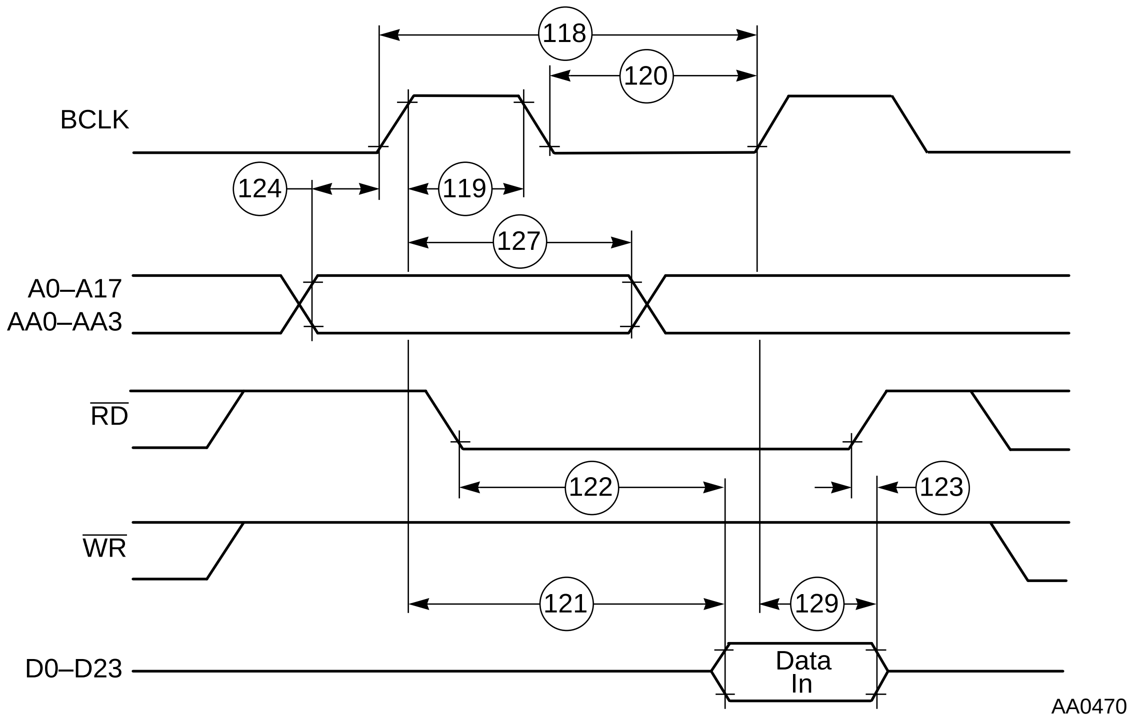


Figure 2-14 SSRAM Read Access

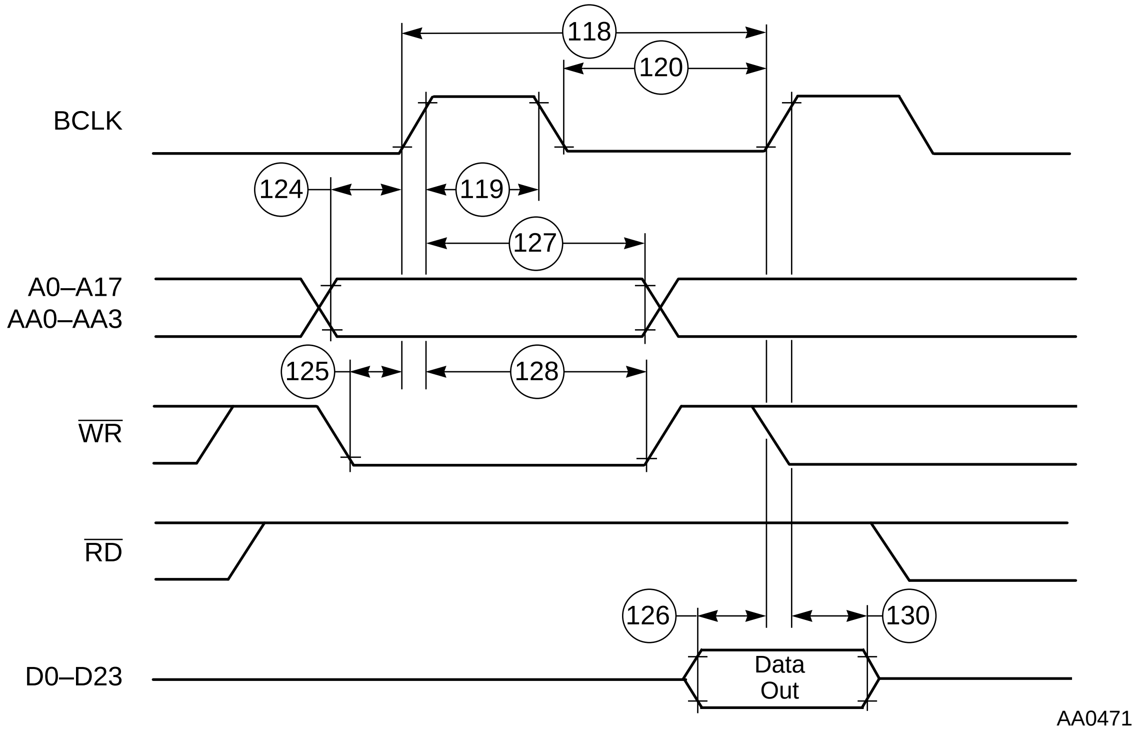


Figure 2-15 SSRAM Write Access

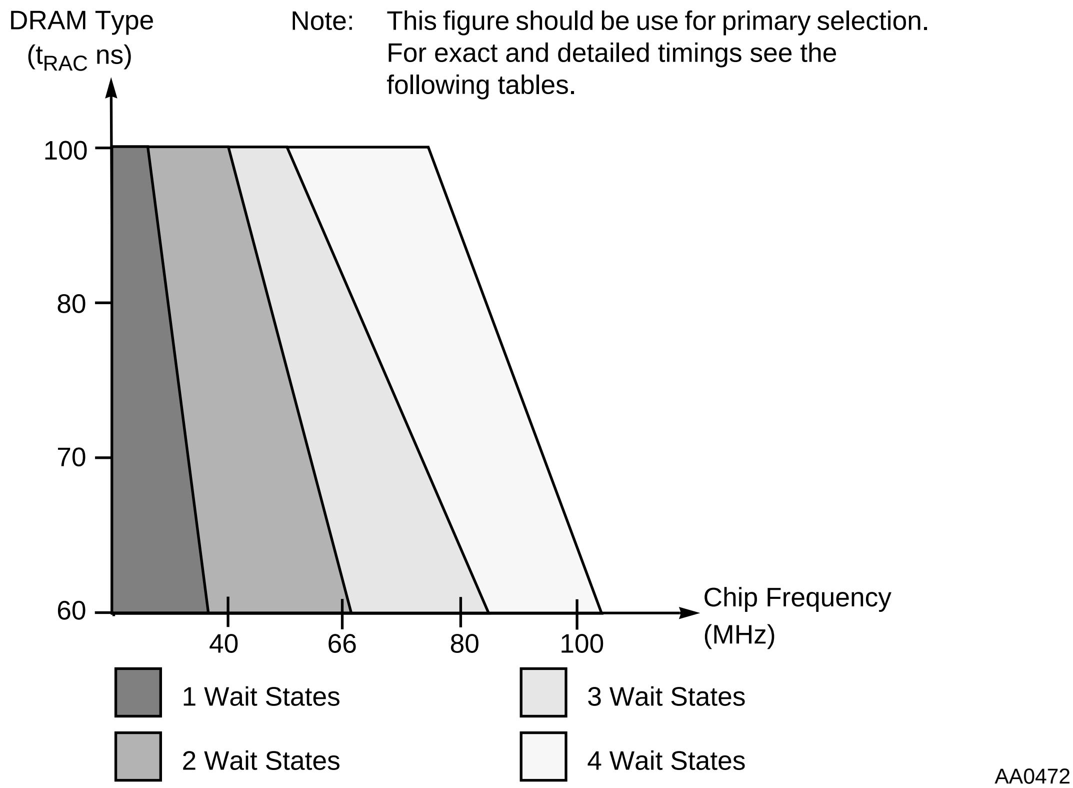


Figure 2-16 DRAM Page Mode Wait States Selection Guide

Table 2-10 DRAM Page Mode Timings, One Wait State (Low-Power Applications)[1, 2, 3]

No.	Characteristics	Symbol	Expression	20 MHz[6]		30 MHz[6]		Unit
				Min	Max	Min	Max	
131	Page mode cycle time	t_{PC}	$1.25 \times T_C$	62.5	—	41.7	—	ns
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

Table 2-10 DRAM Page Mode Timings, One Wait State (Low-Power Applications)[1, 2, 3]

No.	Characteristics	Symbol	Expression	20 MHz[6]		30 MHz[6]		Unit
				Min	Max	Min	Max	
138	Last $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion[4]	t_{CRP}						
	• BRW[1:0] = 00		$1.75 \times T_C - 6.0$	81.5	—	52.3	—	ns
	• BRW[1:0] = 01		$3.25 \times T_C - 6.0$	156.5	—	102.2	—	ns
	• BRW[1:0] = 10		$4.25 \times T_C - 6.0$	206.5	—	135.5	—	ns
	• BRW[1:0] = 11		$6.25 \times T_C - 6.0$	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
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

Table 2-10 DRAM Page Mode Timings, One Wait State (Low-Power Applications)[1, 2, 3]

No.	Characteristics	Symbol	Expression	20 MHz[6]		30 MHz[6]		Unit
				Min	Max	Min	Max	
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 [5]	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

Note:
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. 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).
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.
5. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is t_{OFF} and not t_{GZ}.
6. Reduced DSP clock speed allows use of Page Mode DRAM with one wait state (See **Figure 2-16**.).

Table 2-11 DRAM Page Mode Timings, Two Wait States[1, 2, 3]

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
131	Page mode cycle time	t_{PC}	$2.75 \times T_C$	41.7	—	34.4	—	ns
132	$\overline{CAS}$ assertion to data valid (read)	t_{CAC}	**66 MHz**: $1.5 \times T_C - 7.5$ **80 MHz**: $1.5 \times T_C - 6.5$	— —	15.2 —	— —	— 12.3	ns ns
133	Column address valid to data valid (read)	t_{AA}	**66 MHz**: $2.5 \times T_C - 7.5$ **80 MHz**: $2.5 \times T_C - 6.5$	— —	30.4 —	— —	— 24.8	ns 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

Table 2-11 DRAM Page Mode Timings, Two Wait States[1, 2, 3] (Continued)

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
137	$\overline{CAS}$ assertion pulse width	t_{CAS}	$1.5 \times T_C - 4.0$	18.7	—	14.8	—	ns
138	Last $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion[5]	t_{CRP}						
	• BRW[1:0] = 00		$2.0 \times T_C - 6.0$	24.4	—	19.0	—	ns
	• BRW[1:0] = 01		$3.5 \times T_C - 6.0$	47.2	—	37.8	—	ns
	• BRW[1:0] = 10		$4.5 \times T_C - 6.0$	62.4	—	50.3	—	ns
	• BRW[1:0] = 11		$6.5 \times T_C - 6.0$	92.8	—	75.3	—	ns
139	$\overline{CAS}$ deassertion pulse width	t_{CP}	$1.25 \times T_C - 4.0$	14.9	—	11.6	—	ns
140	Column address valid to $\overline{CAS}$ assertion	t_{ASC}	$T_C - 4.0$	11.2	—	8.5	—	ns
141	$\overline{CAS}$ assertion to column address not valid	t_{CAH}	$1.75 \times T_C - 4.0$	22.5	—	17.9	—	ns
142	Last column address valid to $\overline{RAS}$ deassertion	t_{RAL}	$3 \times T_C - 4.0$	41.5	—	33.5	—	ns
143	$\overline{WR}$ deassertion to $\overline{CAS}$ assertion	t_{RCS}	$1.25 \times T_C - 3.8$	15.1	—	11.8	—	ns
144	$\overline{CAS}$ deassertion to $\overline{WR}$ assertion	t_{RCH}	$0.5 \times T_C - 3.7$	3.9	—	2.6	—	ns
145	$\overline{CAS}$ assertion to $\overline{WR}$ deassertion	t_{WCH}	$1.5 \times T_C - 4.2$	18.5	—	14.6	—	ns
146	$\overline{WR}$ assertion pulse width	t_{WP}	$2.5 \times T_C - 4.5$	33.4	—	26.8	—	ns
147	Last $\overline{WR}$ assertion to $\overline{RAS}$ deassertion	t_{RWL}	$2.75 \times T_C - 4.3$	37.4	—	30.1	—	ns
148	$\overline{WR}$ assertion to $\overline{CAS}$ deassertion	t_{CWL}	$2.5 \times T_C - 4.3$	33.6	—	27.0	—	ns

Table 2-11 DRAM Page Mode Timings, Two Wait States[1, 2, 3] (Continued)

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
149	Data valid to $\overline{CAS}$ assertion (write)	t_{DS}	**66 MHz**: $0.25 \times T_C - 3.7$	0.1	—	—	—	ns
			80 MHz: $0.25 \times T_C - 3.0$		—	0.1	—	ns
150	$\overline{CAS}$ assertion to data not valid (write)	t_{DH}	$1.75 \times T_C - 4.0$	22.5	—	17.9	—	ns
151	$\overline{WR}$ assertion to $\overline{CAS}$ assertion	t_{WCS}	$T_C - 4.3$	10.9	—	8.2	—	ns
152	Last $\overline{RD}$ assertion to $\overline{RAS}$ deassertion	t_{ROH}	$2.5 \times T_C - 4.0$	33.9	—	27.3	—	ns
153	$\overline{RD}$ assertion to data valid	t_{GA}	$1.75 \times T_C - 7.5$	—	19.0	—	15.4	ns
154	$\overline{RD}$ deassertion to data not valid[6]	t_{GZ}		0.0	—	0.0	—	ns
155	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 0.3$	11.1	—	9.1	—	ns
156	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C$	—	3.8	—	3.1	ns

Note:
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 DSP56304.
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}.

Table 2-12 DRAM Page Mode Timings, Three Wait States[1, 2, 3]

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
131	Page mode cycle time	t_{PC}	$3.5 \times T_C$	53.0	—	43.8	—	ns
132	$\overline{CAS}$ assertion to data valid (read)	t_{CAC}	**66 MHz**: $2 \times T_C - 7.5$	—	22.8	—	—	ns
			80 MHz: $2 \times T_C - 6.5$	—	—	—	18.5	ns
133	Column address valid to data valid (read)	t_{AA}	**66 MHz**: $3 \times T_C - 7.5$	—	37.9	—	—	ns
			80 MHz: $3 \times T_C - 6.5$	—	—	—	31.0	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}	$2.5 \times T_C - 4.0$	33.9	—	27.3	—	ns
136	Previous $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion	t_{RHCP}	$4.5 \times T_C - 4.0$	64.2	—	52.3	—	ns
137	$\overline{CAS}$ assertion pulse width	t_{CAS}	$2 \times T_C - 4.0$	26.3	—	21.0	—	ns
138	Last $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion[5]	t_{CRP}						
	• BRW[1:0] = 00		$2.25 \times T_C - 6.0$	28.2	—	22.2	—	ns
	• BRW[1:0] = 01		$3.75 \times T_C - 6.0$	51.0	—	40.9	—	ns
	• BRW[1:0] = 10		$4.75 \times T_C - 6.0$	66.2	—	53.4	—	ns
	• BRW[1:0] = 11		$6.75 \times T_C - 6.0$	96.6	—	78.4	—	ns
139	$\overline{CAS}$ deassertion pulse width	t_{CP}	$1.5 \times T_C - 4.0$	18.7	—	14.8	—	ns
140	Column address valid to $\overline{CAS}$ assertion	t_{ASC}	$T_C - 4.0$	11.2	—	8.5	—	ns
141	$\overline{CAS}$ assertion to column address not valid	t_{CAH}	$2.5 \times T_C - 4.0$	33.9	—	27.3	—	ns
142	Last column address valid to $\overline{RAS}$ deassertion	t_{RAL}	$4 \times T_C - 4.0$	56.6	—	46.0	—	ns

Table 2-12 DRAM Page Mode Timings, Three Wait States[1, 2, 3] (Continued)

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
143	$\overline{WR}$ deassertion to $\overline{CAS}$ assertion	t_{RCS}	$1.25 \times T_C - 3.8$	15.1	—	11.8	—	ns
144	$\overline{CAS}$ deassertion to $\overline{WR}$ assertion	t_{RCH}	$0.75 \times T_C - 3.7$	7.7	—	5.7	—	ns
145	$\overline{CAS}$ assertion to $\overline{WR}$ deassertion	t_{WCH}	$2.25 \times T_C - 4.2$	29.9	—	23.9	—	ns
146	$\overline{WR}$ assertion pulse width	t_{WP}	$3.5 \times T_C - 4.5$	48.5	—	39.3	—	ns
147	Last $\overline{WR}$ assertion to $\overline{RAS}$ deassertion	t_{RWL}	$3.75 \times T_C - 4.3$	52.5	—	42.6	—	ns
148	$\overline{WR}$ assertion to $\overline{CAS}$ deassertion	t_{CWL}	$3.25 \times T_C - 4.3$	44.9	—	36.3	—	ns
149	Data valid to $\overline{CAS}$ assertion (write)	t_{DS}	$0.5 \times T_C - 4.0$	3.6	—	2.3	—	ns
150	$\overline{CAS}$ assertion to data not valid (write)	t_{DH}	$2.5 \times T_C - 4.0$	33.9	—	27.3	—	ns
151	$\overline{WR}$ assertion to $\overline{CAS}$ assertion	t_{WCS}	$1.25 \times T_C - 4.3$	14.6	—	11.3	—	ns
152	Last $\overline{RD}$ assertion to $\overline{RAS}$ deassertion	t_{ROH}	$3.5 \times T_C - 4.0$	49.0	—	39.8	—	ns
153	$\overline{RD}$ assertion to data valid	t_{GA}	**66 MHz**: $2.5 \times T_C - 7.5$	—	30.4	—	—	ns
			80 MHz: $2.5 \times T_C - 6.5$	—	—	—	24.8	ns
154	$\overline{RD}$ deassertion to data not valid[6]	t_{GZ}		0.0	—	0.0	—	ns
155	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 0.3$	11.1	—	9.1	—	ns
156	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C$	—	3.8	—	3.1	ns

Note:
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 DSP56304.
4. All the timings are calculated for the worst case. Some of the timings are better for specific cases (e.g., t_{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. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is t_{OFF} and not t_{GZ}.

Preliminary Data

Table 2-13 DRAM Page Mode Timings, Four Wait States[1, 2, 3]

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
131	Page mode cycle time	t_{PC}	$4.5 \times T_C$	68.2	—	56.3	—	ns
132	$\overline{CAS}$ assertion to data valid (read)	t_{CAC}	**66 MHz**: $2.75 \times T_C - 7.5$	—	34.2	—	—	ns
			80 MHz: $2.75 \times T_C - 6.5$	—	—	—	27.9	ns
133	Column address valid to data valid (read)	t_{AA}	**66 MHz**: $3.75 \times T_C - 7.5$	—	49.3	—	—	ns
			80 MHz: $3.75 \times T_C - 6.5$	—	—	—	40.4	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}	$3.5 \times T_C - 4.0$	49.0	—	39.8	—	ns
136	Previous $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion	t_{RHCP}	$6 \times T_C - 4.0$	86.9	—	71.0	—	ns
137	$\overline{CAS}$ assertion pulse width	t_{CAS}	$2.5 \times T_C - 4.0$	33.9	—	27.3	—	ns
138	Last $\overline{CAS}$ deassertion to $\overline{RAS}$ deassertion[5]	t_{CRP}						
	• BRW[1:0] = 00		$2.75 \times T_C - 6.0$	35.8	—	28.4	—	ns
	• BRW[1:0] = 01		$4.25 \times T_C - 6.0$	58.6	—	47.2	—	ns
	• BRW[1:0] = 10		$5.25 \times T_C - 6.0$	73.8	—	59.7	—	ns
	• BRW[1:0] = 11		$6.25 \times T_C - 6.0$	89.0	—	72.2	—	ns
139	$\overline{CAS}$ deassertion pulse width	t_{CP}	$2 \times T_C - 4.0$	26.3	—	21.0	—	ns
140	Column address valid to $\overline{CAS}$ assertion	t_{ASC}	$T_C - 4.0$	11.2	—	8.5	—	ns

Table 2-13 DRAM Page Mode Timings, Four Wait States[1, 2, 3] (Continued)

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
141	$\overline{CAS}$ assertion to column address not valid	t_{CAH}	$3.5 \times T_C - 4.0$	49.0	—	39.8	—	ns
142	Last column address valid to $\overline{RAS}$ deassertion	t_{RAL}	$5 \times T_C - 4.0$	71.8	—	58.5	—	ns
143	$\overline{WR}$ deassertion to $\overline{CAS}$ assertion	t_{RCS}	$1.25 \times T_C - 3.8$	15.1	—	11.8	—	ns
144	$\overline{CAS}$ deassertion to $\overline{WR}$ assertion	t_{RCH}	$1.25 \times T_C - 3.7$	15.2	—	11.9	—	ns
145	$\overline{CAS}$ assertion to $\overline{WR}$ deassertion	t_{WCH}	$3.25 \times T_C - 4.2$	45.0	—	36.4	—	ns
146	$\overline{WR}$ assertion pulse width	t_{WP}	$4.5 \times T_C - 4.5$	63.7	—	51.8	—	ns
147	Last $\overline{WR}$ assertion to $\overline{RAS}$ deassertion	t_{RWL}	$4.75 \times T_C - 4.3$	67.7	—	55.1	—	ns
148	$\overline{WR}$ assertion to $\overline{CAS}$ deassertion	t_{CWL}	$3.75 \times T_C - 4.3$	52.5	—	42.6	—	ns
149	Data valid to $\overline{CAS}$ assertion (write)	t_{DS}	$0.5 \times T_C - 4.0$	3.6	—	2.3	—	ns
150	$\overline{CAS}$ assertion to data not valid (write)	t_{DH}	$3.5 \times T_C - 4.0$	49.0	—	39.8	—	ns
151	$\overline{WR}$ assertion to $\overline{CAS}$ assertion	t_{WCS}	$1.25 \times T_C - 4.3$	14.6	—	11.3	—	ns
152	Last $\overline{RD}$ assertion to $\overline{RAS}$ deassertion	t_{ROH}	$4.5 \times T_C - 4.0$	64.2	—	52.3	—	ns
153	$\overline{RD}$ assertion to data valid	t_{GA}	**66 MHz**: $3.25 \times T_C - 7.5$	—	41.7	—	—	ns
			80 MHz: $3.25 \times T_C - 6.5$	—	—	—	34.1	ns
154	$\overline{RD}$ deassertion to data not valid[6]	t_{GZ}		0.0	—	0.0	—	ns
155	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 0.3$	11.1	—	9.1	—	ns

Table 2-13 DRAM Page Mode Timings, Four Wait States[1, 2, 3] (Continued)

No.	Characteristics	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
156	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C$	—	3.8	—	3.1	ns

Note:
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 DSP56304.
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}.

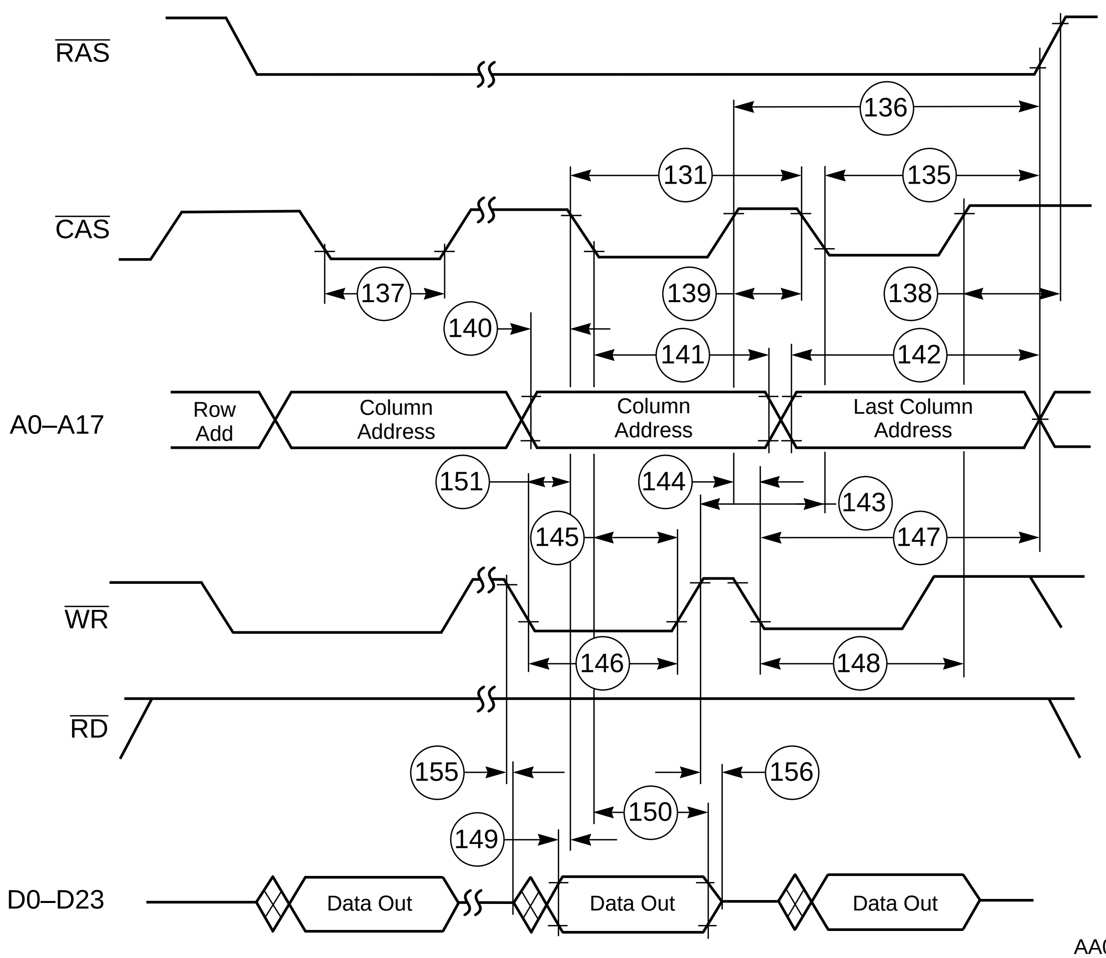


Figure 2-17 DRAM Page Mode Write Accesses

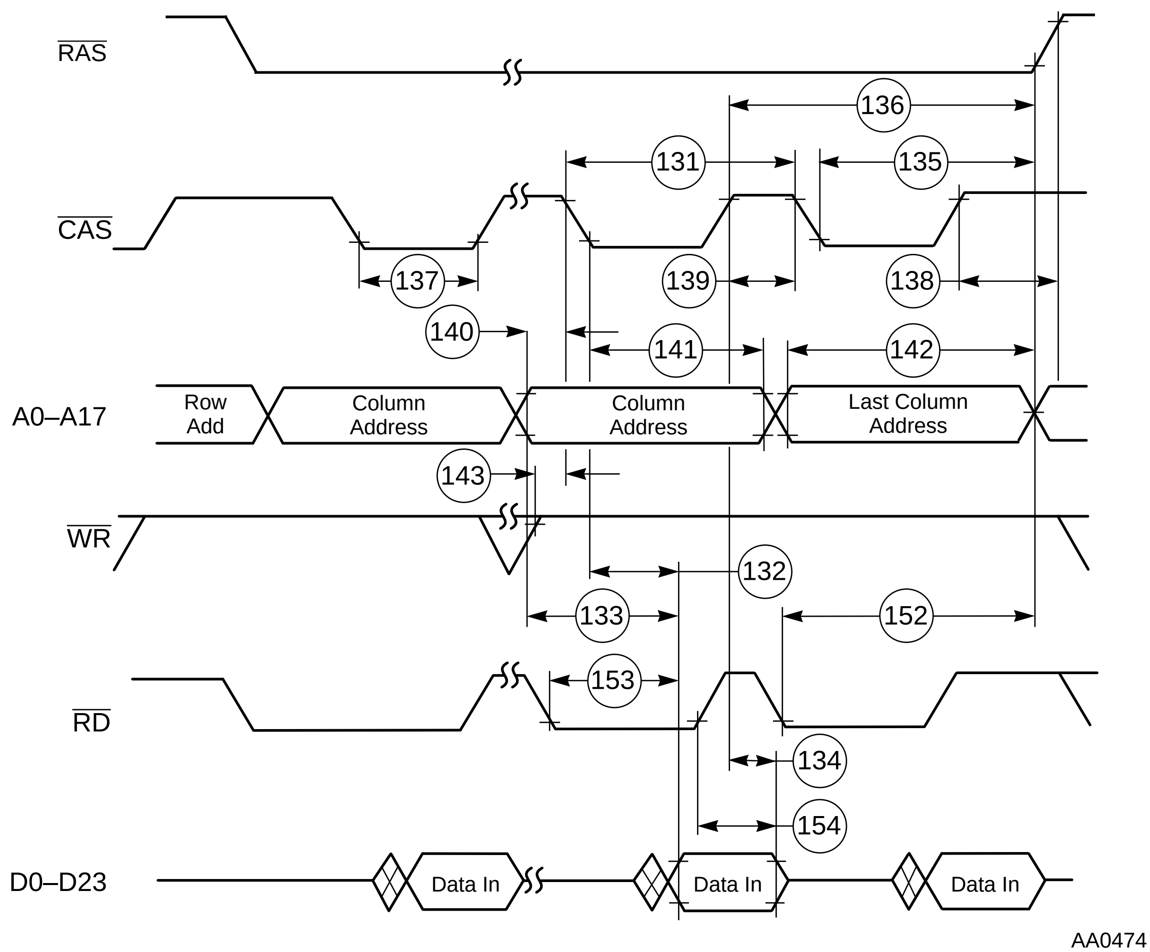


Figure 2-18 DRAM Page Mode Read Accesses

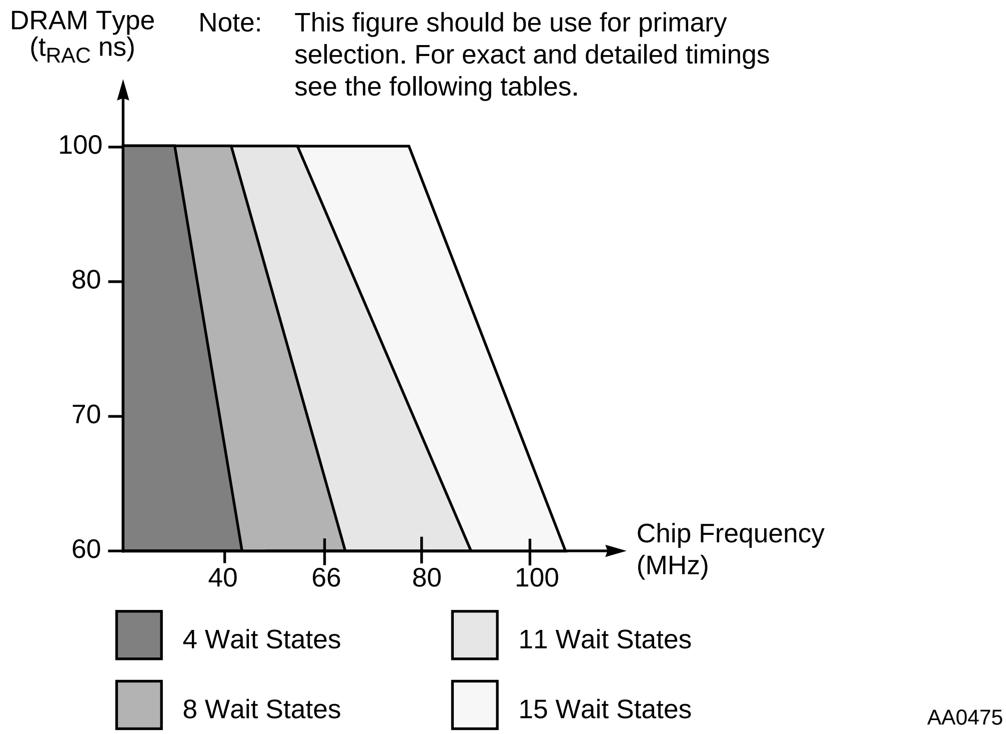


Figure 2-19 DRAM Out-of-Page Wait States Selection Guide

Table 2-14 DRAM Out-of-Page and Refresh Timings, Four Wait States[1, 2]

No.	Characteristics[3]	Symbol	Expression	20 MHz[4]		30 MHz[4]		Unit
				Min	Max	Min	Max	
157	Random read or write cycle time	t_{RC}	$5 \times T_C$	250.0	—	166.7	—	ns
158	$\overline{RAS}$ assertion to data valid (read)	t_{RAC}	$2.75 \times T_C - 7.5$	—	130.0	—	84.2	ns
159	$\overline{CAS}$ assertion to data valid (read)	t_{CAC}	$1.25 \times T_C - 7.5$	—	55.0	—	34.2	ns
160	Column address valid to data valid (read)	t_{AA}	$1.5 \times T_C - 7.5$	—	67.5	—	42.5	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}	$1.75 \times T_C - 4.0$	83.5	—	54.3	—	ns
163	$\overline{RAS}$ assertion pulse width	t_{RAS}	$3.25 \times T_C - 4.0$	158.5	—	104.3	—	ns

Table 2-14 DRAM Out-of-Page and Refresh Timings, Four Wait States[1, 2] (Continued)

No.	Characteristics[3]	Symbol	Expression	20 MHz[4]		30 MHz[4]		Unit
				Min	Max	Min	Max	
164	$\overline{CAS}$ assertion to $\overline{RAS}$ deassertion	t_{RSH}	$1.75 \times T_C - 4.0$	83.5	—	54.3	—	ns
165	$\overline{RAS}$ assertion to $\overline{CAS}$ deassertion	t_{CSH}	$2.75 \times T_C - 4.0$	133.5	—	87.7	—	ns
166	$\overline{CAS}$ assertion pulse width	t_{CAS}	$1.25 \times T_C - 4.0$	58.5	—	37.7	—	ns
167	$\overline{RAS}$ assertion to $\overline{CAS}$ assertion	t_{RCD}	$1.5 \times T_C \pm 2$	73.0	77.0	48.0	52.0	ns
168	$\overline{RAS}$ assertion to column address valid	t_{RAD}	$1.25 \times T_C \pm 2$	60.5	64.5	39.7	43.7	ns
169	$\overline{CAS}$ deassertion to $\overline{RAS}$ assertion	t_{CRP}	$2.25 \times T_C - 4.0$	108.5	—	71.0	—	ns
170	$\overline{CAS}$ deassertion pulse width	t_{CP}	$1.75 \times T_C - 4.0$	83.5	—	54.3	—	ns
171	Row address valid to $\overline{RAS}$ assertion	t_{ASR}	$1.75 \times T_C - 4.0$	83.5	—	54.3	—	ns
172	$\overline{RAS}$ assertion to row address not valid	t_{RAH}	$1.25 \times T_C - 4.0$	58.5	—	37.7	—	ns
173	Column address valid to $\overline{CAS}$ assertion	t_{ASC}	$0.25 \times T_C - 4.0$	8.5	—	4.3	—	ns
174	$\overline{CAS}$ assertion to column address not valid	t_{CAH}	$1.75 \times T_C - 4.0$	83.5	—	54.3	—	ns
175	$\overline{RAS}$ assertion to column address not valid	t_{AR}	$3.25 \times T_C - 4.0$	158.5	—	104.3	—	ns
176	Column address valid to $\overline{RAS}$ deassertion	t_{RAL}	$2 \times T_C - 4.0$	96.0	—	62.7	—	ns
177	$\overline{WR}$ deassertion to $\overline{CAS}$ assertion	t_{RCS}	$1.5 \times T_C - 3.8$	71.2	—	46.2	—	ns
178	$\overline{CAS}$ deassertion to $\overline{WR}$ assertion	t_{RCH}	$0.75 \times T_C - 3.7$	33.8	—	21.3	—	ns
179	$\overline{RAS}$ deassertion to $\overline{WR}$ assertion	t_{RRH}	$0.25 \times T_C - 3.7$	8.8	—	4.6	—	ns
180	$\overline{CAS}$ assertion to $\overline{WR}$ deassertion	t_{WCH}	$1.5 \times T_C - 4.2$	70.8	—	45.8	—	ns

Table 2-14 DRAM Out-of-Page and Refresh Timings, Four Wait States[1, 2] (Continued)

No.	Characteristics[3]	Symbol	Expression	20 MHz[4]		30 MHz[4]		Unit
				Min	Max	Min	Max	
181	$\overline{RAS}$ assertion to $\overline{WR}$ deassertion	t_{WCR}	$3 \times T_C - 4.2$	145.8	—	95.8	—	ns
182	$\overline{WR}$ assertion pulse width	t_{WP}	$4.5 \times T_C - 4.5$	220.5	—	145.5	—	ns
183	$\overline{WR}$ assertion to $\overline{RAS}$ deassertion	t_{RWL}	$4.75 \times T_C - 4.3$	233.2	—	154.0	—	ns
184	$\overline{WR}$ assertion to $\overline{CAS}$ deassertion	t_{CWL}	$4.25 \times T_C - 4.3$	208.2	—	137.4	—	ns
185	Data valid to $\overline{CAS}$ assertion (write)	t_{DS}	$2.25 \times T_C - 4.0$	108.5	—	71.0	—	ns
186	$\overline{CAS}$ assertion to data not valid (write)	t_{DH}	$1.75 \times T_C - 4.0$	83.5	—	54.3	—	ns
187	$\overline{RAS}$ assertion to data not valid (write)	t_{DHR}	$3.25 \times T_C - 4.0$	158.5	—	104.3	—	ns
188	$\overline{WR}$ assertion to $\overline{CAS}$ assertion	t_{WCS}	$3 \times T_C - 4.3$	145.7	—	95.7	—	ns
189	$\overline{CAS}$ assertion to $\overline{RAS}$ assertion (refresh)	t_{CSR}	$0.5 \times T_C - 4.0$	21.0	—	12.7	—	ns
190	$\overline{RAS}$ deassertion to $\overline{CAS}$ assertion (refresh)	t_{RPC}	$1.25 \times T_C - 4.0$	58.5	—	37.7	—	ns
191	$\overline{RD}$ assertion to $\overline{RAS}$ deassertion	t_{ROH}	$4.5 \times T_C - 4.0$	221.0	—	146.0	—	ns
192	$\overline{RD}$ assertion to data valid	t_{GA}	$4 \times T_C - 7.5$	—	192.5	—	125.8	ns
193	$\overline{RD}$ deassertion to data not valid[3]	t_{GZ}		0.0	—	0.0	—	ns
194	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 0.3$	37.2	—	24.7	—	ns
195	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C$	—	12.5	—	8.3	ns

Note:
1. The number of wait states for out of page access is specified in the DCR.
2. The refresh period is specified in the DCR.
3. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is t_{OFF} and not t_{GZ}.
4. Reduced DSP clock speed allows use of DRAM out-of-page access with four Wait states (See **Figure 2-19**.).

Table 2-15 DRAM Out-of-Page and Refresh Timings, Eight Wait States[1, 2]

No.	Characteristics[4]	Symbol	Expression[3]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
157	Random read or write cycle time	t_{RC}	$9 \times T_C$	136.4	—	112.5	—	ns
158	$\overline{RAS}$ assertion to data valid (read)	t_{RAC}	**66 MHz**: $4.75 \times T_C - 7.5$ **80 MHz**: $4.75 \times T_C - 6.5$	— —	64.5 —	— —	— 52.9	ns ns
159	$\overline{CAS}$ assertion to data valid (read)	t_{CAC}	**66 MHz**: $2.25 \times T_C - 7.5$ **80 MHz**: $2.25 \times T_C - 6.5$	— —	26.6 —	— —	— 21.6	ns ns
160	Column address valid to data valid (read)	t_{AA}	**66 MHz**: $3 \times T_C - 7.5$ **80 MHz**: $3 \times T_C - 6.5$	— —	40.0 —	— —	— 31.0	ns 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}	$3.25 \times T_C - 4.0$	45.2	—	36.6	—	ns
163	$\overline{RAS}$ assertion pulse width	t_{RAS}	$5.75 \times T_C - 4.0$	83.1	—	67.9	—	ns
164	$\overline{CAS}$ assertion to $\overline{RAS}$ deassertion	t_{RSH}	$3.25 \times T_C - 4.0$	45.2	—	36.6	—	ns
165	$\overline{RAS}$ assertion to $\overline{CAS}$ deassertion	t_{CSH}	$4.75 \times T_C - 4.0$	68.0	—	55.4	—	ns
166	$\overline{CAS}$ assertion pulse width	t_{CAS}	$2.25 \times T_C - 4.0$	30.1	—	24.1	—	ns
167	$\overline{RAS}$ assertion to $\overline{CAS}$ assertion	t_{RCD}	$2.5 \times T_C \pm 2$	35.9	39.9	29.3	33.3	ns
168	$\overline{RAS}$ assertion to column address valid	t_{RAD}	$1.75 \times T_C \pm 2$	24.5	28.5	19.9	23.9	ns
169	$\overline{CAS}$ deassertion to $\overline{RAS}$ assertion	t_{CRP}	$4.25 \times T_C - 4.0$	59.8	—	49.1	—	ns
170	$\overline{CAS}$ deassertion pulse width	t_{CP}	$2.75 \times T_C - 4.0$	37.7	—	30.4	—	ns

Table 2-15 DRAM Out-of-Page and Refresh Timings, Eight Wait States[1, 2] (Continued)

No.	Characteristics[4]	Symbol	Expression[3]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
171	Row address valid to $\overline{RAS}$ assertion	t_{ASR}	$3.25 \times T_C - 4.0$	45.2	—	36.6	—	ns
172	$\overline{RAS}$ assertion to row address not valid	t_{RAH}	$1.75 \times T_C - 4.0$	22.5	—	17.9	—	ns
173	Column address valid to $\overline{CAS}$ assertion	t_{ASC}	$0.75 \times T_C - 4.0$	7.4	—	5.4	—	ns
174	$\overline{CAS}$ assertion to column address not valid	t_{CAH}	$3.25 \times T_C - 4.0$	45.2	—	36.6	—	ns
175	$\overline{RAS}$ assertion to column address not valid	t_{AR}	$5.75 \times T_C - 4.0$	83.1	—	67.9	—	ns
176	Column address valid to $\overline{RAS}$ deassertion	t_{RAL}	$4 \times T_C - 4.0$	56.6	—	46.0	—	ns
177	$\overline{WR}$ deassertion to $\overline{CAS}$ assertion	t_{RCS}	$2 \times T_C - 3.8$	26.5	—	21.2	—	ns
178	$\overline{CAS}$ deassertion to $\overline{WR}$ assertion	t_{RCH}	$1.25 \times T_C - 3.7$	15.2	—	11.9	—	ns
179	$\overline{RAS}$ deassertion to $\overline{WR}$ assertion	t_{RRH}	**66 MHz**: $0.25 \times T_C - 3.7$	0.1	—	—	—	ns
			80 MHz: $0.25 \times T_C - 3.0$	—	—	0.1	—	ns
180	$\overline{CAS}$ assertion to $\overline{WR}$ deassertion	t_{WCH}	$3 \times T_C - 4.2$	41.3	—	33.3	—	ns
181	$\overline{RAS}$ assertion to $\overline{WR}$ deassertion	t_{WCR}	$5.5 \times T_C - 4.2$	79.1	—	64.6	—	ns
182	$\overline{WR}$ assertion pulse width	t_{WP}	$8.5 \times T_C - 4.5$	124.3	—	101.8	—	ns
183	$\overline{WR}$ assertion to $\overline{RAS}$ deassertion	t_{RWL}	$8.75 \times T_C - 4.3$	128.3	—	105.1	—	ns
184	$\overline{WR}$ assertion to $\overline{CAS}$ deassertion	t_{CWL}	$7.75 \times T_C - 4.3$	113.1	—	92.6	—	ns
185	Data valid to $\overline{CAS}$ assertion (write)	t_{DS}	$4.75 \times T_C - 4.0$	68.0	—	55.4	—	ns

Table 2-15 DRAM Out-of-Page and Refresh Timings, Eight Wait States[1, 2] (Continued)

No.	Characteristics[4]	Symbol	Expression[3]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
186	$\overline{CAS}$ assertion to data not valid (write)	t_{DH}	$3.25 \times T_C - 4.0$	45.2	—	36.6	—	ns
187	$\overline{RAS}$ assertion to data not valid (write)	t_{DHR}	$5.75 \times T_C - 4.0$	83.1	—	67.9	—	ns
188	$\overline{WR}$ assertion to $\overline{CAS}$ assertion	t_{WCS}	$5.5 \times T_C - 4.3$	79.0	—	64.5	—	ns
189	$\overline{CAS}$ assertion to $\overline{RAS}$ assertion (refresh)	t_{CSR}	$1.5 \times T_C - 4.0$	18.7	—	14.8	—	ns
190	$\overline{RAS}$ deassertion to $\overline{CAS}$ assertion (refresh)	t_{RPC}	$1.75 \times T_C - 4.0$	22.5	—	17.9	—	ns
191	$\overline{RD}$ assertion to $\overline{RAS}$ deassertion	t_{ROH}	$8.5 \times T_C - 4.0$	124.8	—	102.3	—	ns
192	$\overline{RD}$ assertion to data valid	t_{GA}	**66 MHz**: $7.5 \times T_C - 7.5$ **80 MHz**: $7.5 \times T_C - 6.5$	—	106.1	—	87.3	ns ns
193	$\overline{RD}$ deassertion to data not valid[4]	t_{GZ}	0.0	0.0	—	0.0	—	ns
194	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 0.3$	11.1	—	9.1	—	ns
195	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C$	—	3.8	—	3.1	ns

Note:
1. The number of wait states for out-of-page 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 DSP56304.
4. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is t_{OFF} and not t_{GZ}.

Table 2-16 DRAM Out-of-Page and Refresh Timings, Eleven Wait States[1, 2]

No.	Characteristics[4]	Symbol	Expression[3]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
157	Random read or write cycle time	t_{RC}	$12 \times T_C$	181.8	—	150.0	—	ns
158	$\overline{RAS}$ assertion to data valid (read)	t_{RAC}	**66 MHz**: $6.25 \times T_C - 7.5$	—	87.2	—	—	ns
			80 MHz: $6.25 \times T_C - 6.5$	—	—	—	71.6	ns
159	$\overline{CAS}$ assertion to data valid (read)	t_{CAC}	**66 MHz**: $3.75 \times T_C - 7.5$	—	49.3	—	—	ns
			80 MHz: $3.75 \times T_C - 6.5$	—	—	—	40.4	ns
160	Column address valid to data valid (read)	t_{AA}	**66 MHz**: $4.5 \times T_C - 7.5$	—	60.7	—	—	ns
			80 MHz: $4.5 \times T_C - 6.5$	—	—	—	49.8	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}	$4.25 \times T_C - 4.0$	60.4	—	49.1	—	ns
163	$\overline{RAS}$ assertion pulse width	t_{RAS}	$7.75 \times T_C - 4.0$	113.4	—	92.9	—	ns
164	$\overline{CAS}$ assertion to $\overline{RAS}$ deassertion	t_{RSH}	$5.25 \times T_C - 4.0$	75.5	—	61.6	—	ns
165	$\overline{RAS}$ assertion to $\overline{CAS}$ deassertion	t_{CSH}	$6.25 \times T_C - 4.0$	90.7	—	74.1	—	ns
166	$\overline{CAS}$ assertion pulse width	t_{CAS}	$3.75 \times T_C - 4.0$	52.8	—	42.9	—	ns
167	$\overline{RAS}$ assertion to $\overline{CAS}$ assertion	t_{RCD}	$2.5 \times T_C \pm 2$	35.9	39.9	29.3	33.3	ns
168	$\overline{RAS}$ assertion to column address valid	t_{RAD}	$1.75 \times T_C \pm 2$	24.5	28.5	19.9	23.9	ns
169	$\overline{CAS}$ deassertion to $\overline{RAS}$ assertion	t_{CRP}	$5.75 \times T_C - 4.0$	83.1	—	67.9	—	ns
170	$\overline{CAS}$ deassertion pulse width	t_{CP}	$4.25 \times T_C - 4.0$	60.4	—	49.1	—	ns

Table 2-16 DRAM Out-of-Page and Refresh Timings, Eleven Wait States[1, 2] (Continued)

No.	Characteristics[4]	Symbol	Expression[3]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
171	Row address valid to $\overline{RAS}$ assertion	t_{ASR}	$4.25 \times T_C - 4.0$	60.4	—	49.1	—	ns
172	$\overline{RAS}$ assertion to row address not valid	t_{RAH}	$1.75 \times T_C - 4.0$	22.5	—	17.9	—	ns
173	Column address valid to $\overline{CAS}$ assertion	t_{ASC}	$0.75 \times T_C - 4.0$	7.4	—	5.4	—	ns
174	$\overline{CAS}$ assertion to column address not valid	t_{CAH}	$5.25 \times T_C - 4.0$	75.5	—	61.6	—	ns
175	$\overline{RAS}$ assertion to column address not valid	t_{AR}	$7.75 \times T_C - 4.0$	113.4	—	92.9	—	ns
176	Column address valid to $\overline{RAS}$ deassertion	t_{RAL}	$6 \times T_C - 4.0$	86.9	—	71.0	—	ns
177	$\overline{WR}$ deassertion to $\overline{CAS}$ assertion	t_{RCS}	$3.0 \times T_C - 3.8$	41.7	—	33.7	—	ns
178	$\overline{CAS}$ deassertion to $\overline{WR}$ assertion	t_{RCH}	$1.75 \times T_C - 3.7$	22.8	—	18.2	—	ns
179	$\overline{RAS}$ deassertion to $\overline{WR}$ assertion	t_{RRH}	**66 MHz**: $0.25 \times T_C - 3.7$ **80 MHz**: $0.25 \times T_C - 3.0$	0.1 0.1	— —	0.1 0.1	— —	ns ns
180	$\overline{CAS}$ assertion to $\overline{WR}$ deassertion	t_{WCH}	$5 \times T_C - 4.2$	71.6	—	58.3	—	ns
181	$\overline{RAS}$ assertion to $\overline{WR}$ deassertion	t_{WCR}	$7.5 \times T_C - 4.2$	109.4	—	89.6	—	ns
182	$\overline{WR}$ assertion pulse width	t_{WP}	$11.5 \times T_C - 4.5$	169.7	—	139.3	—	ns
183	$\overline{WR}$ assertion to $\overline{RAS}$ deassertion	t_{RWL}	$11.75 \times T_C - 4.3$	173.7	—	142.7	—	ns
184	$\overline{WR}$ assertion to $\overline{CAS}$ deassertion	t_{CWL}	$10.25 \times T_C - 4.3$	151.0	—	130.1	—	ns
185	Data valid to $\overline{CAS}$ assertion (write)	t_{DS}	$5.75 \times T_C - 4.0$	83.1	—	67.9	—	ns

Table 2-16 DRAM Out-of-Page and Refresh Timings, Eleven Wait States[1, 2] (Continued)

No.	Characteristics[4]	Symbol	Expression[3]	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
186	$\overline{CAS}$ assertion to data not valid (write)	t_{DH}	$5.25 \times T_C - 4.0$	75.5	—	61.6	—	ns
187	$\overline{RAS}$ assertion to data not valid (write)	t_{DHR}	$7.75 \times T_C - 4.0$	113.4	—	92.9	—	ns
188	$\overline{WR}$ assertion to $\overline{CAS}$ assertion	t_{WCS}	$6.5 \times T_C - 4.3$	94.2	—	77.0	—	ns
189	$\overline{CAS}$ assertion to $\overline{RAS}$ assertion (refresh)	t_{CSR}	$1.5 \times T_C - 4.0$	18.7	—	14.8	—	ns
190	$\overline{RAS}$ deassertion to $\overline{CAS}$ assertion (refresh)	t_{RPC}	$2.75 \times T_C - 4.0$	37.7	—	30.4	—	ns
191	$\overline{RD}$ assertion to $\overline{RAS}$ deassertion	t_{ROH}	$11.5 \times T_C - 4.0$	170.2	—	139.8	—	ns
192	$\overline{RD}$ assertion to data valid	t_{GA}	**66 MHz**: $10 \times T_C - 7.5$	—	144.0	—	—	ns
			80 MHz: $10 \times T_C - 6.5$	—	—	—	118.5	ns
193	$\overline{RD}$ deassertion to data not valid[4]	t_{GZ}		0.0	—	0.0	—	ns
194	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 0.3$	11.1	—	9.1	—	ns
195	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C$	—	3.8	—	3.1	ns

Note:
1. The number of wait states for out-of-page 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 DSP56304.
4. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is t_{OFF} and not t_{GZ}.

Table 2-17 DRAM Out-of-Page and Refresh Timings, Fifteen Wait States[1, 2]

No.	Characteristics[3]	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
157	Random read or write cycle time	t_{RC}	$16 \times T_C$	242.4	—	200.0	—	ns
158	$\overline{RAS}$ assertion to data valid (read)	t_{RAC}	**66 MHz**: $8.25 \times T_C - 7.5$	—	117.5	—	—	ns
			80 MHz: $8.25 \times T_C - 6.5$	—	—	—	96.6	ns
159	$\overline{CAS}$ assertion to data valid (read)	t_{CAC}	**66 MHz**: $4.75 \times T_C - 7.5$	—	64.5	—	—	ns
			80 MHz: $4.75 \times T_C - 6.5$	—	—	—	52.9	ns
160	Column address valid to data valid (read)	t_{AA}	**66 MHz**: $5.5 \times T_C - 7.5$	—	75.8	—	—	ns
			80 MHz: $5.5 \times T_C - 6.5$	—	—	—	62.3	ns
161	$\overline{CAS}$ deassertion to data not valid (read hold time)	t_{OFF}	0.0	0.0	—	0.0	—	ns
162	$\overline{RAS}$ deassertion to $\overline{RAS}$ assertion	t_{RP}	$6.25 \times T_C - 4.0$	90.7	—	74.1	—	ns
163	$\overline{RAS}$ assertion pulse width	t_{RAS}	$9.75 \times T_C - 4.0$	143.7	—	117.9	—	ns
164	$\overline{CAS}$ assertion to $\overline{RAS}$ deassertion	t_{RSH}	$6.25 \times T_C - 4.0$	90.7	—	74.1	—	ns
165	$\overline{RAS}$ assertion to $\overline{CAS}$ deassertion	t_{CSH}	$8.25 \times T_C - 4.0$	121.0	—	99.1	—	ns
166	$\overline{CAS}$ assertion pulse width	t_{CAS}	$4.75 \times T_C - 4.0$	68.0	—	55.4	—	ns
167	$\overline{RAS}$ assertion to $\overline{CAS}$ assertion	t_{RCD}	$3.5 \times T_C \pm 2$	51.0	55.0	41.8	45.8	ns
168	$\overline{RAS}$ assertion to column address valid	t_{RAD}	$2.75 \times T_C \pm 2$	39.7	43.7	32.4	36.4	ns
169	$\overline{CAS}$ deassertion to $\overline{RAS}$ assertion	t_{CRP}	$7.75 \times T_C - 4.0$	113.4	—	92.9	—	ns
170	$\overline{CAS}$ deassertion pulse width	t_{CP}	$6.25 \times T_C - 4.0$	90.7	—	74.1	—	ns

Table 2-17 DRAM Out-of-Page and Refresh Timings, Fifteen Wait States[1, 2] (Continued)

No.	Characteristics[3]	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
171	Row address valid to $\overline{RAS}$ assertion	t_{ASR}	$6.25 \times T_C - 4.0$	90.7	—	74.1	—	ns
172	$\overline{RAS}$ assertion to row address not valid	t_{RAH}	$2.75 \times T_C - 4.0$	37.7	—	30.4	—	ns
173	Column address valid to $\overline{CAS}$ assertion	t_{ASC}	$0.75 \times T_C - 4.0$	7.4	—	5.4	—	ns
174	$\overline{CAS}$ assertion to column address not valid	t_{CAH}	$6.25 \times T_C - 4.0$	90.7	—	74.1	—	ns
175	$\overline{RAS}$ assertion to column address not valid	t_{AR}	$9.75 \times T_C - 4.0$	143.7	—	117.9	—	ns
176	Column address valid to $\overline{RAS}$ deassertion	t_{RAL}	$7 \times T_C - 4.0$	102.1	—	83.5	—	ns
177	$\overline{WR}$ deassertion to $\overline{CAS}$ assertion	t_{RCS}	$5 \times T_C - 3.8$	72.0	—	58.7	—	ns
178	$\overline{CAS}$ deassertion to $\overline{WR}$ assertion	t_{RCH}	$1.75 \times T_C - 3.7$	22.8	—	18.1	—	ns
179	$\overline{RAS}$ deassertion to $\overline{WR}$ assertion	t_{RRH}	**66 MHz**: $0.25 \times T_C - 3.7$	0.1	—	—	—	ns
			80 MHz: $0.25 \times T_C - 3.0$	—	—	0.1	—	ns
180	$\overline{CAS}$ assertion to $\overline{WR}$ deassertion	t_{WCH}	$6 \times T_C - 4.2$	86.7	—	70.8	—	ns
181	$\overline{RAS}$ assertion to $\overline{WR}$ deassertion	t_{WCR}	$9.5 \times T_C - 4.2$	139.7	—	114.6	—	ns
182	$\overline{WR}$ assertion pulse width	t_{WP}	$15.5 \times T_C - 4.5$	230.3	—	189.3	—	ns
183	$\overline{WR}$ assertion to $\overline{RAS}$ deassertion	t_{RWL}	$15.75 \times T_C - 4.3$	234.3	—	192.6	—	ns
184	$\overline{WR}$ assertion to $\overline{CAS}$ deassertion	t_{CWL}	$14.25 \times T_C - 4.3$	211.6	—	180.1	—	ns
185	Data valid to $\overline{CAS}$ assertion (write)	t_{DS}	$8.75 \times T_C - 4.0$	128.6	—	105.4	—	ns
186	$\overline{CAS}$ assertion to data not valid (write)	t_{DH}	$6.25 \times T_C - 4.0$	90.7	—	74.1	—	ns

Table 2-17 DRAM Out-of-Page and Refresh Timings, Fifteen Wait States[1, 2] (Continued)

No.	Characteristics[3]	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
187	$\overline{RAS}$ assertion to data not valid (write)	t_{DHR}	$9.75 \times T_C - 4.0$	143.7	—	117.9	—	ns
188	$\overline{WR}$ assertion to $\overline{CAS}$ assertion	t_{WCS}	$9.5 \times T_C - 4.3$	139.6	—	114.5	—	ns
189	$\overline{CAS}$ assertion to $\overline{RAS}$ assertion (refresh)	t_{CSR}	$1.5 \times T_C - 4.0$	18.7	—	14.8	—	ns
190	$\overline{RAS}$ deassertion to $\overline{CAS}$ assertion (refresh)	t_{RPC}	$4.75 \times T_C - 4.0$	68.0	—	55.4	—	ns
191	$\overline{RD}$ assertion to $\overline{RAS}$ deassertion	t_{ROH}	$15.5 \times T_C - 4.0$	230.8	—	189.8	—	ns
192	$\overline{RD}$ assertion to data valid	t_{GA}	**66 MHz**: $14 \times T_C - 7.5$	—	204.6	—	—	ns
			80 MHz: $14 \times T_C - 6.5$	—	—	—	168.5	ns
193	$\overline{RD}$ deassertion to data not valid[3]	t_{GZ}		0.0	—	0.0	—	ns
194	$\overline{WR}$ assertion to data active		$0.75 \times T_C - 0.3$	11.1	—	9.1	—	ns
195	$\overline{WR}$ deassertion to data high impedance		$0.25 \times T_C$	—	3.8	—	3.1	ns

Note:
1. The number of wait states for out-of-page access is specified in the DCR.
2. The refresh period is specified in the DCR.
3. $\overline{RD}$ deassertion will always occur after $\overline{CAS}$ deassertion; therefore, the restricted timing is t_{OFF} and not t_{GZ}.

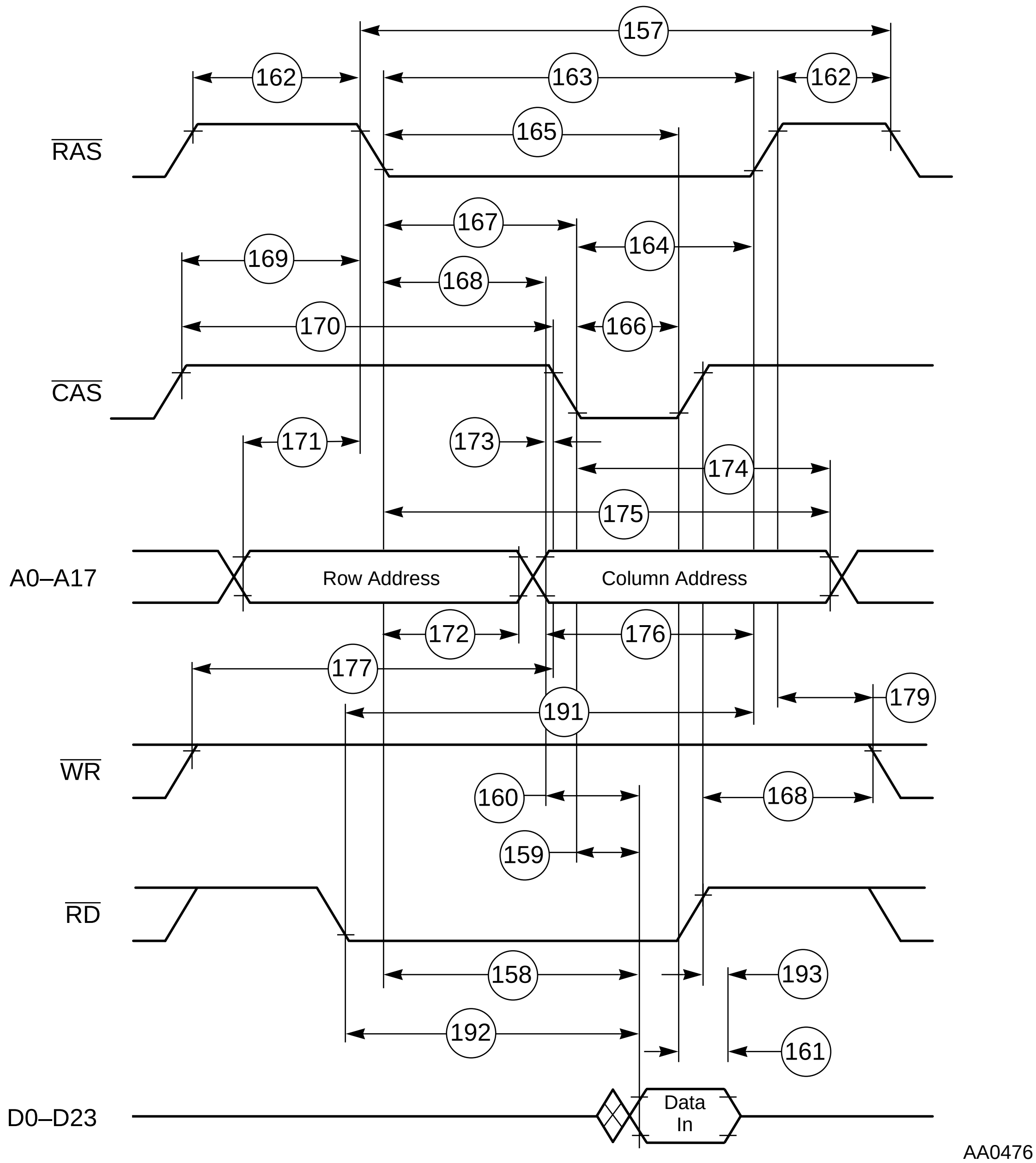


Figure 2-20 DRAM Out-of-Page Read Access

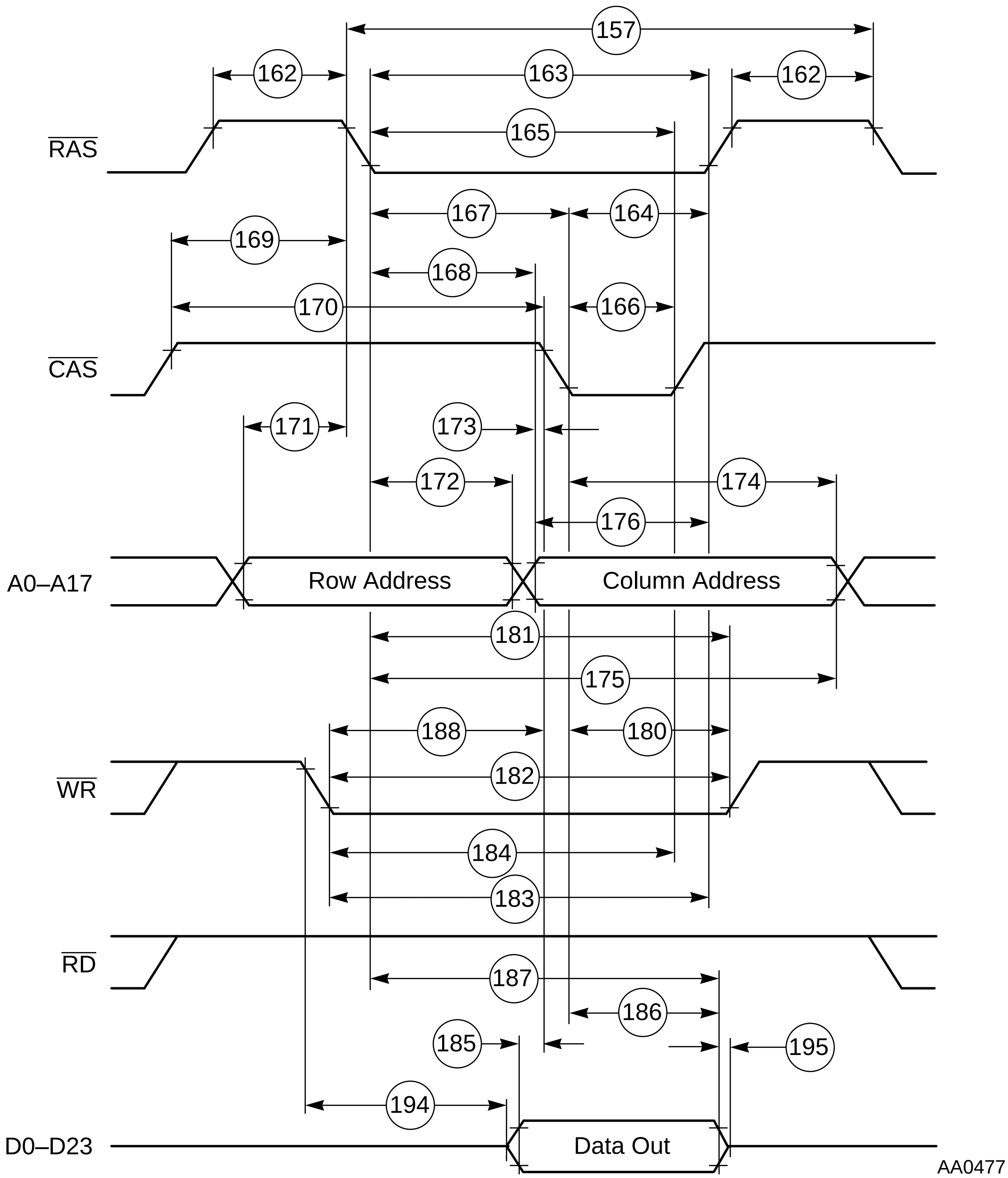


Figure 2-21 DRAM Out-of-Page Write Access

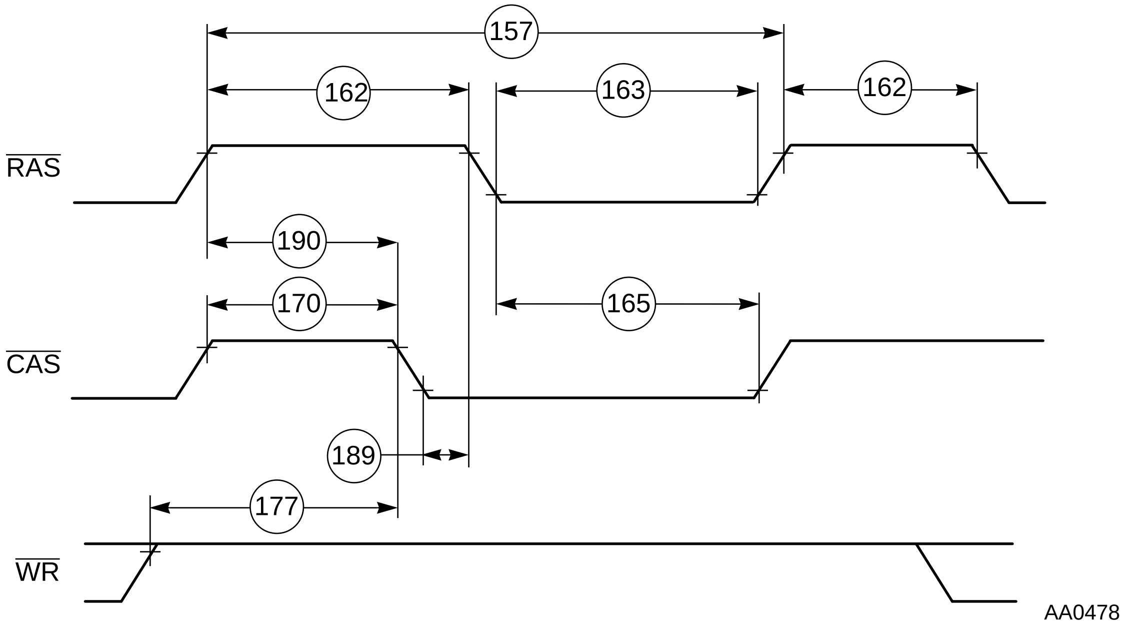


Figure 2-22 DRAM Refresh Access

Table 2-18 External Bus Synchronous Timings (SRAM Access)[4]

No.	Characteristics	Expression[1, 2]	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
198	CLKOUT high to address, and AA valid	**66 MHz**: $0.25 \times T_C + 5.0$	—	8.8	—	—	ns
		80 MHz: $0.25 \times T_C + 4.5$	—	—	—	7.6	ns
199	CLKOUT high to address, and AA invalid	$0.25 \times T_C$	3.8	—	3.1	—	ns
200	$\overline{TA}$ valid to CLKOUT high (setup time)		6.0	—	5.0	—	ns
201	CLKOUT high to $\overline{TA}$ invalid (hold time)		0.0	—	0.0	—	ns
202	CLKOUT high to data out active	$0.25 \times T_C$	3.8	—	3.1	—	ns
203	CLKOUT high to data out valid	**66 MHz**: $0.25 \times T_C + 5.0$	4.8	8.8	—	—	ns
		80 MHz: $0.25 \times T_C + 4.5$	—	—	4.1	7.6	ns
204	CLKOUT high to data out invalid	$0.25 \times T_C$	3.8	—	3.1	—	ns

Table 2-18 External Bus Synchronous Timings (SRAM Access)[4] (Continued)

No.	Characteristics	Expression[1, 2]	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
205	CLKOUT high to data out high impedance	**66 MHz**: $0.25 \times T_C + 1.0$ **80 MHz**: $0.25 \times T_C + 0.5$	— —	4.8 —	— —	— 3.6	ns ns
206	Data in valid to CLKOUT high (setup)		5.0	—	5.0	—	ns
207	CLKOUT high to data in invalid (hold)		0.0	—	0.0	—	ns
208	CLKOUT high to $\overline{RD}$ assertion	**66 MHz**: $0.75 \times T_C + 5.0$ **80 MHz**: $0.75 \times T_C + 4.5$	12.4 —	16.4 —	— 10.4	— 13.9	ns ns
209	CLKOUT high to $\overline{RD}$ deassertion		0.0	5.0	0.0	4.5	ns
210	CLKOUT high to $\overline{WR}$ assertion[3]	**66 MHz**: $0.5 \times T_C + 5.3$ [WS = 1 or WS ≥ 4] **80 MHz**: $0.5 \times T_C + 4.8$ [WS = 1 or WS ≥ 4] [2 ≤ WS ≤ 3]	8.9 — 1.3	12.9 — 5.3	— 7.6 1.3	— 11.1 4.8	ns ns ns
211	CLKOUT high to $\overline{WR}$ deassertion		0.0	4.8	0.0	4.3	ns

Note:
1. WS is the number of wait states specified in the BCR.
2. The asynchronous delays specified in the expressions are valid for DSP56304.
3. If WS > 1, $\overline{WR}$ assertion refers to the next rising edge of CLKOUT.
4. External bus synchronous timings should be used only for reference to the clock and *not* for relative timings.

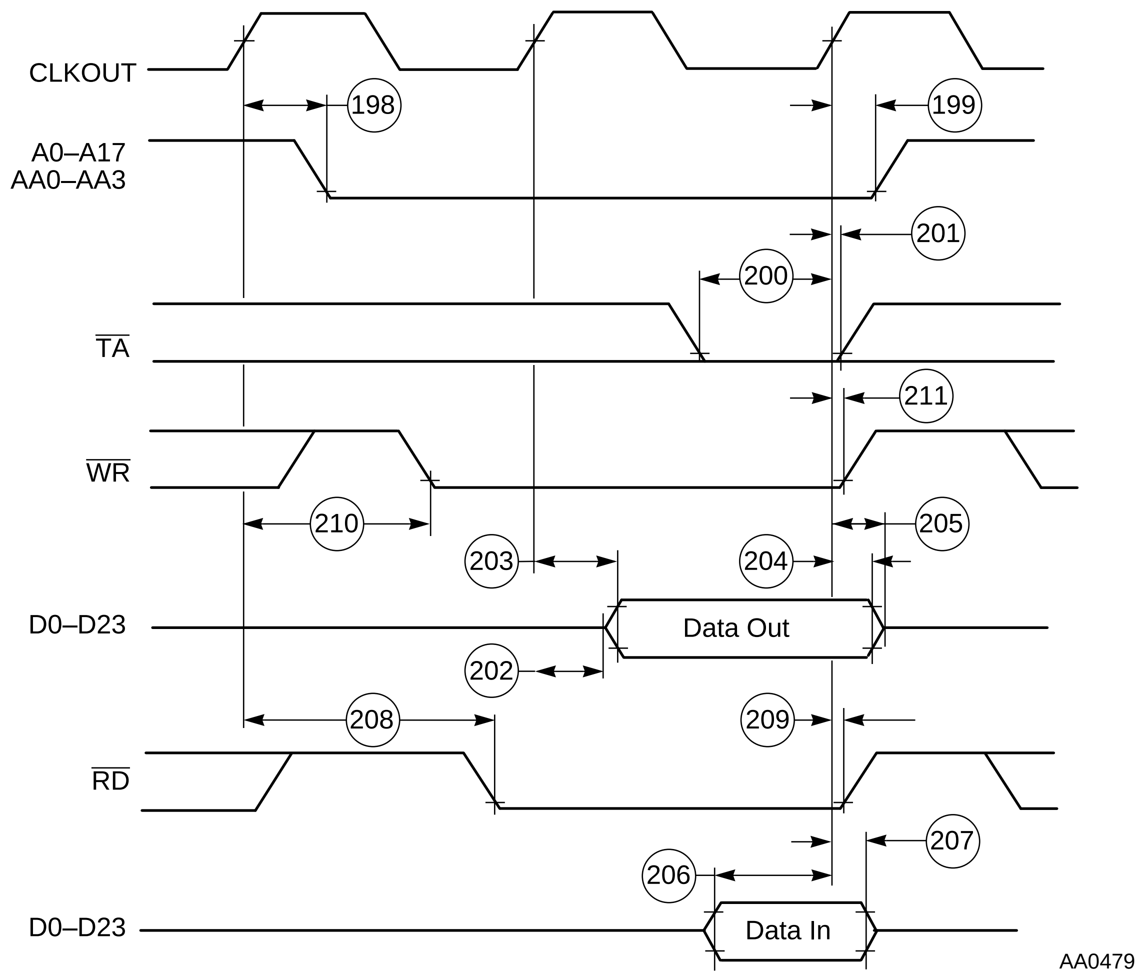


Figure 2-23 Synchronous Bus Timings SRAM 1 WS (BCR Controlled)

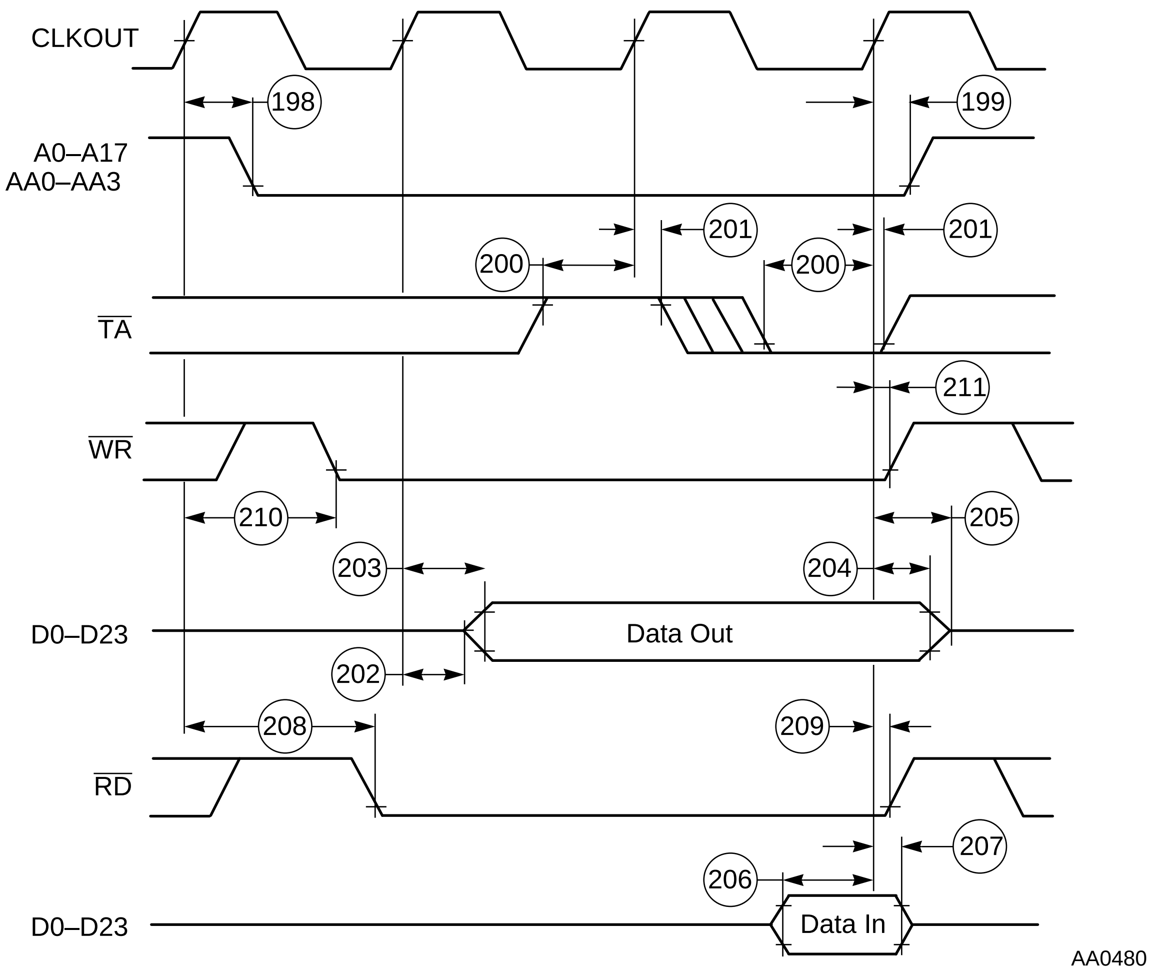


Figure 2-24 Synchronous Bus Timings SRAM 2 WS (TA Controlled)

Table 2-19 Arbitration Bus Timings

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
212	CLKOUT high to BR assertion/ deassertion		1.0	5.0	1.0	4.5	ns
213	BG asserted/deasserted to CLKOUT high (setup)		6.0	—	5.0	—	ns
214	CLKOUT high to BG deasserted/asserted (hold)		0.0	—	0.0	—	ns
215	BB deassertion to CLKOUT high (input setup)		6.0	—	5.0	—	ns

Table 2-19 Arbitration Bus Timings (Continued)

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
216	CLKOUT high to $\overline{BB}$ assertion (input hold)		0.0	—	0.0	—	ns
217	CLKOUT high to $\overline{BB}$ assertion (output)		1.0	5.0	1.0	4.5	ns
218	CLKOUT high to $\overline{BB}$ deassertion (output)		1.0	5.0	1.0	4.5	ns
219	$\overline{BB}$ high to $\overline{BB}$ high impedance (output)		—	2.7	—	2.2	ns
220	CLKOUT high to address and controls active	$0.25 \times T_C$	3.8	—	3.1	—	ns
221	CLKOUT high to address and controls high impedance	**66 MHz**: $0.25 \times T_C + 1.0$	—	4.8	—	—	ns
		80 MHz: $0.25 \times T_C + 0.5$	—	—	—	3.6	ns
222	CLKOUT high to AA active	$0.25 \times T_C$	3.8	—	3.1	—	ns
223	CLKOUT high to AA deassertion	**66 MHz**: $0.25 \times T_C + 5.0$	4.8	8.8	—	—	ns
		80 MHz: $0.25 \times T_C + 4.5$	—	—	4.1	7.6	ns
224	CLKOUT high to AA high impedance	**66 MHz**: $0.75 \times T_C + 1.0$	—	12.4	—	—	ns
		80 MHz: $0.75 \times T_C + 0.5$	—	—	—	9.9	ns
Note: The asynchronous delays specified in the expressions are valid for DSP56304.							

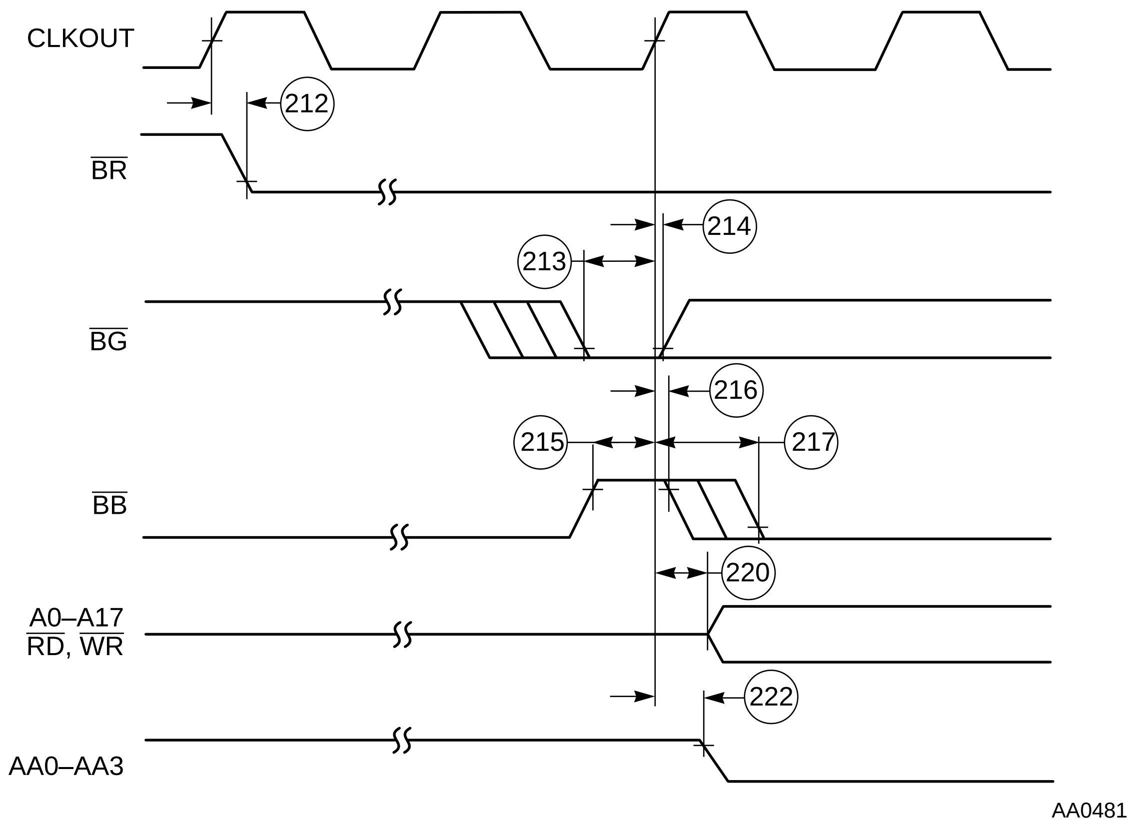


Figure 2-25 Bus Acquisition Timings

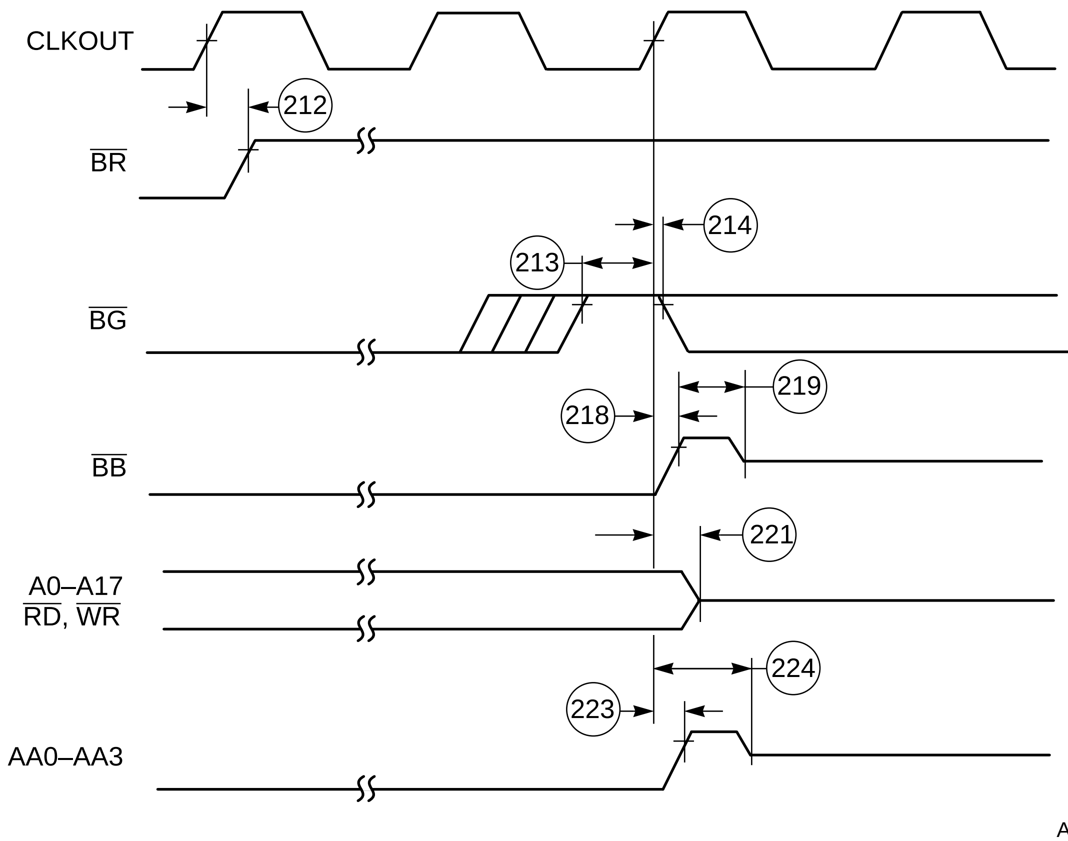


Figure 2-26 Bus Release Timings Case 1 (BRT Bit in OMR Cleared)

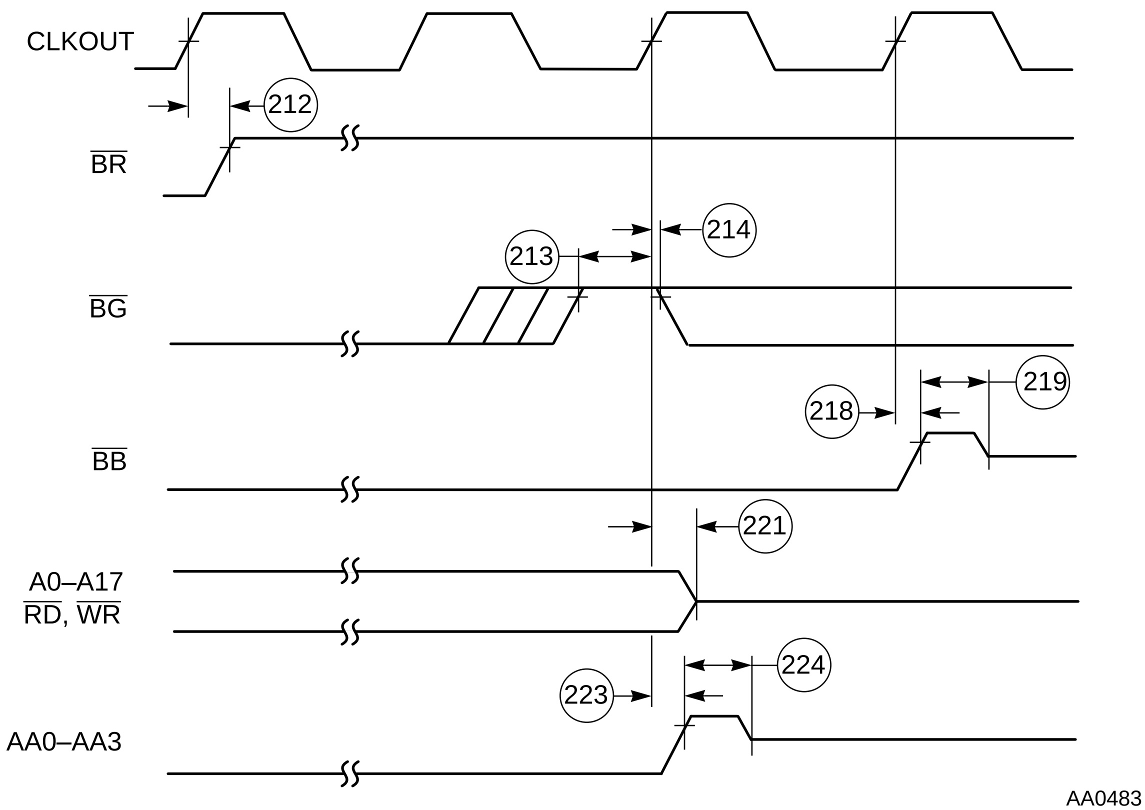


Figure 2-27 Bus Release Timings Case 2 (BRT Bit in OMR Set)

HOST INTERFACE TIMING

Table 2-20 Host Interface Timing[1, 2]

No.	Characteristic[10]	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
300	Access cycle time	$4 \times T_C$	60.6	—	50.0	—	ns
317	Read data strobe assertion width[5] HACK assertion width	**66 MHz**: $T_C + 15.0$	30.2	—	—	—	ns
		80 MHz: $T_C + 12.4$	—	—	24.9	—	ns
318	Read data strobe deassertion width[5] HACK deassertion width		15.0	—	12.4	—	ns
319	Read data strobe deassertion width between two consecutive “Last Data Register” reads, or two consecutive CVR reads, or two consecutive ICR, or two consecutive ISR reads[3, 5, 8]	**66 MHz**: $2.5 \times T_C + 10.0$	47.9	—	—	—	ns
		80 MHz: $2.5 \times T_C + 8.3$	—	—	39.5	—	ns
320	Write data strobe assertion width[6]		20.0	—	16.5	—	ns
321	Write data strobe deassertion width[6]	**66 MHz**: $2.5 \times T_C + 10.0$	47.9	—	—	—	ns
		80 MHz: $2.5 \times T_C + 8.3$	—	—	39.5	—	ns
322	HAS assertion width		15.0	—	12.4	—	ns
323	HAS deassertion to data strobe assertion[4]		0.0	—	0.0	—	ns
324	Host data input setup time before write data strobe deassertion[6]		15.0	—	12.4	—	ns
325	Host data input hold time after write data strobe deassertion[6]		5.0	—	4.1	—	ns
326	Read data strobe assertion to output data active from high impedance[5] HACK assertion to output data active from high impedance		5.0	—	4.1	—	ns
327	Read data strobe assertion to output data valid[5] HACK assertion to output data valid		—	30.0	—	24.8	ns
328	Read data strobe deassertion to output data high impedance[5] HACK deassertion to output data high impedance		—	15.0	—	12.4	ns

Table 2-20 Host Interface Timing[1, 2] (Continued)

No.	Characteristic[10]	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
329	Output data hold time after read data strobe deassertion[5] Output data hold time after HACK deassertion		5.0	—	4.1	—	ns
330	HCS assertion to read data strobe deassertion[5]	**66 MHz**: $T_C + 15.0$ **80 MHz**: $T_C + 12.4$	30.2 —	— —	— 24.9	— —	ns ns
331	HCS assertion to write data strobe deassertion[6]		15.0	—	12.4	—	ns
332	HCS assertion to output data valid		—	25.0	—	20.6	ns
333	HCS hold time after data strobe deassertion[4]		0.0	—	0.0	—	ns
334	Address (AD7–AD0) setup time before HAS deassertion (HMUX=1)		7.0	—	5.8	—	ns
335	Address (AD7–AD0) hold time after HAS deassertion (HMUX=1)		5.0	—	4.1	—	ns
336	A10–A8 (HMUX=1), A2–A0 (HMUX=0), HR/$\overline{W}$ setup time before data strobe assertion[4]		10.0	—	8.3	—	ns
337	A10–A8 (HMUX=1), A2–A0 (HMUX=0), HR/$\overline{W}$ hold time after data strobe deassertion[4]		5.0	—	4.1	—	ns
338	Delay from read data strobe deassertion to host request assertion for “Last Data Register” read[5, 7, 8]	**66 MHz**: $2 \times T_C + 25.0$ **80 MHz**: $2 \times T_C + 20.6$	55.3 —	— —	— 45.6	— —	ns ns
339	Delay from write data strobe deassertion to host request assertion for “Last Data Register” write[6, 7, 8]	**66 MHz**: $1.5 \times T_C + 25.0$ **80 MHz**: $1.5 \times T_C + 20.6$	47.7 —	— —	— 39.4	— —	ns ns
340	Delay from data strobe assertion to host request deassertion for “Last Data Register” read or write (HROD=0)[4, 7, 8]		—	25.0	—	20.6	ns

Table 2-20 Host Interface Timing[1, 2] (Continued)

No.	Characteristic[10]	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
341	Delay from data strobe assertion to host request deassertion for "Last Data Register" read or write (HROD=1, open drain host request)[4, 7, 8, 9]		—	300.0	—	300.0	ns

Note:
1. See **Host Port Usage Considerations** on page 1-12.
2. In the timing diagrams below, the controls pins are drawn as active low. The pin polarity is programmable.
3. This timing must be adhered to only if two consecutive reads from one of these registers are executed.
4. The data strobe is Host Read (HRD) or Host Write (HWR) in the Dual Data Strobe mode and Host Data Strobe (DS) in the Single Data Strobe mode.
5. The read data strobe is HRD in the Dual Data Strobe mode and HDS in the Single Data Strobe mode.
6. The write data strobe is HWR in the Dual Data Strobe mode and HDS in the Single Data Strobe mode.
7. The host request is HREQ in the Single Host Request mode and HRRQ and HTRQ in the Double Host Request mode.
8. The "Last Data Register" is the register at address $7, which is the last location to be read or written in data transfers. This is RXL/TXL in the Little Endian mode (HBE = 0), or RXH/TXH in the Big Endian mode (HBE = 1).
9. In this calculation, the host request signal is pulled up by a 4.7 kΩ resistor in the Open-drain mode.
10. V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100 °C, C_L = 50 pF + 2 TTL loads

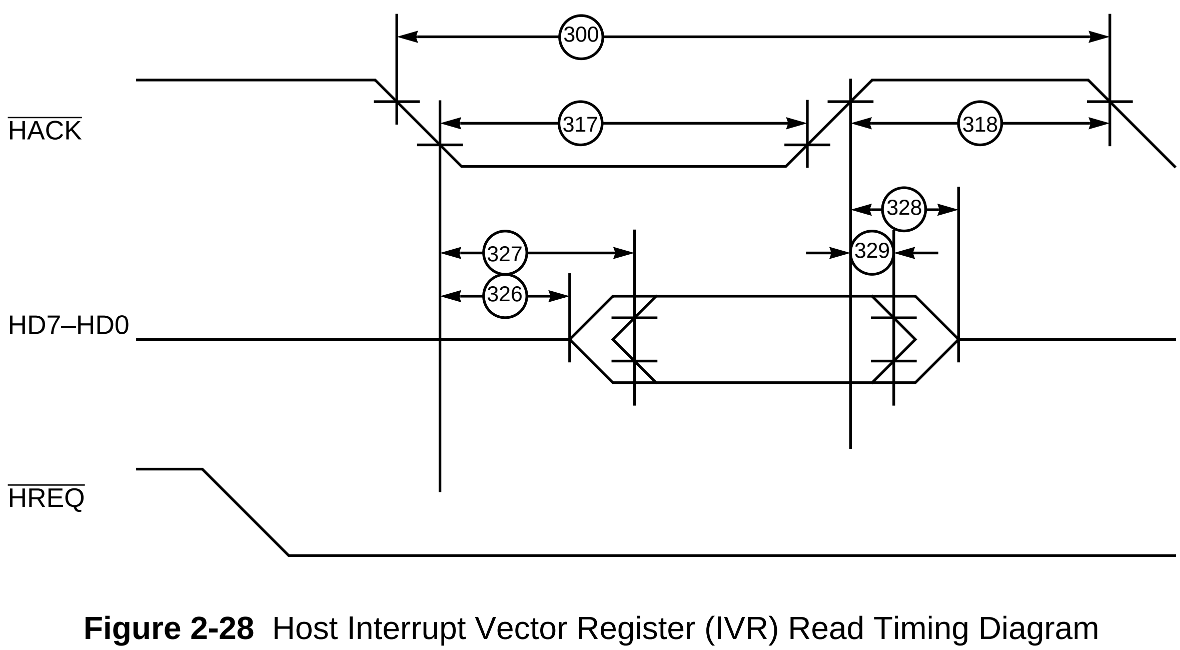


Figure 2-28 Host Interrupt Vector Register (IVR) Read Timing Diagram

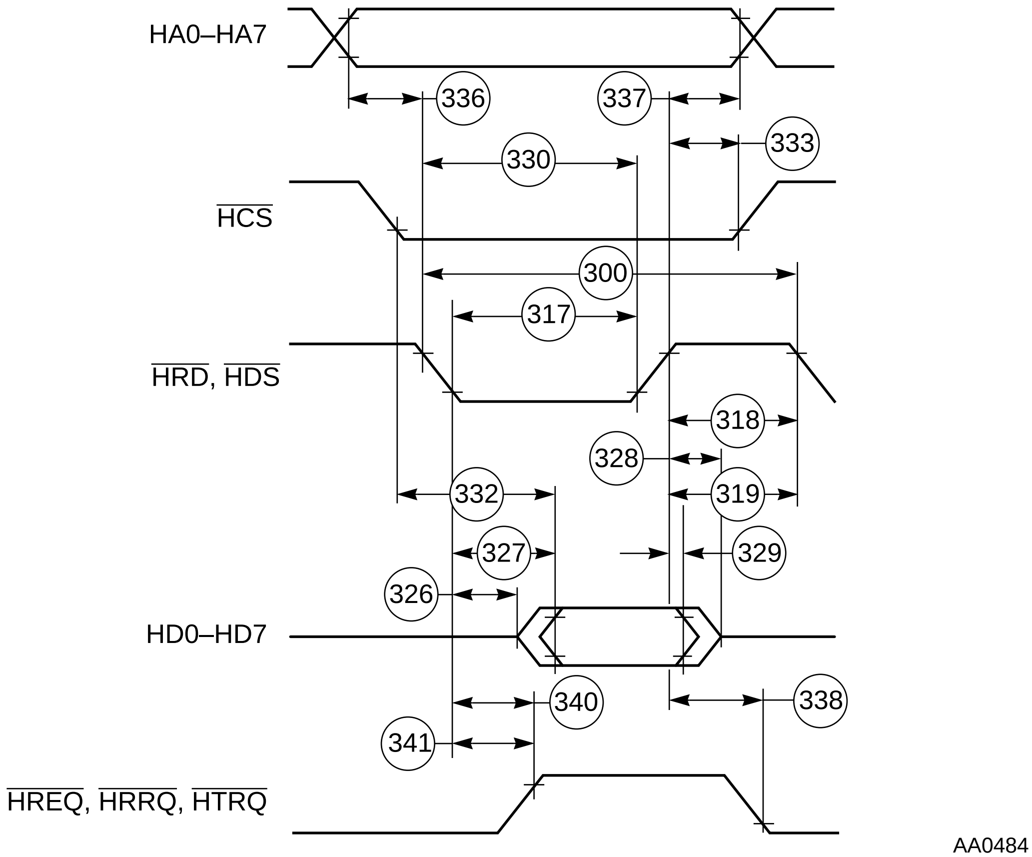


Figure 2-29 Read Timing Diagram, Non-Multiplexed Bus

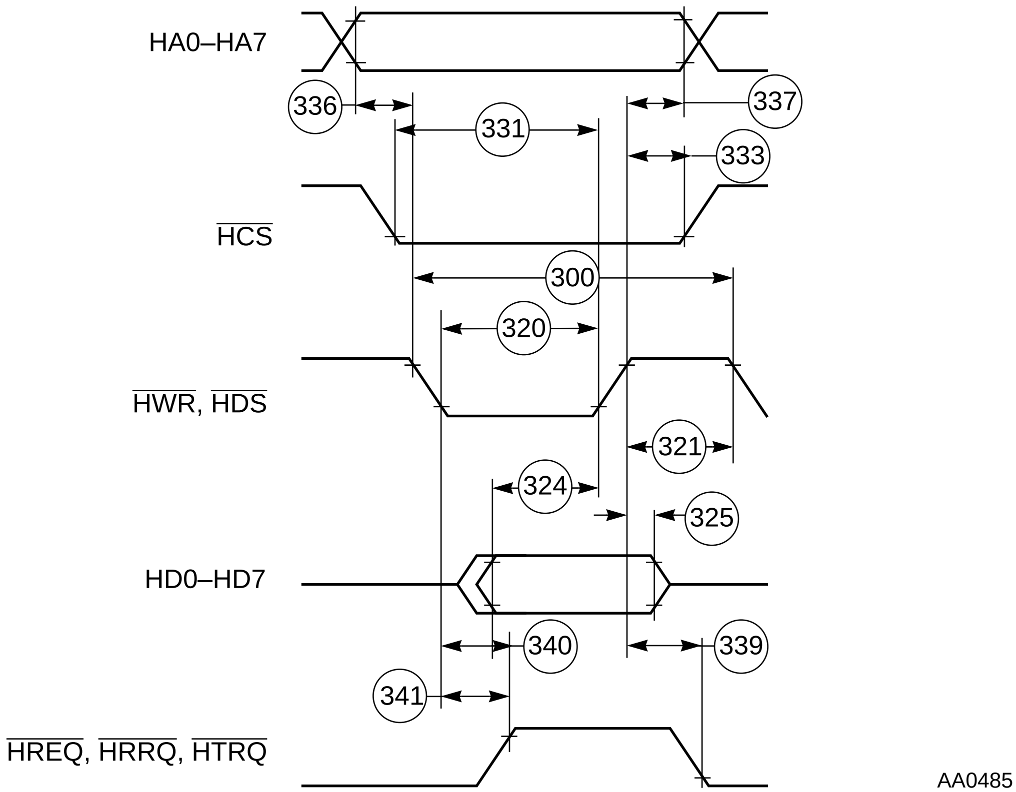


Figure 2-30 Write Timing Diagram, Non-Multiplexed Bus

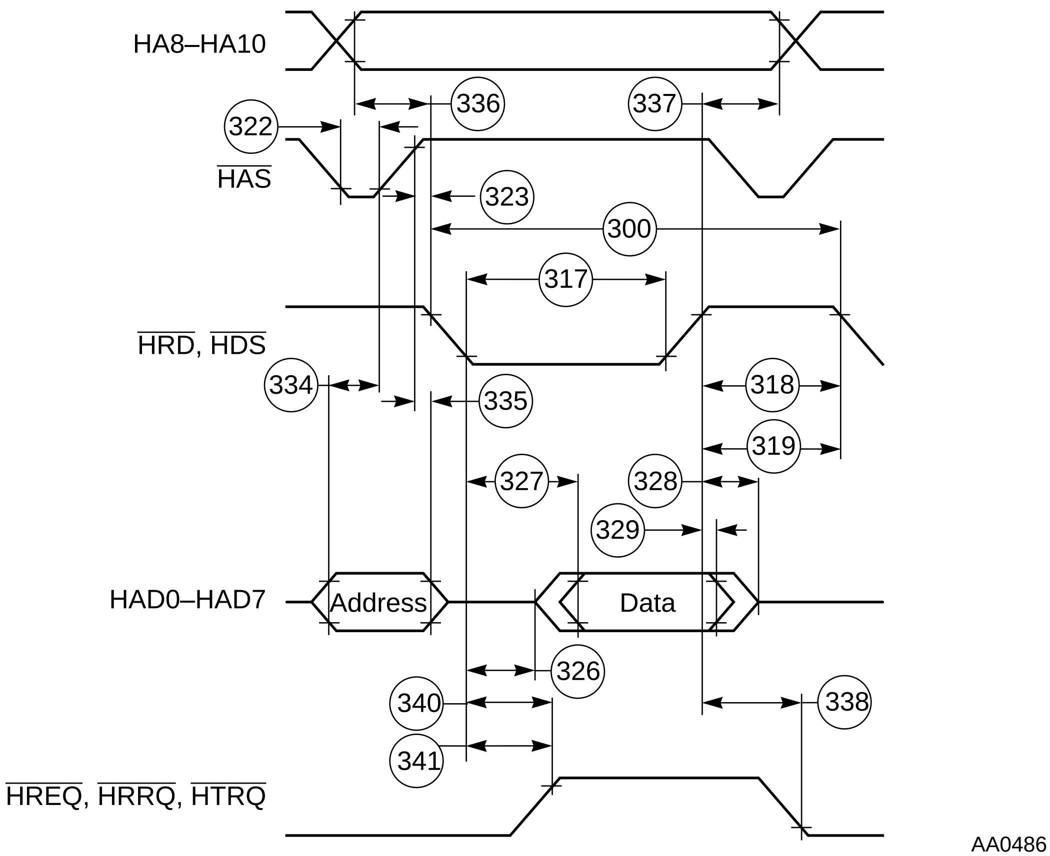


Figure 2-31 Read Timing Diagram, Multiplexed Bus

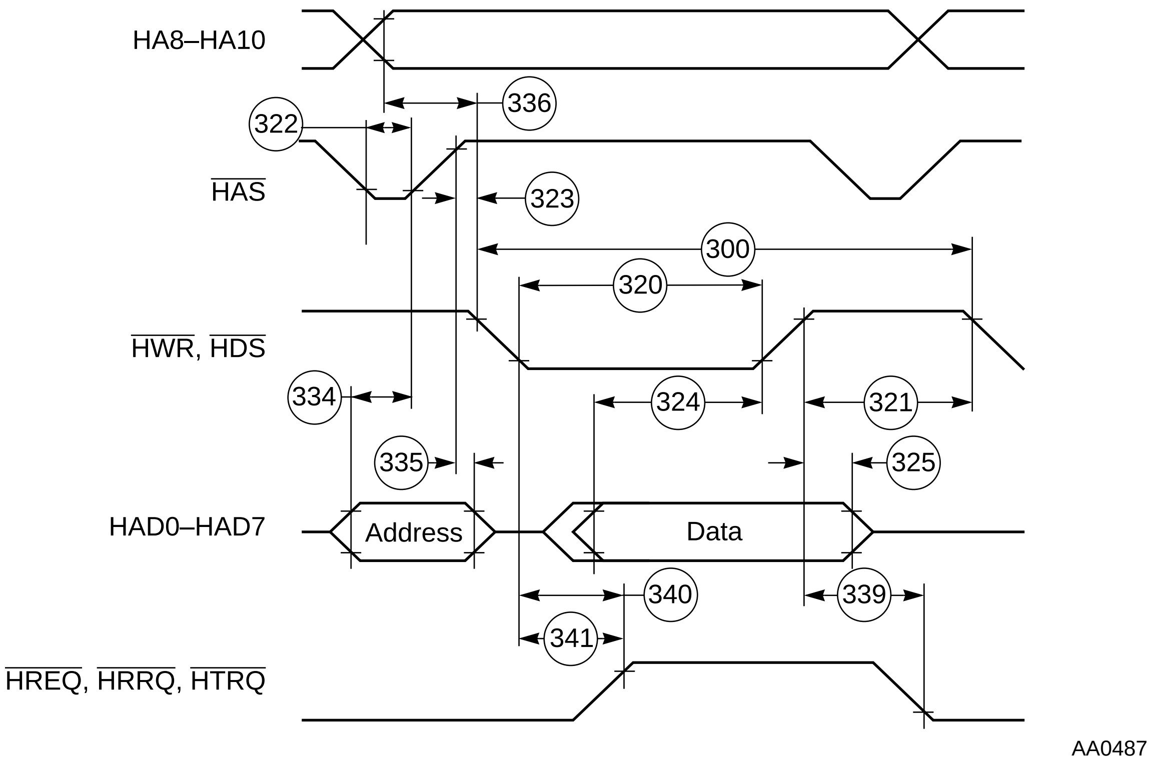


Figure 2-32 Write Timing Diagram, Multiplexed Bus

SCI TIMING

Table 2-21 SCI Timing

No.	Characteristics[1]	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
400	Synchronous clock cycle	t_{SCC}[2]	$8 \times T_C$	121.0	—	100.0	—	ns
401	Clock low period		$t_{SCC}/2 - 10.0$	50.5	—	40.0	—	ns
402	Clock high period		$t_{SCC}/2 - 10.0$	50.5	—	40.0	—	ns
403	Output data setup to clock falling edge (internal clock)		$t_{SCC}/4 + 0.5 \times T_C - 17.0$	20.5	—	14.3	—	ns
404	Output data hold after clock rising edge (internal clock)		$t_{SCC}/4 - 0.5 \times T_C$	22.5	—	18.8	—	ns
405	Input data setup time before clock rising edge (internal clock)		$t_{SCC}/4 + 0.5 \times T_C + 25.0$	63.0	—	56.3	—	ns
406	Input data not valid before clock rising edge (internal clock)		$t_{SCC}/4 + 0.5 \times T_C - 5.5$	—	32.0	—	25.8	ns
407	Clock falling edge to output data valid (external clock)			—	32.0	—	32.0	ns
408	Output data hold after clock rising edge (external clock)		$T_C + 8.0$	23.0	—	20.5	—	ns
409	Input data setup time before clock rising edge (external clock)			0.0	—	0.0	—	ns
410	Input data hold time after clock rising edge (external clock)			9.0	—	9.0	—	ns
411	Asynchronous clock cycle	t_{ACC}[3]	$64 \times T_C$	969.7	—	800.0	—	ns
412	Clock low period		$t_{ACC}/2 - 10.0$	474.8	—	390.0	—	ns

Table 2-21 SCI Timing (Continued)

No.	Characteristics[1]	Symbol	Expression	66 MHz		80 MHz		Unit
				Min	Max	Min	Max	
413	Clock high period		$t_{ACC}/2 - 10.0$	474.8	—	390.0	—	ns
414	Output data setup to clock rising edge (internal clock)		$t_{ACC}/2 - 30.0$	458.8	—	370.0	—	ns
415	Output data hold after clock rising edge (internal clock)		$t_{ACC}/2 - 30.0$	458.8	—	370.0	—	ns

Note:
1. V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100 °C, C_L = 50 pF + 2 TTL Loads
2. t_{SCC} = synchronous clock cycle time (For internal clock, t_{SCC} is determined by the SCI clock control register and T_C.)
3. t_{ACC} = asynchronous clock cycle time; value given for 1X clock mode (For internal clock, t_{ACC} is determined by the SCI clock control register and T_C.)

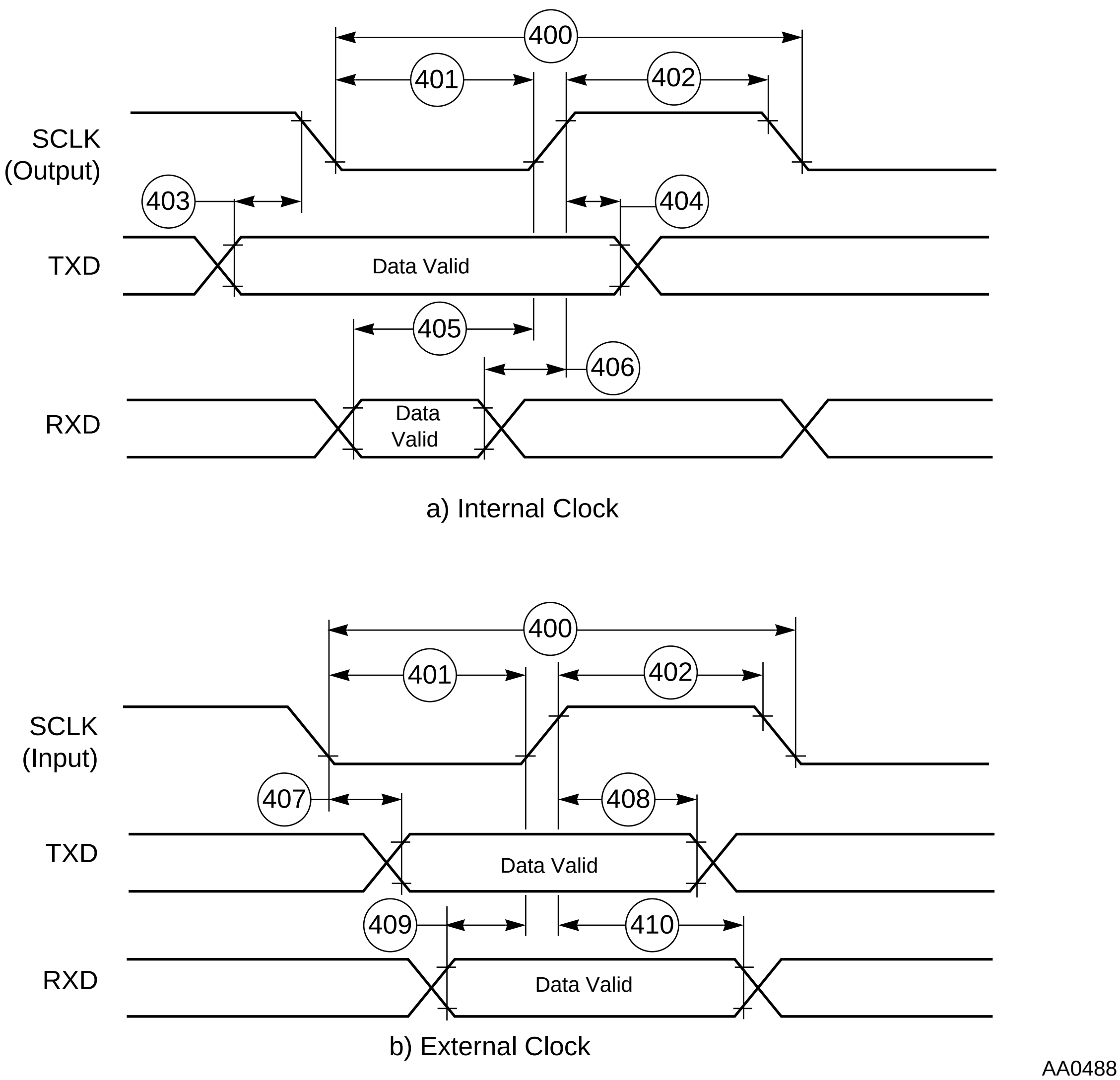


Figure 2-33 SCI Synchronous Mode Timing

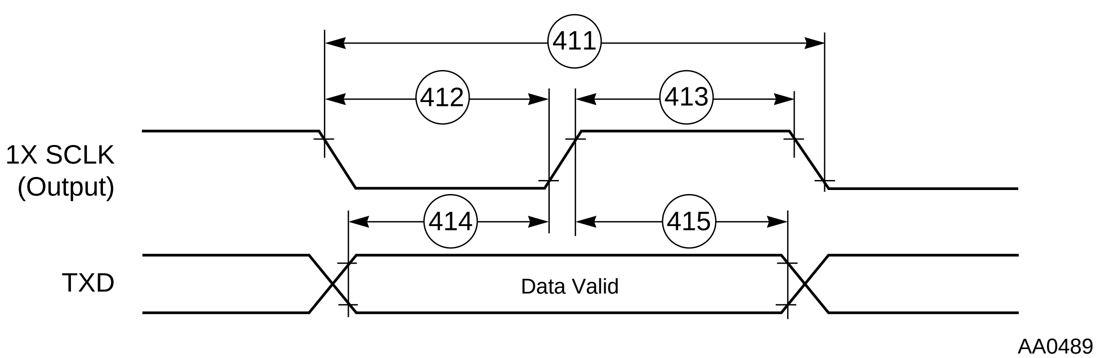


Figure 2-34 SCI Asynchronous Mode Timing

ESSI0/ESSI1 TIMING

Table 2-22 ESSI Timings

No.	Characteristics[4, 6, 7]	Symbol	Expression	66 MHz		80 MHz		Condition[5]	Unit
				Min	Max	Min	Max		
430	Clock cycle[1]	t_{SSICC}	$4 \times T_C$ $3 \times T_C$	60.6 45.5	— —	50.0 37.5	— —	i ck x ck	ns
431	Clock high period • For internal clock • For external clock		 $2 \times T_C - 10.0$ $1.5 \times T_C$	 20.3 22.7	 — —	 15.0 18.8	 — —		ns ns
432	Clock low period • For internal clock • For external clock		 $2 \times T_C - 10.0$ $1.5 \times T_C$	 20.3 22.7	 — —	 15.0 18.8	 — —		 ns ns
433	RXC rising edge to FSR out (bl) high			— —	37.0 22.0	— —	37.0 22.0	x ck i ck a	ns
434	RXC rising edge to FSR out (bl) low			— —	37.0 22.0	— —	37.0 22.0	x ck i ck a	ns
435	RXC rising edge to FSR out (wr) high[2]			— —	39.0 24.0	— —	39.0 24.0	x ck i ck a	ns
436	RXC rising edge to FSR out (wr) low[2]			— —	39.0 24.0	— —	39.0 24.0	x ck i ck a	ns
437	RXC rising edge to FSR out (wl) high			— —	36.0 21.0	— —	36.0 21.0	x ck i ck a	ns
438	RXC rising edge to FSR out (wl) low			— —	37.0 22.0	— —	37.0 22.0	x ck i ck a	ns
439	Data in setup time before RXC (SCK in synchronous mode) falling edge			0.0 19.0	— —	0.0 19.0	— —	x ck i ck	ns
440	Data in hold time after RXC falling edge			5.0 3.0	— —	5.0 3.0	— —	x ck i ck	ns
441	FSR input (bl, wr) high before RXC falling edge [2]			23.0 1.0	— —	23.0 1.0	— —	x ck i ck a	ns

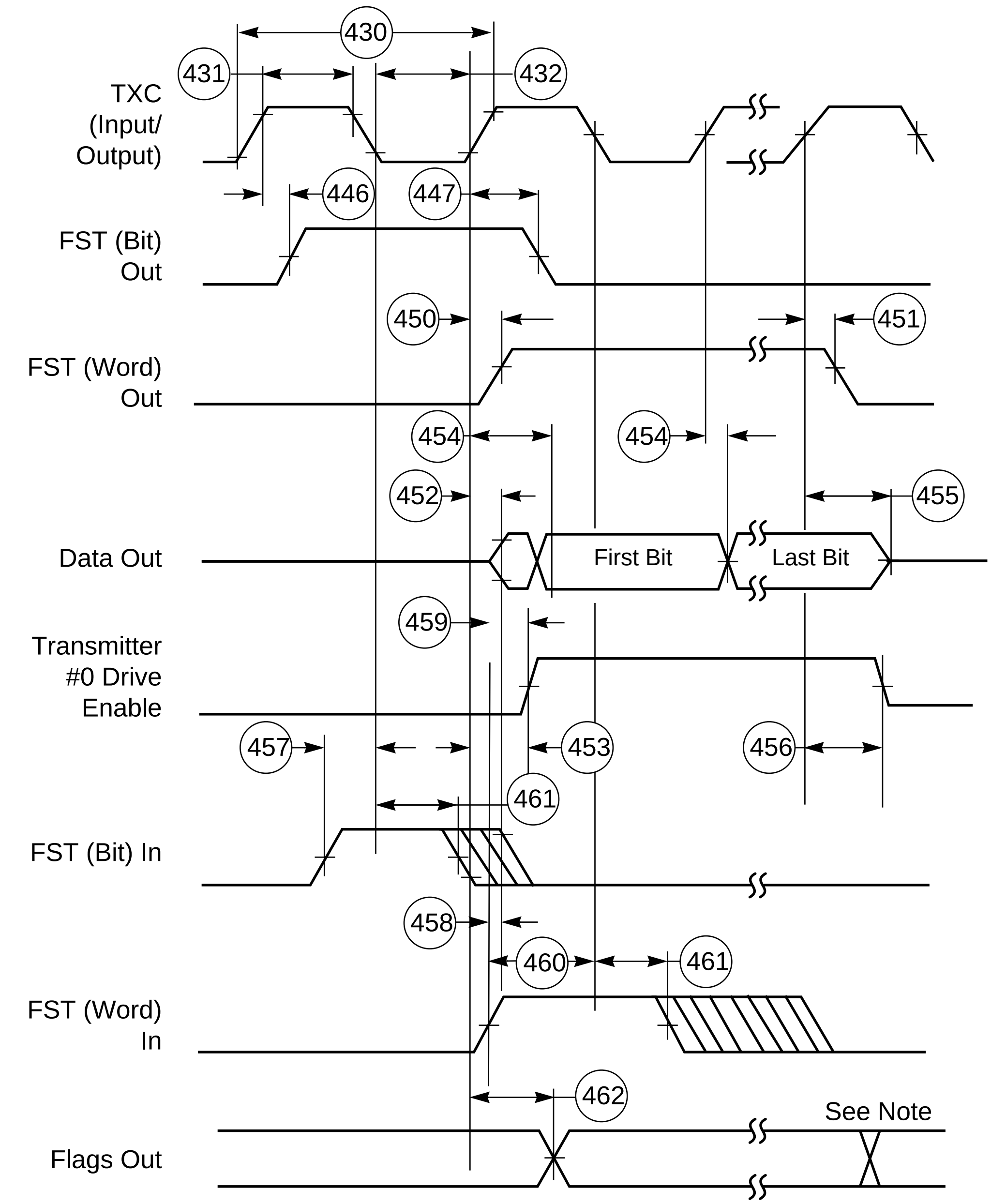
Table 2-22 ESSI Timings (Continued)

No.	Characteristics[4, 6, 7]	Symbol	Expression	66 MHz		80 MHz		Cond-ition[5]	Unit
				Min	Max	Min	Max		
442	FSR input (wl) high before RXC falling edge			23.0 1.0	— —	23.0 1.0	— —	x ck i ck a	ns
443	FSR input hold time after RXC falling edge			3.0 0.0	— —	3.0 0.0	— —	x ck i ck a	ns
444	Flags input setup before RXC falling edge			0.0 19.0	— —	0.0 19.0	— —	x ck i ck s	ns
445	Flags input hold time after RXC falling edge			6.0 0.0	— —	6.0 0.0	— —	x ck i ck s	ns
446	TXC rising edge to FST out (bl) high			— —	29.0 15.0	— —	29.0 15.0	x ck i ck	ns
447	TXC rising edge to FST out (bl) low			— —	31.0 17.0	— —	31.0 17.0	x ck i ck	ns
448	TXC rising edge to FST out (wr) high[2]			— —	31.0 17.0	— —	31.0 17.0	x ck i ck	ns
449	TXC rising edge to FST out (wr) low[2]			— —	33.0 19.0	— —	33.0 19.0	x ck i ck	ns
450	TXC rising edge to FST out (wl) high			— —	30.0 16.0	— —	30.0 16.0	x ck i ck	ns
451	TXC rising edge to FST out (wl) low			— —	31.0 17.0	— —	31.0 17.0	x ck i ck	ns
452	TXC rising edge to data out enable from high impedance			— —	31.0 17.0	— —	31.0 17.0	x ck i ck	ns
453	TXC rising edge to Transmitter #0 drive enable assertion			— —	34.0 20.0	— —	34.0 20.0	x ck i ck	ns
454	TXC rising edge to data out valid		$35 + 0.5 \times T_C$ 21.0	— —	42.6 21.0	— —	41.3 21.0	x ck i ck	ns
455	TXC rising edge to data out high impedance[3]			— —	31.0 16.0	— —	31.0 16.0	x ck i ck	ns
456	TXC rising edge to Transmitter #0 drive enable deassertion[3]			— —	34.0 20.0	— —	34.0 20.0	x ck i ck	ns

Table 2-22 ESSI Timings (Continued)

No.	Characteristics[4, 6, 7]	Symbol	Expression	66 MHz		80 MHz		Cond-ition[5]	Unit
				Min	Max	Min	Max		
457	FST input (bl, wr) setup time before TXC falling edge[2]			2.0 21.0	— —	2.0 21.0	— —	x ck i ck	ns
458	FST input (wl) to data out enable from high impedance			—	27.0	—	27.0	—	ns
459	FST input (wl) to Transmitter #0 drive enable assertion			—	31.0	—	31.0	—	ns
460	FST input (wl) setup time before TXC falling edge			2.0 21.0	— —	2.0 21.0	— —	x ck i ck	ns
461	FST input hold time after TXC falling edge			4.0 0.0	— —	4.0 0.0	— —	x ck i ck	ns
462	Flag output valid after TXC rising edge			— —	32.0 18.0	— —	32.0 18.0	x ck i ck	ns

Note:
1. For the internal clock, the external clock cycle is defined by Icyc and the ESSI control register.
2. 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.
3. Periodically sampled and not 100% tested
4. V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100 °C, C_L = 50 pF + 2 TTL Loads
5. TXC (SCK Pin) = Transmit Clock
   RXC (SC0 or SCK Pin) = Receive Clock
   FST (SC2 Pin) = Transmit Frame Sync
   FSR (SC1 or SC2 Pin) Receive Frame Sync
6. i ck = Internal Clock
   x ck = External Clock
   i ck a = Internal Clock, Asynchronous mode
   (Asynchronous implies that TXC and RXC are two different clocks)
   i ck s = Internal Clock, Synchronous mode
   (Synchronous implies that TXC and RXC are the same clock)
7. bl = bit length
   wl = word length
   wr = word length relative



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.

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Figure 2-35 ESSI Transmitter Timing

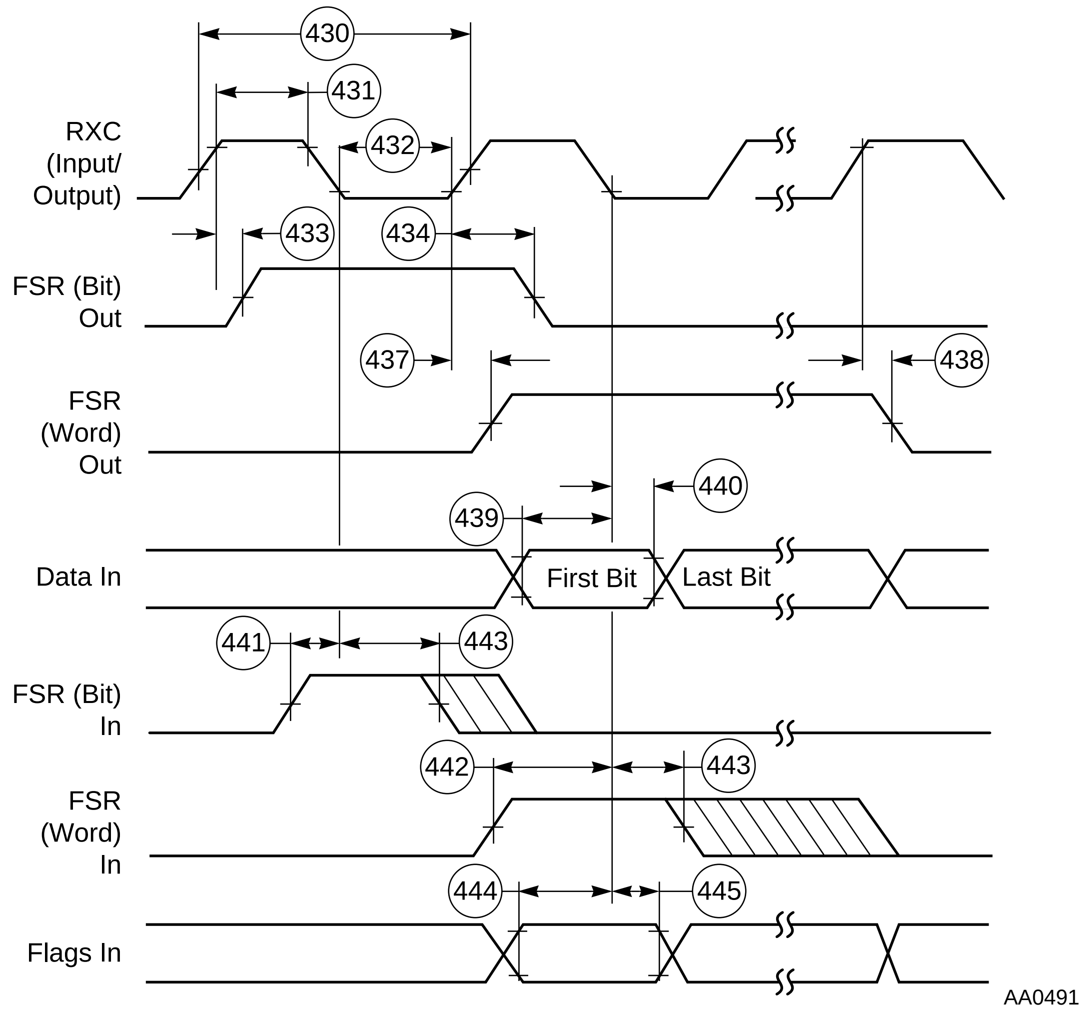


Figure 2-36 ESSI Receiver Timing

TIMER TIMING

Table 2-23 Timer Timing

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
480	TIO Low	$2 \times T_C + 2.0$	32.5	—	27.0	—	ns
481	TIO High	$2 \times T_C + 2.0$	32.5	—	27.0	—	ns
482	Timer setup time from TIO (Input) assertion to CLKOUT rising edge		9.0	T_C	9.0	T_C	ns
483	Synchronous timer delay time from CLKOUT rising edge to the external memory access address out valid caused by first interrupt instruction execution	$10.25 \times T_C + 1.0$	156.0	—	129.1	—	ns
484	CLKOUT rising edge to TIO (Output) assertion						
	• Minimum	**66 MHz**: $0.5 \times T_C + 3.4$	11.0	—	—	—	ns
		80 MHz: $0.5 \times T_C + 3.5$	—	—	9.8	—	ns
	• Maximum	**66 MHz**: $0.5 \times T_C + 20.5$	—	28.1	—	—	ns
		80 MHz: $0.5 \times T_C + 19.8$	—	—	—	26.1	ns
485	CLKOUT rising edge to TIO (Output) deassertion						
	• Minimum	**66 MHz**: $0.5 \times T_C + 3.4$	11.0	28.1	—	—	ns
		80 MHz: $0.5 \times T_C + 3.5$	—	—	9.8	26.1	ns
	• Maximum	**66 MHz**: $0.5 \times T_C + 20.5$	11.0	28.1	—	—	ns
		80 MHz: $0.5 \times T_C + 19.8$	—	—	9.8	26.1	ns

Note: $V_{CC} = 3.3$ V ± 0.3 V; $T_J = -40$°C to +100 °C, $C_L = 50$ pF + 2 TTL Loads

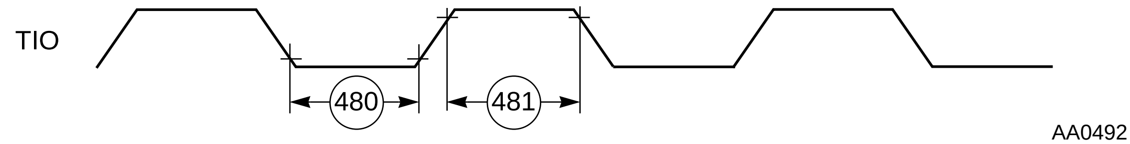


Figure 2-37 TIO Timer Event Input Restrictions

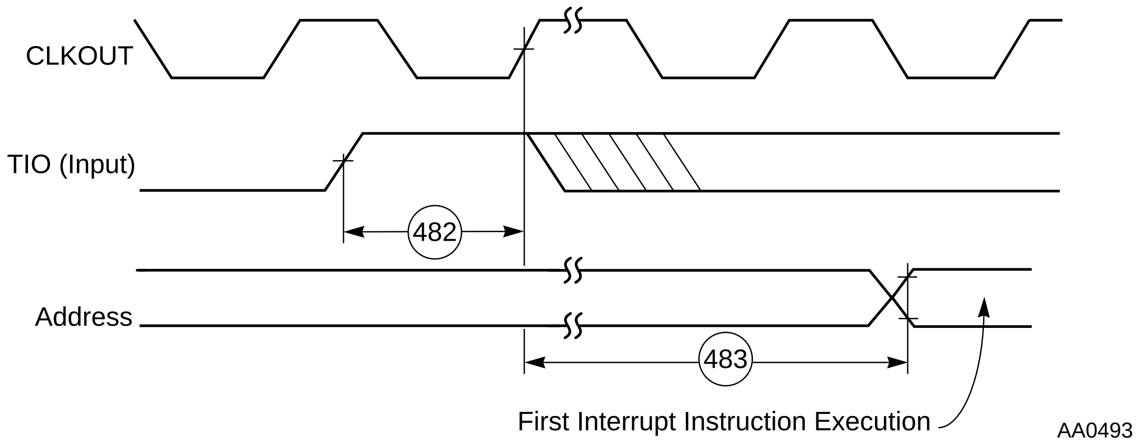


Figure 2-38 Timer Interrupt Generation

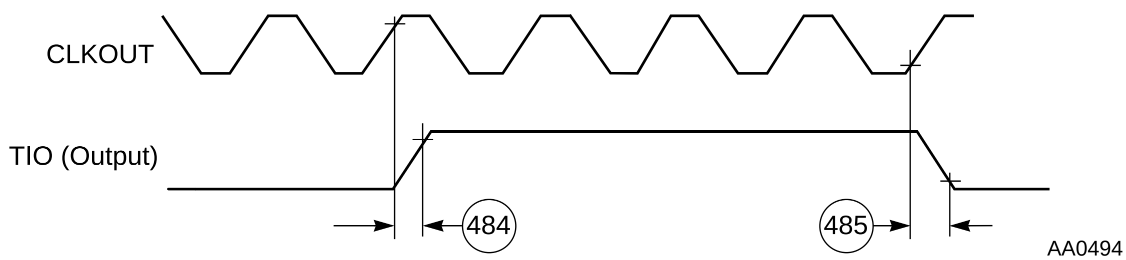


Figure 2-39 External Pulse Generation

GPIO TIMING

Table 2-24 GPIO Timing

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
490	CLKOUT edge to GPIO out valid (GPIO out delay time)		—	31.0	—	31.0	ns
491	CLKOUT edge to GPIO out not valid (GPIO out hold time)		3.0	—	3.0	—	ns
492	GPIO In valid to CLKOUT edge (GPIO in set-up time)		12.0	—	12.0	—	ns
493	CLKOUT edge to GPIO in not valid (GPIO in hold time)		0.0	—	0.0	—	ns
494	Fetch to CLKOUT edge before GPIO change	$6.75 \times T_C$	102.3	—	84.4	—	ns
Note: $V_{CC} = 3.3$ V ± 0.3 V; $T_J = -40$°C to +100 °C, $C_L = 50$ pF + 2 TTL Loads							

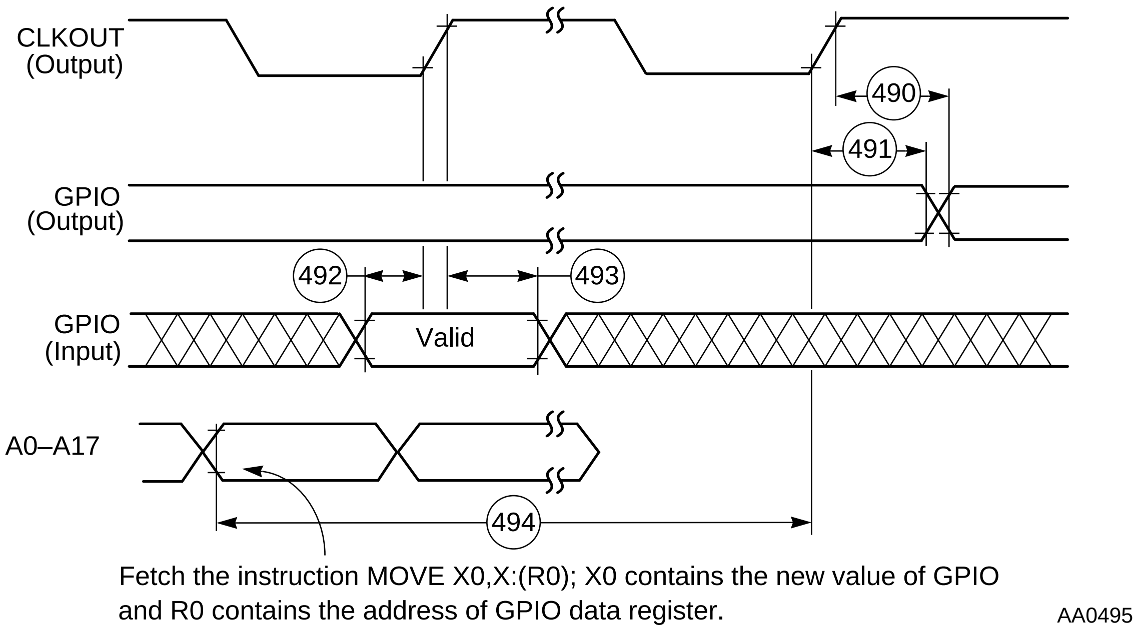


Figure 2-40 GPIO Timing

JTAG TIMING

Table 2-25 JTAG Timing

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
500	TCK frequency of operation		0.0	22.0	0.0	22.0	MHz
501	TCK cycle time in crystal mode		45.0	—	45.0	—	ns
502	TCK clock pulse width measured at 1.5 V		20.0	—	20.0	—	ns
503	TCK rise and fall times		0.0	3.0	0.0	3.0	ns
504	Boundary scan input data setup time		5.0	—	5.0	—	ns
505	Boundary scan input data hold time		24.0	—	24.0	—	ns
506	TCK low to output data valid		0.0	40.0	0.0	40.0	ns
507	TCK low to output high impedance		0.0	40.0	0.0	40.0	ns
508	TMS, TDI data setup time		5.0	—	5.0	—	ns
509	TMS, TDI data hold time		25.0	—	25.0	—	ns
510	TCK low to TDO data valid		0.0	44.0	0.0	44.0	ns
511	TCK low to TDO high impedance		0.0	44.0	0.0	44.0	ns
512	$\overline{TRST}$ assert time		100.0	—	100.0	—	ns
513	$\overline{TRST}$ setup time to TCK low		40.0	—	40.0	—	ns
Note: 1. V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100 °C, C_L = 50 pF + 2 TTL Loads 2. All timings apply to OnCE module data transfers because it uses the JTAG port as an interface.							

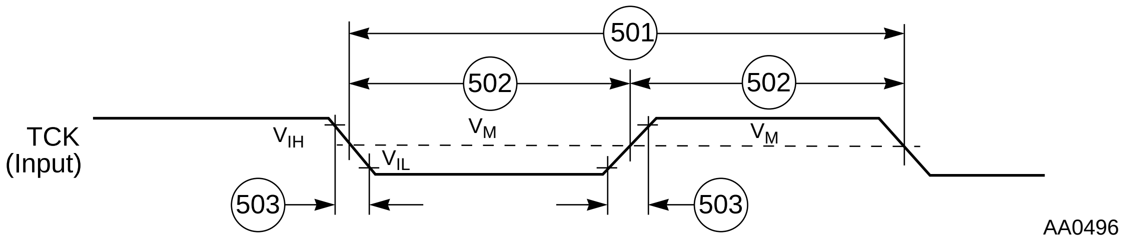


Figure 2-41 Test Clock Input Timing Diagram

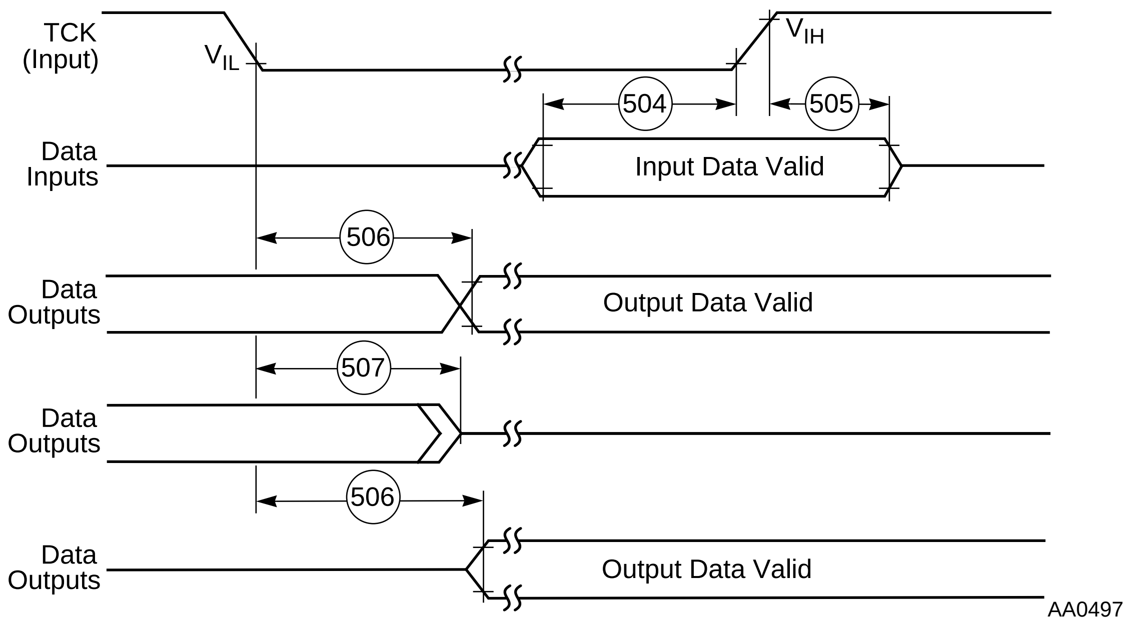


Figure 2-42 Boundary Scan (JTAG) Timing Diagram

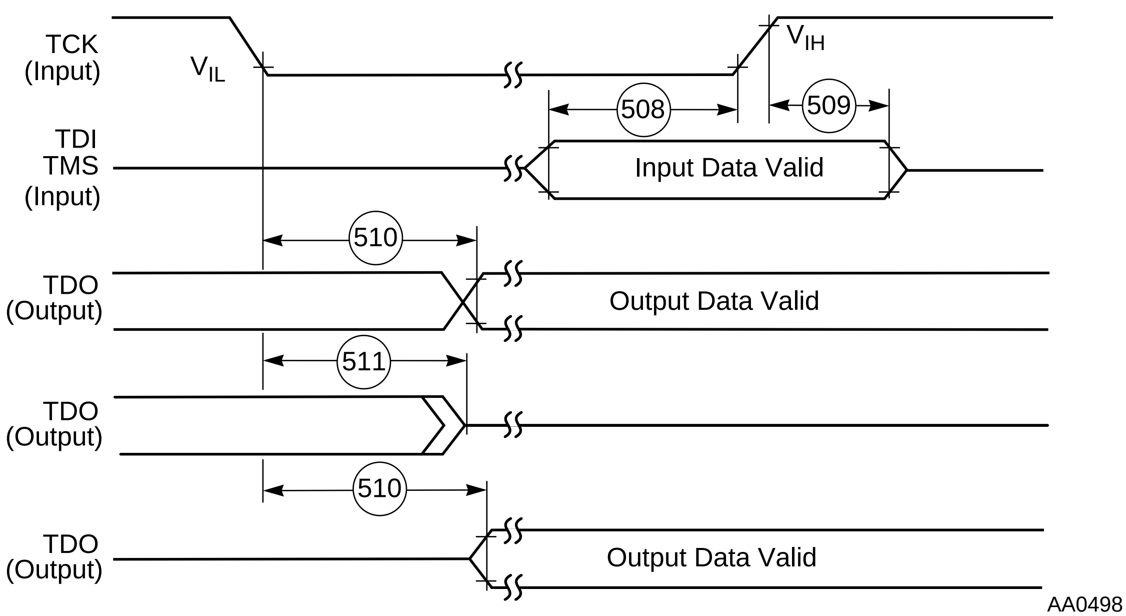


Figure 2-43 Test Access Port Timing Diagram

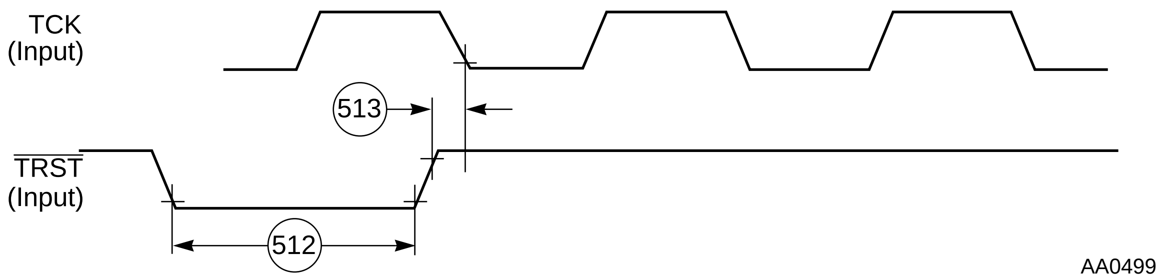


Figure 2-44 $\overline{\text{TRST}}$ Timing Diagram

OnCE MODULE TIMING

Table 2-26 OnCE Module Timing

No.	Characteristics	Expression	66 MHz		80 MHz		Unit
			Min	Max	Min	Max	
500	TCK frequency of operation	$1/(3 \times T_C)$, max 22.0 MHz	0.0	22.0	0.0	22.0	MHz
514	$\overline{\text{DE}}$ assertion time in order to enter debug mode	$1.5 \times T_C + 10.0$	32.0	—	28.8	—	ns
515	Response time when DSP56304 is executing NOP instructions from internal memory	$5.5 \times T_C + 30.0$	—	114.0	—	98.8	ns
516	Debug acknowledge assertion time	$3 \times T_C + 10.0$	55.5	—	47.5	—	ns
Note: V_{CC} = 3.3 V ± 0.3 V; T_J = –40°C to +100 °C, C_L = 50 pF + 2 TTL Loads							

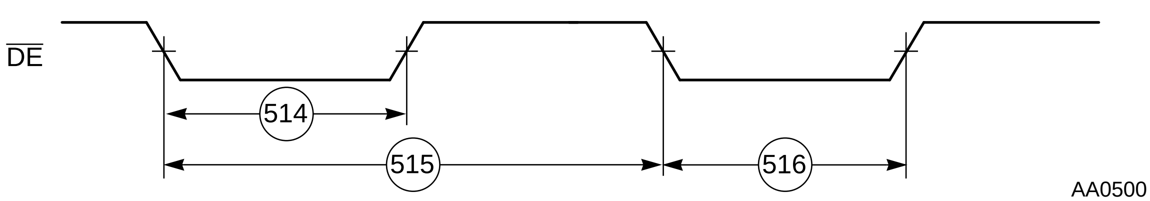


Figure 2-45 OnCE—Debug Request

SECTION 3

PACKAGING

PIN-OUT AND PACKAGE INFORMATION

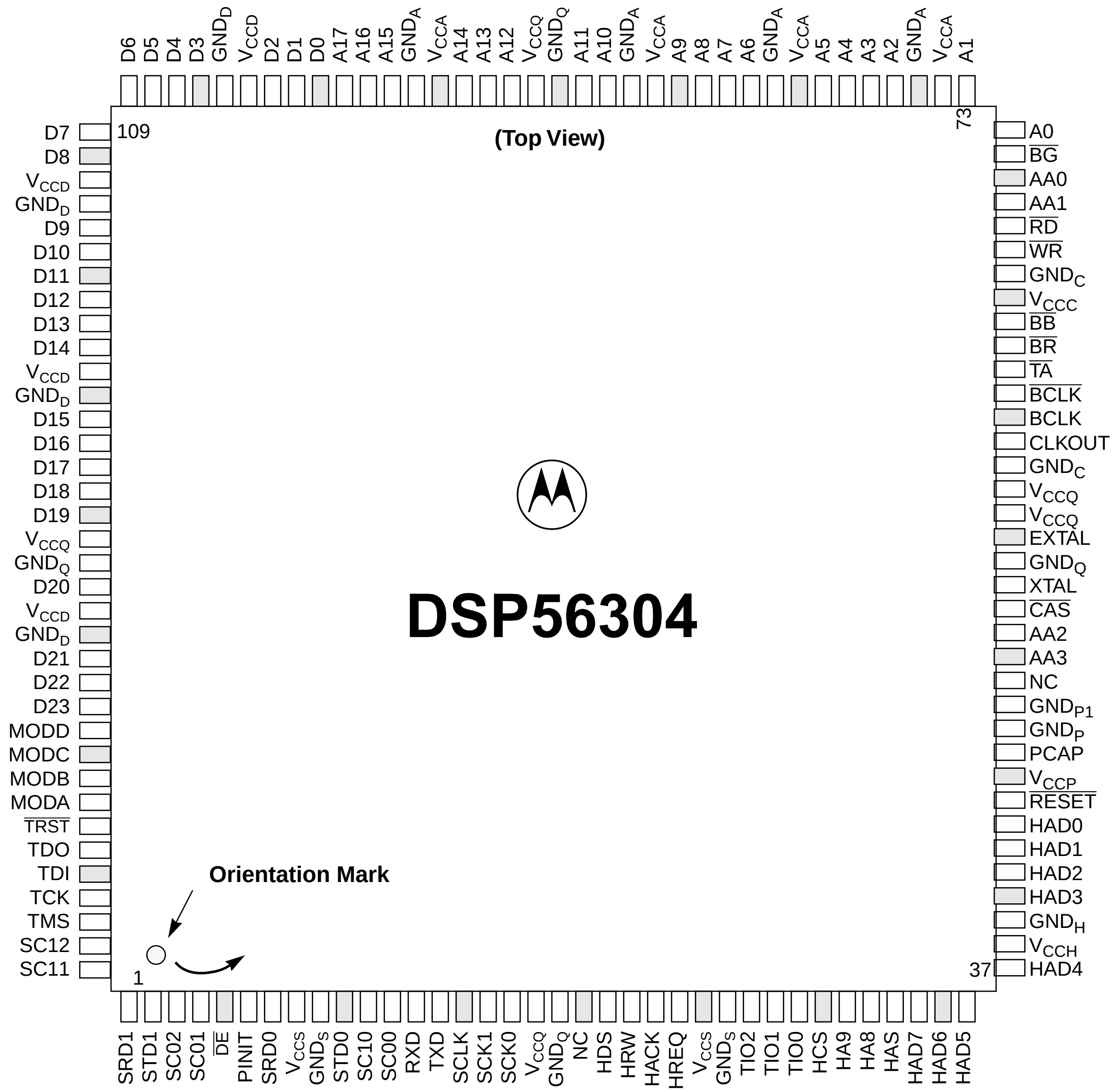
This sections provides information about the available packages for this product, including diagrams of the package pinouts and tables describing how the signals described in **Section 1** are allocated for each package.

The DSP56304 is available in two package types:

- 144-pin Thin Quad Flat Pack (TQFP)
- 196-pin Plastic Ball Grid Array (PBGA)

TQFP Package Description

Top and bottom views of the TQFP package are shown in **Figure 3-1** and **Figure 3-2** with their pin-outs.



Note: Because of size constraints in this figure, only one name is shown for multiplexed pins. Refer to **Table 3-1** and **Table 3-2** for detailed information about pin functions and signal names.

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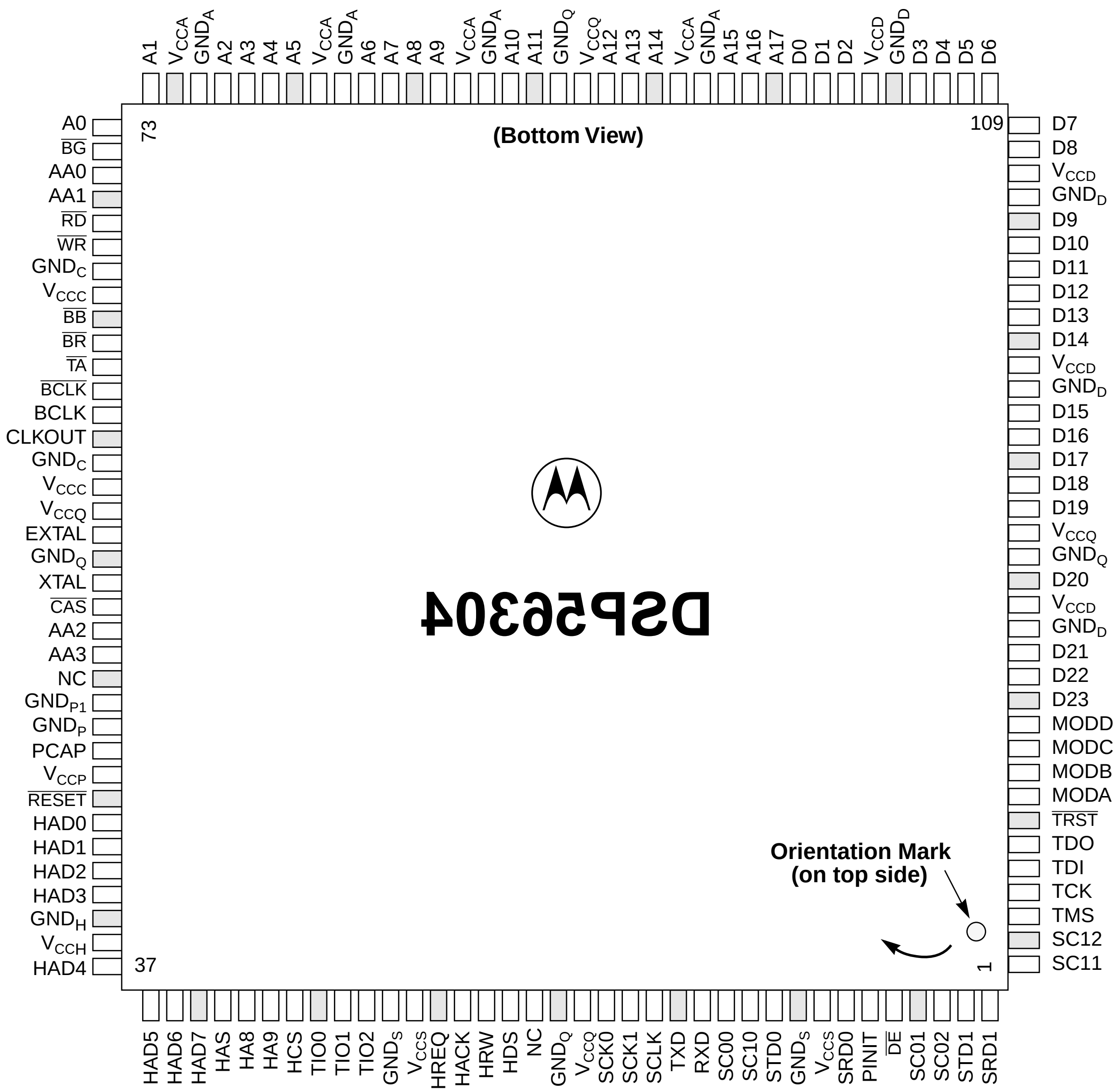
Figure 3-1 DSP56304 Thin Quad Flat Pack (TQFP), Top View



Note: Because of size constraints in this figure, only one name is shown for multiplexed pins. Refer to **Table 3-1** and **Table 3-2** for detailed information about pin functions and signal names.

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Figure 3-2 DSP56304 Thin Quad Flat Pack (TQFP), Bottom View

Table 3-1 DSP56304 TQFP Signal Identification by Pin Number

Pin No.	Signal Name	Pin No.	Signal Name	Pin No.	Signal Name
1	SRD1 or PD4	26	GND_S	51	AA2/$\overline{RAS2}$
2	STD1 or PD5	27	TIO2	52	$\overline{CAS}$
3	SC02 or PC2	28	TIO1	53	XTAL
4	SC01 or PC1	29	TIO0	54	GND_Q
5	$\overline{DE}$	30	$\overline{HCS}$/HCS, HA10, or PB13	55	EXTAL
6	PINIT/$\overline{NMI}$	31	HA2, HA9, or PB10	56	V_{CCQ}
7	SRD0 or PC4	32	HA1, HA8, or PB9	57	V_{CCC}
8	V_{CCS}	33	HA0, $\overline{HAS}$/HAS, or PB8	58	GND_C
9	GND_S	34	H7, HAD7, or PB7	59	CLKOUT
10	STD0 or PC5	35	H6, HAD6, or PB6	60	BCLK
11	SC10 or PD0	36	H5, HAD5, or PB5	61	$\overline{BCLK}$
12	SC00 or PC0	37	H4, HAD4, or PB4	62	$\overline{TA}$
13	RXD or PE0	38	V_{CCH}	63	$\overline{BR}$
14	TXD or PE1	39	GND_H	64	$\overline{BB}$
15	SCLK or PE2	40	H3, HAD3, or PB3	65	V_{CCC}
16	SCK1 or PD3	41	H2, HAD2, or PB2	66	GND_C
17	SCK0 or PC3	42	H1, HAD1, or PB1	67	$\overline{WR}$
18	V_{CCQ}	43	H0, HAD0, or PB0	68	$\overline{RD}$
19	GND_Q	44	$\overline{RESET}$	69	AA1/$\overline{RAS1}$
20	Not Connected (NC), reserved	45	V_{CCP}	70	AA0/$\overline{RAS0}$
21	$\overline{HDS}$/HDS, $\overline{HWR}$/HWR, or PB12	46	PCAP	71	$\overline{BG}$
22	HRW, $\overline{HRD}$/HRD, or PB11	47	GND_P	72	A0
23	$\overline{HACK}$/HACK, $\overline{HRRQ}$/HRRQ, or PB15	48	GND_{P1}	73	A1
24	$\overline{HREQ}$/HREQ, $\overline{HTRQ}$/HTRQ, or PB14	49	Not Connected (NC), reserved	74	V_{CCA}
25	V_{CCS}	50	AA3/$\overline{RAS3}$	75	GND_A

Table 3-1 DSP56304 TQFP Signal Identification by Pin Number (Continued)

Pin No.	Signal Name	Pin No.	Signal Name	Pin No.	Signal Name
76	A2	99	A17	122	D16
77	A3	100	D0	123	D17
78	A4	101	D1	124	D18
79	A5	102	D2	125	D19
80	V_{CCA}	103	V_{CCD}	126	V_{CCQ}
81	GND_A	104	GND_D	127	GND_Q
82	A6	105	D3	128	D20
83	A7	106	D4	129	V_{CCD}
84	A8	107	D5	130	GND_D
85	A9	108	D6	131	D21
86	V_{CCA}	109	D7	132	D22
87	GND_A	110	D8	133	D23
88	A10	111	V_{CCD}	134	MODD/$\overline{IRQD}$
89	A11	112	GND_D	135	MODC/$\overline{IRQC}$
90	GND_Q	113	D9	136	MODB/$\overline{IRQB}$
91	V_{CCQ}	114	D10	137	MODA/$\overline{IRQA}$
92	A12	115	D11	138	$\overline{TRST}$
93	A13	116	D12	139	TDO
94	A14	117	D13	140	TDI
95	V_{CCA}	118	D14	141	TCK
96	GND_A	119	V_{CCD}	142	TMS
97	A15	120	GND_D	143	SC12 or PD2
98	A16	121	D15	144	SC11 or PD1

Note: Signal names are based on configured functionality. Most pins supply a single signal. Some pins provide a signal with dual functionality, such as the MODx/$\overline{IRQx}$ pins that select an operating mode after $\overline{RESET}$ is deasserted, but act as interrupt lines during operation. Some signals have configurable polarity; these names are shown with and without overbars, such as $\overline{HAS}$/HAS. Some pins have two or more configurable functions; names assigned to these pins indicate the function for a specific configuration. For example, Pin 34 is data line H7 in non-multiplexed bus mode, data/address line HAD7 in multiplexed bus mode, or GPIO line PB7 when the GPIO function is enabled for this pin.

Table 3-2 DSP56304 TQFP Signal Identification by Name

Signal Name	Pin No.	Signal Name	Pin No.	Signal Name	Pin No.
A0	72	$\overline{BG}$	71	D7	109
A1	73	$\overline{BR}$	63	D8	110
A10	88	$\overline{CAS}$	52	D9	113
A11	89	CLKOUT	59	$\overline{DE}$	5
A12	92	D0	100	EXTAL	55
A13	93	D1	101	GND_A	75
A14	94	D10	114	GND_A	81
A15	97	D11	115	GND_A	87
A16	98	D12	116	GND_A	96
A17	99	D13	117	GND_C	58
A2	76	D14	118	GND_C	66
A3	77	D15	121	GND_D	104
A4	78	D16	122	GND_D	112
A5	79	D17	123	GND_D	120
A6	82	D18	124	GND_D	130
A7	83	D19	125	GND_H	39
A8	84	D2	102	GND_P	47
A9	85	D20	128	GND_{P1}	48
AA0	70	D21	131	GND_Q	19
AA1	69	D22	132	GND_Q	54
AA2	51	D23	133	GND_Q	90
AA3	50	D3	105	GND_Q	127
$\overline{BB}$	64	D4	106	GND_S	9
BCLK	60	D5	107	GND_S	26
$\overline{BCLK}$	61	D6	108	H0	43

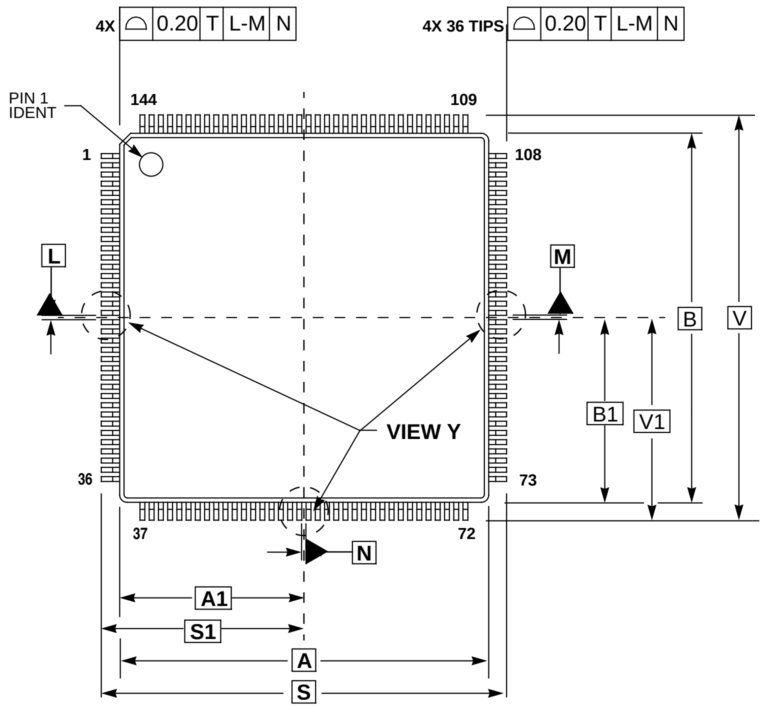
Table 3-2 DSP56304 TQFP Signal Identification by Name (Continued)

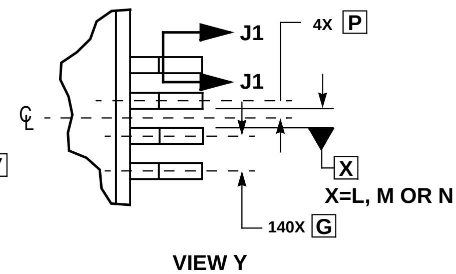
Signal Name	Pin No.	Signal Name	Pin No.	Signal Name	Pin No.
H1	42	$\overline{\text{HRD}}$/HRD	22	PB2	41
H2	41	$\overline{\text{HREQ}}$/HREQ	24	PB3	40
H3	40	$\overline{\text{HRRQ}}$/HRRQ	23	PB4	37
H4	37	HRW	22	PB5	36
H5	36	$\overline{\text{HTRQ}}$/HTRQ	24	PB6	35
H6	35	$\overline{\text{HWR}}$/HWR	21	PB7	34
H7	34	$\overline{\text{IRQA}}$	137	PB8	33
HA0	33	$\overline{\text{IRQB}}$	136	PB9	32
HA1	32	$\overline{\text{IRQC}}$	135	PC0	12
HA10	30	$\overline{\text{IRQD}}$	134	PC1	4
HA2	31	MODA	137	PC2	3
HA8	32	MODB	136	PC3	17
HA9	31	MODC	135	PC4	7
$\overline{\text{HACK}}$/HACK	23	MODD	134	PC5	10
HAD0	43	NC	20	PCAP	46
HAD1	42	$\overline{\text{NMI}}$	6	PD0	11
HAD2	41	NC	49	PD1	144
HAD3	40	PB0	43	PD2	143
HAD4	37	PB1	42	PD3	16
HAD5	36	PB10	31	PD4	1
HAD6	35	PB11	22	PD5	2
HAD7	34	PB12	21	PE0	13
HAS	33	PB13	30	PE1	14
HCS/HCS	30	PB14	24	PE2	15
HDS/HDS	21	PB15	23	PINIT	6

Table 3-2 DSP56304 TQFP Signal Identification by Name (Continued)

Signal Name	Pin No.	Signal Name	Pin No.	Signal Name	Pin No.
$\overline{RAS0}$	70	SRD1	1	V_{CCC}	57
$\overline{RAS1}$	69	STD0	10	V_{CCC}	65
$\overline{RAS2}$	51	STD1	2	V_{CCD}	103
$\overline{RAS3}$	50	$\overline{TA}$	62	V_{CCD}	111
$\overline{RD}$	68	TCK	141	V_{CCD}	119
$\overline{RESET}$	44	TDI	140	V_{CCD}	129
RXD	13	TDO	139	V_{CCH}	38
SC00	12	TIO0	29	V_{CCP}	45
SC01	4	TIO1	28	V_{CCQ}	18
SC02	3	TIO2	27	V_{CCQ}	56
SC10	11	TMS	142	V_{CCQ}	91
SC11	144	$\overline{TRST}$	138	V_{CCQ}	126
SC12	143	TXD	14	V_{CCS}	8
SCK0	17	V_{CCA}	74	V_{CCS}	25
SCK1	16	V_{CCA}	80	$\overline{WR}$	67
SCLK	15	V_{CCA}	86	XTAL	53
SRD0	7	V_{CCA}	95		

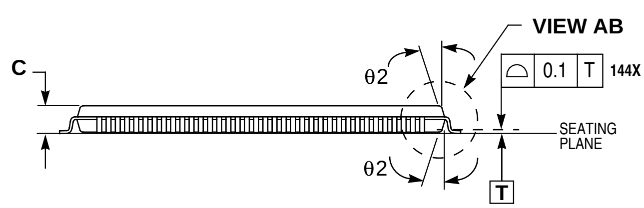
TQFP Package Mechanical Drawing



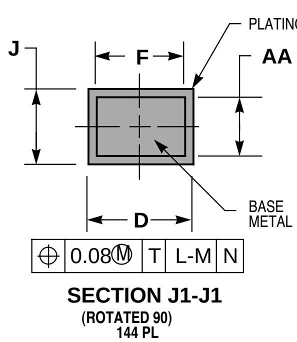


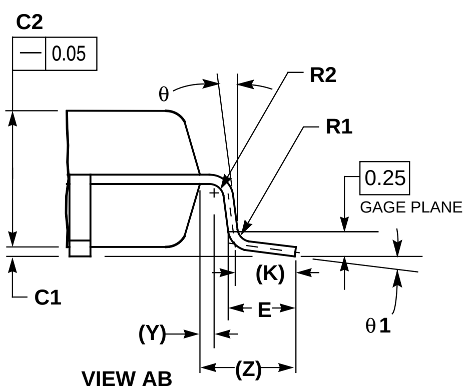
NOTES:

1. DIMENSIONS AND TOLERANCING PER ASME Y14.5-1994.
2. DIMENSIONS IN MILLIMETERS.
3. DATUMS L, M AND N TO BE DETERMINED AT THE SEATING PLANE, DATUM T.
4. DIMENSIONS S AND V TO BE DETERMINED AT SEATING PLANE, DATUM T.
5. DIMENSIONS A AND B DO NOT INCULDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25 PER SIDE. DIMENSIONS A AND B DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE H.
6. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLED DAMBAR PROTRUSION SHALL NOT CAUSE THE D DIMENSION TO EXCEED 0.35.



	MILLIMETERS	
DIM	MIN	MAX
A	20.00 BSC	
A1	10.00 BSC	
B	20.00 BSC	
B1	10.00 BSC	
C	1.40	1.60
C1	0.05	0.15
C2	1.35	1.45
D	0.17	0.27
E	0.45	0.75
F	0.17	0.23
G	0.50 BSC	
J	0.09	0.20
K	0.50 REF	
P	0.25 BSC	
R1	0.13	0.20
R2	0.13	0.20
S	22.00 BSC	
S1	11.00 BSC	
V	22.00 BSC	
V1	11.00 BSC	
Y	0.25 REF	
Z	1.00 REF	
AA	0.09	0.16
θ	0°	
θ1	0°	7°
θ2	11°	13°





Case 918-03

Figure 3-3 DSP56304 Mechanical Information, 144-pin TQFP Package

PBGA Package Description

Top and bottom views of the PBGA package are shown in **Figure 3-4** and **Figure 3-5** with their pin-outs.

Top View

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	NC	SC11	TMS	TDO	MODB	D23	V_{CCD}	D19	D16	D14	D11	D9	D7	NC
B	SRD1	SC12	TDI	$\overline{TRST}$	MODD	D21	D20	D17	D15	D13	D10	D8	D5	NC
C	SC02	STD1	TCK	MODA	MODC	D22	V_{CCQ}	D18	V_{CCD}	D12	V_{CCD}	D6	D3	D4
D	PINIT	SC01	$\overline{DE}$	GND	GND	GND	GND	GND	GND	GND	GND	D1	D2	V_{CCD}
E	STD0	V_{CCS}	SRD0	GND	GND	GND	GND	GND	GND	GND	GND	A17	A16	D0
F	RXD	SC10	SC00	GND	GND	GND	GND	GND	GND	GND	GND	V_{CCA}	A14	A15
G	SCK1	SCLK	TXD	GND	GND	GND	GND	GND	GND	GND	GND	A13	V_{CCQ}	A12
H	NC	V_{CCQ}	SCK0	GND	GND	GND	GND	GND	GND	GND	GND	V_{CCA}	A10	A11
J	$\overline{HACK}$	HRW	$\overline{HDS}$	GND	GND	GND	GND	GND	GND	GND	GND	A8	A7	A9
K	V_{CCS}	$\overline{HREQ}$	TIO2	GND	GND	GND	GND	GND	GND	GND	GND	V_{CCA}	A5	A6
L	$\overline{HCS}$	TIO1	TIO0	GND	GND	GND	GND	GND	GND	GND	GND	V_{CCA}	A3	A4
M	HA1	HA2	HA0	V_{CCH}	PB0	V_{CCP}	NC	EXTAL	CLK OUT	$\overline{BCLK}$	$\overline{WR}$	$\overline{RD}$	A1	A2
N	H6	H7	H4	H2	$\overline{RESET}$	GND_P	AA3	$\overline{CAS}$	V_{CCQ}	BCLK	$\overline{BR}$	V_{CCC}	AA0	A0
P	NC	H5	H3	H1	PCAP	GND_{P1}	AA2	XTAL	V_{CCC}	$\overline{TA}$	$\overline{BB}$	AA1	$\overline{BG}$	NC

Figure 3-4 DSP56304 Plastic Ball Grid Array (PBGA), Top View

Bottom View

	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
	NC	D7	D9	D11	D14	D16	D19	V_{CCD}	D23	MODB	TDO	TMS	SC11	NC	A
	NC	D5	D8	D10	D13	D15	D17	D20	D21	MODD	$\overline{TRST}$	TDI	SC12	SRD1	B
	D4	D3	D6	V_{CCD}	D12	V_{CCD}	D18	V_{CCQ}	D22	MODC	MODA	TCK	STD1	SC02	C
	V_{CCD}	D2	D1	GND	GND	GND	GND	GND	GND	GND	GND	$\overline{DE}$	SC01	PINIT	D
	D0	A16	A17	GND	GND	GND	GND	GND	GND	GND	GND	SRD0	V_{CCS}	STD0	E
	A15	A14	V_{CCA}	GND	GND	GND	GND	GND	GND	GND	GND	SC00	SC10	RXD	F
	A12	V_{CCQ}	A13	GND	GND	GND	GND	GND	GND	GND	GND	TXD	SCLK	SCK1	G
	A11	A10	V_{CCA}	GND	GND	GND	GND	GND	GND	GND	GND	SCK0	V_{CCQ}	NC	H
	A9	A7	A8	GND	GND	GND	GND	GND	GND	GND	GND	$\overline{HDS}$	HRW	$\overline{HACK}$	J
	A6	A5	V_{CCA}	GND	GND	GND	GND	GND	GND	GND	GND	TIO2	$\overline{HREQ}$	V_{CCS}	K
	A4	A3	V_{CCA}	GND	GND	GND	GND	GND	GND	GND	GND	TIO0	TIO1	$\overline{HCS}$	L
	A2	A1	$\overline{RD}$	$\overline{WR}$	$\overline{BCLK}$	CLK OUT	EXTAL	NC	V_{CCP}	PB0	V_{CCH}	HA0	HA2	HA1	M
	A0	AA0	V_{CCC}	$\overline{BR}$	BCLK	V_{CCQ}	$\overline{CAS}$	AA3	GND_P	$\overline{RESET}$	H2	H4	H7	H6	N
	NC	$\overline{BG}$	AA1	$\overline{BB}$	$\overline{TA}$	V_{CCC}	XTAL	AA2	GND_{P1}	PCAP	H1	H3	H5	NC	P

Figure 3-5 DSP56304 Plastic Ball Grid Array (PBGA), Bottom View

Table 3-3 DSP56304 PBGA Signal Identification by Pin Number

Pin No.	Signal Name	Pin No.	Signal Name	Pin No.	Signal Name
A1	Not Connected (NC), reserved	B12	D8	D9	GND
A2	SC11 or PD1	B13	D5	D10	GND
A3	TMS	B14	NC	D11	GND
A4	TDO	C1	SC02 or PC2	D12	D1
A5	MODB/$\overline{IRQB}$	C2	STD1 or PD5	D13	D2
A6	D23	C3	TCK	D14	V_{CCD}
A7	V_{CCD}	C4	MODA/$\overline{IRQA}$	E1	STD0 or PC5
A8	D19	C5	MODC/$\overline{IRQC}$	E2	V_{CCS}
A9	D16	C6	D22	E3	SRD0 or PC4
A10	D14	C7	V_{CCQ}	E4	GND
A11	D11	C8	D18	E5	GND
A12	D9	C9	V_{CCD}	E6	GND
A13	D7	C10	D12	E7	GND
A14	NC	C11	V_{CCD}	E8	GND
B1	SRD1 or PD4	C12	D6	E9	GND
B2	SC12 or PD2	C13	D3	E10	GND
B3	TDI	C14	D4	E11	GND
B4	$\overline{TRST}$	D1	PINIT/$\overline{NMI}$	E12	A17
B5	MODD/$\overline{IRQD}$	D2	SC01 or PC1	E13	A16
B6	D21	D3	$\overline{DE}$	E14	D0
B7	D20	D4	GND	F1	RXD or PE0
B8	D17	D5	GND	F2	SC10 or PD0
B9	D15	D6	GND	F3	SC00 or PC0
B10	D13	D7	GND	F4	GND
B11	D10	D8	GND	F5	GND

Table 3-3 DSP56304 PBGA Signal Identification by Pin Number (Continued)

Pin No.	Signal Name	Pin No.	Signal Name	Pin No.	Signal Name
F6	GND	H3	SCK0 or PC3	J14	A9
F7	GND	H4	GND	K1	V_{CCS}
F8	GND	H5	GND	K2	$\overline{HREQ}$/HREQ, $\overline{HTRQ}$/HTRQ, or PB14
F9	GND	H6	GND	K3	TIO2
F10	GND	H7	GND	K4	GND
F11	GND	H8	GND	K5	GND
F12	V_{CCA}	H9	GND	K6	GND
F13	A14	H10	GND	K7	GND
F14	A15	H11	GND	K8	GND
G1	SCK1 or PD3	H12	V_{CCA}	K9	GND
G2	SCLK or PE2	H13	A10	K10	GND
G3	TXD or PE1	H14	A11	K11	GND
G4	GND	J1	$\overline{HACK}$/HACK, $\overline{HRRQ}$/HRRQ, or PB15	K12	V_{CCA}
G5	GND	J2	HRW, $\overline{HRD}$/HRD, or PB11	K13	A5
G6	GND	J3	$\overline{HDS}$/HDS, $\overline{HWR}$/HWR, or PB12	K14	A6
G7	GND	J4	GND	L1	$\overline{HCS}$/HCS, HA10, or PB13
G8	GND	J5	GND	L2	TIO1
G9	GND	J6	GND	L3	TIO0
G10	GND	J7	GND	L4	GND
G11	GND	J8	GND	L5	GND
G12	A13	J9	GND	L6	GND
G13	V_{CCQ}	J10	GND	L7	GND
G14	A12	J11	GND	L8	GND
H1	NC	J12	A8	L9	GND
H2	V_{CCQ}	J13	A7	L10	GND

Table 3-3 DSP56304 PBGA Signal Identification by Pin Number (Continued)

Pin No.	Signal Name	Pin No.	Signal Name	Pin No.	Signal Name
L11	GND	M13	A1	P1	NC
L12	V_{CCA}	M14	A2	P2	H5, HAD5, or PB5
L13	A3	N1	H6, HAD6, or PB6	P3	H3, HAD3, or PB3
L14	A4	N2	H7, HAD7, or PB7	P4	H1, HAD1, or PB1
M1	HA1, HA8, or PB9	N3	H4, HAD4, or PB4	P5	PCAP
M2	HA2, HA9, or PB10	N4	H2, HAD2, or PB2	P6	GND_{P1}
M3	HA0, $\overline{HAS}$/HAS, or PB8	N5	$\overline{RESET}$	P7	AA2/$\overline{RAS2}$
M4	V_{CCH}	N6	GND_P	P8	XTAL
M5	H0, HAD0, or PB0	N7	AA3/$\overline{RAS3}$	P9	V_{CCC}
M6	V_{CCP}	N8	$\overline{CAS}$	P10	$\overline{TA}$
M7	NC	N9	V_{CCQ}	P11	$\overline{BB}$
M8	EXTAL	N10	BCLK	P12	AA1/$\overline{RAS1}$
M9	CLKOUT	N11	$\overline{BR}$	P13	$\overline{BG}$
M10	$\overline{BCLK}$	N12	V_{CCC}	P14	NC
M11	$\overline{WR}$	N13	AA0/$\overline{RAS0}$		
M12	$\overline{RD}$	N14	A0		

Note: Signal names are based on configured functionality. Most connections supply a single signal. Some connections provide a signal with dual functionality, such as the MODx/$\overline{IRQx}$ pins that select an operating mode after $\overline{RESET}$ is deasserted, but act as interrupt lines during operation. Some signals have configurable polarity; these names are shown with and without overbars, such as $\overline{HAS}$/HAS. Some connections have two or more configurable functions; names assigned to these connections indicate the function for a specific configuration. For example, connection N2 is data line H7 in non-multiplexed bus mode, data/address line HAD7 in multiplexed bus mode, or GPIO line PB7 when the GPIO function is enabled for this pin. Unlike the TQFP package, most of the GND pins are connected internally in the center of the connection array and act as heat sink for the chip. Therefore, except for GND_P and GND_{P1} that support the PLL, other GND signals do not support individual subsystems in the chip.

Table 3-4 DSP56304 PBGA Signal Identification by Name

Signal Name	Pin No.	Signal Name	Pin No.	Signal Name	Pin No.
A0	N14	$\overline{\text{BG}}$	P13	D7	A13
A1	M13	$\overline{\text{BR}}$	N11	D8	B12
A10	H13	$\overline{\text{CAS}}$	N8	D9	A12
A11	H14	CLKOUT	M9	$\overline{\text{DE}}$	D3
A12	G14	D0	E14	EXTAL	M8
A13	G12	D1	D12	GND	D4
A14	F13	D10	B11	GND	D5
A15	F14	D11	A11	GND	D6
A16	E13	D12	C10	GND	D7
A17	E12	D13	B10	GND	D8
A2	M14	D14	A10	GND	D9
A3	L13	D15	B9	GND	D10
A4	L14	D16	A9	GND	D11
A5	K13	D17	B8	GND	E4
A6	K14	D18	C8	GND	E5
A7	J13	D19	A8	GND	E6
A8	J12	D2	D13	GND	E7
A9	J14	D20	B7	GND	E8
AA0	N13	D21	B6	GND	E9
AA1	P12	D22	C6	GND	E10
AA2	P7	D23	A6	GND	E11
AA3	N7	D3	C13	GND	F4
$\overline{\text{BB}}$	P11	D4	C14	GND	F5
$\overline{\text{BCLK}}$	M10	D5	B13	GND	F6
BCLK	N10	D6	C12	GND	F7

Table 3-4 DSP56304 PBGA Signal Identification by Name (Continued)

Signal Name	Pin No.	Signal Name	Pin No.	Signal Name	Pin No.
GND	F8	GND	J9	H4	N3
GND	F9	GND	J10	H5	P2
GND	F10	GND	J11	H6	N1
GND	F11	GND	K4	H7	N2
GND	G4	GND	K5	HA0	M3
GND	G5	GND	K6	HA1	M1
GND	G6	GND	K7	HA10	L1
GND	G7	GND	K8	HA2	M2
GND	G8	GND	K9	HA8	M1
GND	G9	GND	K10	HA9	M2
GND	G10	GND	K11	$\overline{HACK}$/HACK	J1
GND	G11	GND	L4	HAD0	M5
GND	H4	GND	L5	HAD1	P4
GND	H5	GND	L6	HAD2	N4
GND	H6	GND	L7	HAD3	P3
GND	H7	GND	L8	HAD4	N3
GND	H8	GND	L9	HAD5	P2
GND	H9	GND	L10	HAD6	N1
GND	H10	GND	L11	HAD7	N2
GND	H11	GND_P	N6	$\overline{HAS}$/HAS	M3
GND	J4	GND_{P1}	P6	$\overline{HCS}$/HCS	L1
GND	J5	H0	M5	$\overline{HDS}$/HDS	J3
GND	J6	H1	P4	$\overline{HRD}$/HRD	J2
GND	J7	H2	N4	$\overline{HREQ}$/HREQ	K2
GND	J8	H3	P3	$\overline{HRRQ}$/HRRQ	J1

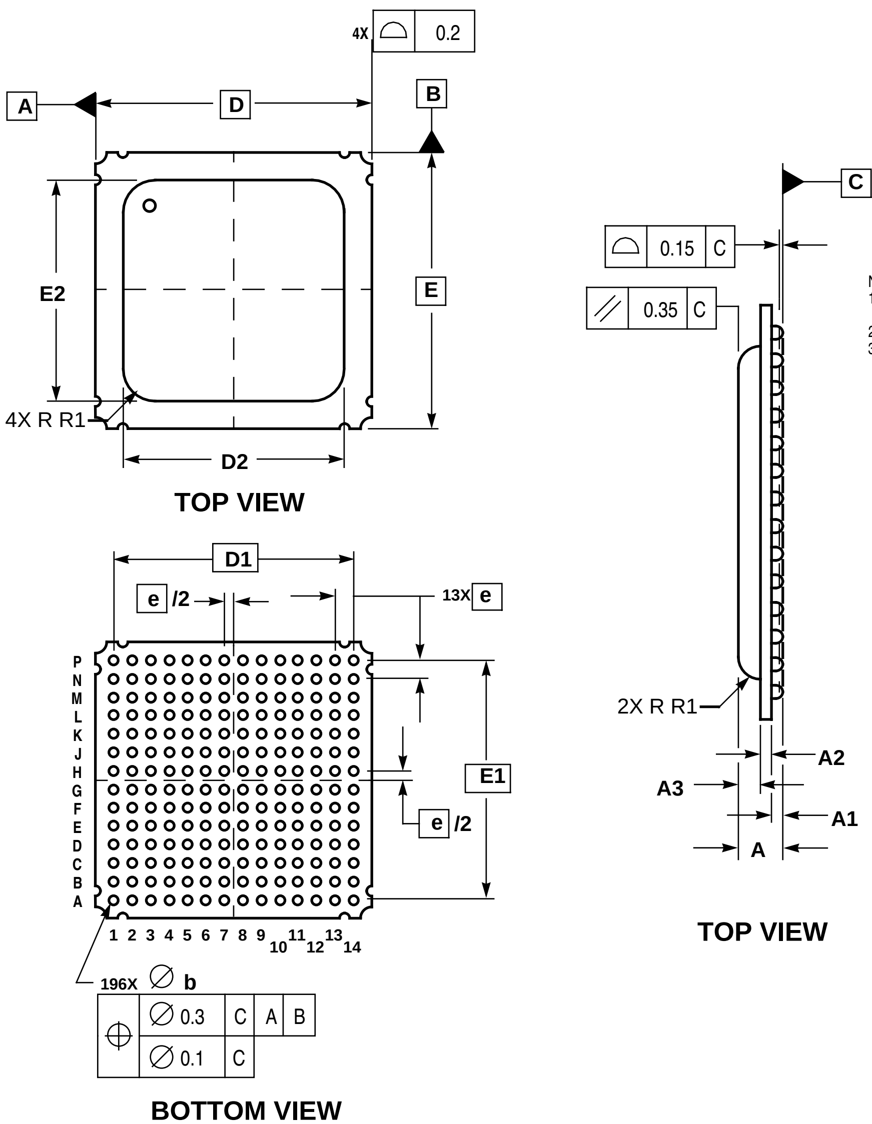
Table 3-4 DSP56304 PBGA Signal Identification by Name (Continued)

Signal Name	Pin No.	Signal Name	Pin No.	Signal Name	Pin No.
HRW	J2	PB14	K2	PE2	G2
$\overline{\text{HTRQ}}$/HTRQ	K2	PB15	J1	PINIT	D1
$\overline{\text{HWR}}$/HWR	J3	PB2	N4	$\overline{\text{RAS0}}$	N13
$\overline{\text{IRQA}}$	C4	PB3	P3	$\overline{\text{RAS1}}$	P12
$\overline{\text{IRQB}}$	A5	PB4	N3	$\overline{\text{RAS2}}$	P7
$\overline{\text{IRQC}}$	C5	PB5	P2	$\overline{\text{RAS3}}$	N7
$\overline{\text{IRQD}}$	B5	PB6	N1	$\overline{\text{RD}}$	M12
MODA	C4	PB7	N2	$\overline{\text{RESET}}$	N5
MODB	A5	PB8	M3	RXD	F1
MODC	C5	PB9	M1	SC00	F3
MODD	B5	PC0	F3	SC01	D2
NC	A1	PC1	D2	SC02	C1
NC	A14	PC2	C1	SC10	F2
NC	B14	PC3	H3	SC11	A2
NC	H1	PC4	E3	SC12	B2
NC	M7	PC5	E1	SCK0	H3
NC	P1	PCAP	P5	SCK1	G1
NC	P14	PD0	F2	SCLK	G2
$\overline{\text{NMI}}$	D1	PD1	A2	SRD0	E3
PB0	M5	PD2	B2	SRD1	B1
PB1	P4	PD3	G1	STD0	E1
PB10	M2	PD4	B1	STD1	C2
PB11	J2	PD5	C2	$\overline{\text{TA}}$	P10
PB12	J3	PE0	F1	TCK	C3
PB13	L1	PE1	G3	TDI	B3

Table 3-4 DSP56304 PBGA Signal Identification by Name (Continued)

Signal Name	Pin No.	Signal Name	Pin No.	Signal Name	Pin No.
TDO	A4	V_{CCA}	K12	V_{CCP}	M6
TIO0	L3	V_{CCA}	L12	V_{CCQ}	C7
TIO1	L2	V_{CCC}	N12	V_{CCQ}	G13
TIO2	K3	V_{CCC}	P9	V_{CCQ}	H2
TMS	A3	V_{CCD}	A7	V_{CCQ}	N9
$\overline{TRST}$	B4	V_{CCD}	C9	V_{CCS}	E2
TXD	G3	V_{CCD}	C11	V_{CCS}	K1
V_{CCA}	F12	V_{CCD}	D14	$\overline{WR}$	M11
V_{CCA}	H12	V_{CCH}	M4	XTAL	P8

PBGA Package Mechanical Drawing



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. DIMENSIONS IN MILLIMETERS.
3. DIMENSION b IS THE SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM C.

	MILLIMETERS	
DIM	MIN	MAX
A	1.32	1.75
A1	0.27	0.47
A2	0.30	0.40
A3	0.75	0.88
b	0.35	0.65
D	15.00 BSC	
D1	13.00 BSC	
D2	12.00	15.00
E	15.00 BSC	
E1	13.00 BSC	
E2	12.00	15.00
e	1.00 BSC	
R1	—	2.00

CASE 1128-01

Figure 3-6 DSP56304 Mechanical Information, 196-pin PBGA Package

ORDERING DRAWINGS

All devices manufactured by Motorola conform to current JEDEC standards. Complete mechanical information regarding DSP56304 packaging is available by facsimile through Motorola's Mfax™ system. Call the following number to obtain information by facsimile:

(602) 244-6591

The Mfax automated system requests the following information:

- The receiving facsimile telephone number including area code or country code
- The caller’s Personal Identification Number (PIN)

Note: For first time callers, the system provides instructions for setting up a PIN, which requires entry of a name and telephone number.

- The type of information requested:
  - Instructions for using the system
  - A literature order form
  - Specific part technical information or data sheets
  - Other information described by the system messages

A total of three documents may be ordered per call.

The DSP56304 144-pin TQFP package mechanical drawing is referenced as 918-03. The reference number for the 196-pin PBGA package is 1128-01.

SECTION 4

DESIGN CONSIDERATIONS

THERMAL DESIGN CONSIDERATIONS

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

Equation 1: $T_J = T_A + (P_D \times R_{\theta JA})$

Where:

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

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

Equation 2: $R_{\theta JA} = R_{\theta JC} + R_{\theta CA}$

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, or otherwise change the thermal dissipation capability of the area surrounding the device on a printed circuit board. 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 printed circuit board, 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 printed circuit board 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.
- 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 Ψ_{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 protective circuitry to guard against damage due to high static voltage or electrical fields. However, normal precautions are advised to avoid application of any voltages higher than maximum rated voltages to this high-impedance circuit. Reliability of operation is enhanced if unused inputs are tied to an appropriate logic voltage level (e.g., either GND or V_{CC}).

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 µF 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 0.5 in per capacitor lead.
- Use at least a four-layer Printed Circuit Board (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 $\overline{IRQA}$, $\overline{IRQB}$, $\overline{IRQC}$, $\overline{IRQD}$, $\overline{TA}$, and $\overline{BG}$ pins. Maximum PCB trace lengths on the order of 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 ($\overline{TRST}$, TMS, $\overline{DE}$).

- Take special care to minimize noise levels on the V_{CCP}, GND_P, and GND_{P1} pins.
- The following pins must be asserted after power-up: $\overline{RESET}$ and $\overline{TRST}$ (See note 4 in **Table 2-7**).
- If multiple DSP56304 devices are on the same board, check for cross-talk or excessive spikes on the supplies due to synchronous operation of the devices.

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 formula:

Equation 3: $I = C \times V \times f$

where: C = node/pin capacitance
V = voltage swing
f = frequency of node/pin toggle

Example 4-1 Current Consumption

For a Port A address pin loaded with 50 pF capacitance, operating at 3.3 V, and with a 66 MHz clock, toggling at its maximum possible rate (33 MHz), the current consumption is:

Equation 4: $I = 50 \times 10^{-12} \times 3.3 \times 33 \times 10^{6} = 5.48 \text{ mA}$

The Maximum Internal Current (I_{CCI}max) 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_{CCItyp}) value reflects the average switching of the internal buses on typical operating conditions.

For applications that require very low current consumption:

- 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. Unused output pins may be left unconnected. Unused GPIO pins may either be connected to pull-up or pull-down resistors, or defined as outputs and left unconnected.
- Disable unused peripherals.
- Disable unused pin activity (e.g., CLKOUT, XTAL).

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:

Equation 5: $I/MIPS = I/MHz = (I_{typF2} - I_{typF1})/(F2 - F1)$

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 Skew Performance

The phase skew of the PLL is defined as the time difference between the falling edges of EXTAL and CLKOUT for a given capacitive load on CLKOUT, over the entire process, temperature and voltage ranges. As defined in **Figure 2-2** on page 2-7, for input frequencies greater than 15 MHz and the MF ≤ 4, this skew is greater than or equal to 0.0 ns and less than 1.8 ns; otherwise, this skew is not guaranteed. However, for MF < 10 and input frequencies greater than 10 MHz, this skew is between –1.4 ns and +3.2 ns.

Phase Jitter Performance

The phase jitter of the PLL is defined as the variations in the skew between the falling edges of EXTAL and CLKOUT for a given device in specific temperature, voltage, input frequency, MF, and capacitive load on CLKOUT. These variations are a result of the PLL locking mechanism. For input frequencies greater than 15 MHz and MF ≤ 4, this jitter is less than ±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 ±2 ns.

Frequency Jitter Performance

The frequency jitter of the PLL is defined as the variation of the frequency of CLKOUT. 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.

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
DSP56304	3 V	Thin Quad Flat Pack (TQFP)	144	66	DSP56304PV66
DSP56304	3 V	Thin Quad Flat Pack (TQFP)	144	80	DSP56304PV80
DSP56304	3 V	Plastic Ball Grid Array (PBGA)	196	66	DSP56304GC66
DSP56304	3 V	Plastic Ball Grid Array (PBGA)	196	80	DSP56304GC80

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 (MAC) 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)
; Area 2 : 0 w.s (SSRAM)
; 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

;***************************************************************************
;
;     EQUATES for DSP56304 I/O registers and ports
;
;     Last update: June 11 1995
;
;***************************************************************************

          page      132,55,0,0,0
          opt       mex

ioequ   ident   1,0

;-------------------------------------------------------------------------
;
;       EQUATES for I/O Port Programming
;
;-------------------------------------------------------------------------

;       Register Addresses

M_HDR EQU $FFFFC9    ; Host port GPIO data Register
M_HDDR EQU $FFFFC8   ; Host port GPIO direction Register
```

```
M_PCRC EQU $FFFFBF   ; Port C Control Register
M_PRRC EQU $FFFFBE         ; Port C Direction Register
M_PDRC EQU $FFFFBD         ; Port C GPIO Data Register
M_PCRD EQU $FFFFAF         ; Port D Control register
M_PRRD EQU $FFFFAE         ; Port D Direction Data Register
M_PDRD EQU $FFFFAD         ; Port D GPIO Data Register
M_PCRE EQU $FFFF9F         ; Port E Control register
M_PRRE EQU $FFFF9E         ; Port E Direction Register
M_PDRE EQU $FFFF9D         ; Port E Data Register
M_OGDB EQU $FFFFFC         ; OnCE GDB Register


;------------------------------------------------------------------------
;
;       EQUATES for Host Interface
;
;------------------------------------------------------------------------

;       Register Addresses

M_HCR EQU $FFFFC2              ; Host Control Register
M_HSR EQU $FFFFC3              ; Host Status Rgister
M_HPCR EQU $FFFFC4             ; Host Polarity Control Register
M_HBAR EQU $FFFFC5             ; Host Base Address Register
M_HRX EQU $FFFFC6              ; Host Receive Register
M_HTX EQU $FFFFC7              ; Host Transmit Register

;       HCR bits definition
M_HRIE EQU $0                  ; Host Receive interrupts Enable
M_HTIE EQU $1                  ; Host Transmit Interrupt Enable
M_HCIE EQU $2                  ; Host Command Interrupt Enable
M_HF2 EQU $3                   ; Host Flag 2
M_HF3 EQU $4                   ; Host Flag 3

;       HSR bits definition
M_HRDF EQU $0                  ; Host Receive Data Full
M_HTDE EQU $1                  ; Host Receive Data Emptiy
M_HCP EQU $2                   ; Host Command Pending
M_HF0 EQU $3                   ; Host Flag 0
M_HF1 EQU $4                   ; Host Flag 1


;       HPCR bits definition
M_HGEN EQU $0                  ; Host Port GPIO Enable
M_HA8EN EQU $1                 ; Host Address 8 Enable
M_HA9EN EQU $2                 ; Host Address 9 Enable
M_HCSEN EQU $3                 ; Host Chip Select Enable
M_HREN EQU $4                  ; Host Request Enable
M_HAEN EQU $5                  ; Host Acknowledge Enable
M_HEN EQU $6                   ; Host Enable
M_HOD EQU $8                   ; Host Request Open Drain mode
M_HDSP EQU $9                  ; Host Data Strobe Polarity
M_HASP EQU $A                  ; Host Address Strobe Polarity
```

```
M_HMUX EQU $B                  ; Host Multiplexed bus select
M_HD_HS EQU $C                 ; Host Double/Single Strobe select
M_HCSP EQU $D                  ; Host Chip Select Polarity
M_HRP EQU $E                   ; Host Request PolarityPolarity
M_HAP EQU $F                   ; Host Acknowledge Polarity


;------------------------------------------------------------------------
;
;       EQUATES for Serial Communications Interface (SCI)
;
;------------------------------------------------------------------------

;       Register Addresses

M_STXH EQU $FFFF97             ; SCI Transmit Data Register (high)
M_STXM EQU $FFFF96             ; SCI Transmit Data Register (middle)
M_STXL EQU $FFFF95             ; SCI Transmit Data Register (low)
M_SRXH EQU $FFFF9A             ; SCI Receive Data Register (high)
M_SRXM EQU $FFFF99             ; SCI Receive Data Register (middle)
M_SRXL EQU $FFFF98             ; SCI Receive Data Register (low)
M_STXA EQU $FFFF94             ; SCI Transmit Address Register
M_SCR EQU $FFFF9C              ; SCI Control Register
M_SSR EQU $FFFF93              ; SCI Status Register
M_SCCR EQU $FFFF9B             ; SCI Clock Control Register

;       SCI Control Register Bit Flags

M_WDS EQU $7                   ; Word Select Mask (WDS0-WDS3)
M_WDS0 EQU 0                   ; Word Select 0
M_WDS1 EQU 1                   ; Word Select 1
M_WDS2 EQU 2                   ; Word Select 2
M_SSFTD EQU 3                  ; SCI Shift Direction
M_SBK EQU 4                    ; Send Break
M_WAKE EQU 5                   ; Wakeup Mode Select
M_RWU EQU 6                    ; Receiver Wakeup Enable
M_WOMS EQU 7                   ; Wired-OR Mode Select
M_SCRE EQU 8                   ; SCI Receiver Enable
M_SCTE EQU 9                   ; SCI Transmitter Enable
M_ILIE EQU 10                  ; Idle Line Interrupt Enable
M_SCRIE EQU 11                 ; SCI Receive Interrupt Enable
M_SCTIE EQU 12                 ; SCI Transmit Interrupt Enable
M_TMIE EQU 13                  ; Timer Interrupt Enable
M_TIR EQU 14                   ; Timer Interrupt Rate
M_SCKP EQU 15                  ; SCI Clock Polarity
M_REIE EQU 16                  ; SCI Error Interrupt Enable (REIE)

;       SCI Status Register Bit Flags

M_TRNE EQU 0                   ; Transmitter Empty
M_TDRE EQU 1                   ; Transmit Data Register Empty
M_RDRF EQU 2                   ; Receive Data Register Full
M_IDLE EQU 3                   ; Idle Line Flag
```

```
M_OR EQU 4                     ; Overrun Error Flag
M_PE EQU 5                     ; Parity Error
M_FE EQU 6                     ; Framing Error Flag
M_R8 EQU 7                     ; Received Bit 8 (R8) Address

;       SCI Clock Control Registe
r

M_CD EQU $FFF                  ; Clock Divider Mask (CD0-CD11)
M_COD EQU 12                   ; Clock Out Divider
M_SCP EQU 13                   ; Clock Prescaler
M_RCM EQU 14                   ; Receive Clock Mode Source Bit
M_TCM EQU 15                   ; Transmit Clock Source Bit

;------------------------------------------------------------------------
;
;       EQUATES for Synchronous Serial Interface (SSI)
;
;------------------------------------------------------------------------

;
;       Register Addresses Of SSI0
M_TX00 EQU $FFFFBC             ; SSI0 Transmit Data Register 0
M_TX01 EQU $FFFFBB             ; SSIO Transmit Data Register 1
M_TX02 EQU $FFFFBA             ; SSIO Transmit Data Register 2
M_TSR0 EQU $FFFFB9             ; SSI0 Time Slot Register
M_RX0 EQU $FFFFB8              ; SSI0 Receive Data Register
M_SSISR0 EQU $FFFFB7           ; SSI0 Status Register
M_CRB0 EQU $FFFFB6             ; SSI0 Control Register B
M_CRA0 EQU $FFFFB5             ; SSI0 Control Register A
M_TSMA0 EQU $FFFFB4            ; SSI0 Transmit Slot Mask Register A
M_TSMB0 EQU $FFFFB3            ; SSI0 Transmit Slot Mask Register B
M_RSMA0 EQU $FFFFB2            ; SSI0 Receive Slot Mask Register A
M_RSMB0 EQU $FFFFB1            ; SSI0 Receive Slot Mask Register B

;       Register Addresses Of SSI1
M_TX10 EQU $FFFFAC             ; SSI1 Transmit Data Register 0
M_TX11 EQU $FFFFAB             ; SSI1 Transmit Data Register 1
M_TX12 EQU $FFFFAA             ; SSI1 Transmit Data Register 2
M_TSR1 EQU $FFFFA9             ; SSI1 Time Slot Register
M_RX1 EQU $FFFFA8              ; SSI1 Receive Data Register
M_SSISR1 EQU $FFFFA7           ; SSI1 Status Register
M_CRB1 EQU $FFFFA6             ; SSI1 Control Register B
M_CRA1 EQU $FFFFA5             ; SSI1 Control Register A
M_TSMA1 EQU $FFFFA4            ; SSI1 Transmit Slot Mask Register A
M_TSMB1 EQU $FFFFA3            ; SSI1 Transmit Slot Mask Register B
M_RSMA1 EQU $FFFFA2            ; SSI1 Receive Slot Mask Register A
M_RSMB1 EQU $FFFFA1            ; SSI1 Receive Slot Mask Register B

;       SSI Control Register A Bit Flags

M_PM EQU $FF                   ; Prescale Modulus Select Mask (PM0-PM7)
M_PSR EQU 11                   ; Prescaler Range
```

Preliminary Data

```
M_DC EQU $1F000              ; Frame Rate Divider Control Mask (DC0-DC7)
M_ALC EQU 18                 ; Alignment Control (ALC)
M_WL EQU $380000             ; Word Length Control Mask (WL0-WL7)
M_SSC1 EQU 22                ; Select SC1 as TR #0 drive enable (SSC1)

;       SSI Control Register B Bit Flags

M_OF EQU $3                  ; Serial Output Flag Mask
M_OF0 EQU 0                  ; Serial Output Flag 0
M_OF1 EQU 1                  ; Serial Output Flag 1
M_SCD EQU $1C                ; Serial Control Direction Mask
M_SCD0 EQU 2                 ; Serial Control 0 Direction
M_SCD1 EQU 3                 ; Serial Control 1 Direction
M_SCD2 EQU 4                 ; Serial Control 2 Direction
M_SCKD EQU 5                 ; Clock Source Direction
M_SHFD EQU 6                 ; Shift Direction
M_FSL EQU $180               ; Frame Sync Length Mask (FSL0-FSL1)
M_FSL0 EQU 7                 ; Frame Sync Length 0
M_FSL1 EQU 8                 ; Frame Sync Length 1
M_FSR EQU 9                  ; Frame Sync Relative Timing
M_FSP EQU 10                 ; Frame Sync Polarity
M_CKP EQU 11                 ; Clock Polarity
M_SYN EQU 12                 ; Sync/Async Control
M_MOD EQU 13                 ; SSI Mode Select
M_SSTE EQU $1C000            ; SSI Transmit enable Mask
M_SSTE2 EQU 14               ; SSI Transmit #2 Enable
M_SSTE1 EQU 15               ; SSI Transmit #1 Enable
M_SSTE0 EQU 16               ; SSI Transmit #0 Enable
M_SSRE EQU 17                ; SSI Receive Enable
M_SSTIE EQU 18               ; SSI Transmit Interrupt Enable
M_SSRIE EQU 19               ; SSI Receive Interrupt Enable
M_STLIE EQU 20               ; SSI Transmit Last Slot Interrupt Enable
M_SRLIE EQU 21               ; SSI Receive Last Slot Interrupt Enable
M_STEIE EQU 22               ; SSI Transmit Error Interrupt Enable
M_SREIE EQU 23               ; SI Receive Error Interrupt Enable

;       SSI Status Register Bit Flags

M_IF EQU $3                  ; Serial Input Flag Mask
M_IF0 EQU 0                  ; Serial Input Flag 0
M_IF1 EQU 1                  ; Serial Input Flag 1
M_TFS EQU 2                  ; Transmit Frame Sync Flag
M_RFS EQU 3                  ; Receive Frame Sync Flag
M_TUE EQU 4                  ; Transmitter Underrun Error FLag
M_ROE EQU 5                  ; Receiver Overrun Error Flag
M_TDE EQU 6                  ; Transmit Data Register Empty
M_RDF EQU 7                  ; Receive Data Register Full

;       SSI Transmit Slot Mask Register A

M_SSTSA EQU $FFFF            ; SSI Transmit Slot Bits Mask A (TS0-TS15)

;       SSI Transmit Slot Mask Register B
```

```
M_SSTSB EQU $FFFF              ; SSI Transmit Slot Bits Mask B (TS16-TS31)

;       SSI Receive Slot Mask Register A

M_SSRSA EQU $FFFF              ; SSI Receive Slot Bits Mask A (RS0-RS15)

;       SSI Receive Slot Mask Register B

M_SSRSB EQU $FFFF              ; SSI Receive Slot Bits Mask B (RS16-RS31)


;------------------------------------------------------------------------
;
;       EQUATES for Exception Processing
;
;------------------------------------------------------------------------


;       Register Addresses

M_IPRC EQU $FFFFFF             ; Interrupt Priority Register Core
M_IPRP EQU $FFFFFE             ; Interrupt Priority Register Peripheral

;       Interrupt Priority Register Core (IPRC)

M_IAL EQU $7                   ; IRQA Mode Mask
M_IAL0 EQU 0                   ; IRQA Mode Interrupt Priority Level (low)
M_IAL1 EQU 1                   ; IRQA Mode Interrupt Priority Level (high)
M_IAL2 EQU 2                   ; IRQA Mode Trigger Mode
M_IBL EQU $38                  ; IRQB Mode Mask
M_IBL0 EQU 3                   ; IRQB Mode Interrupt Priority Level (low)
M_IBL1 EQU 4                   ; IRQB Mode Interrupt Priority Level (high)
M_IBL2 EQU 5                   ; IRQB Mode Trigger Mode
M_ICL EQU $1C0                 ; IRQC Mode Mask
M_ICL0 EQU 6                   ; IRQC Mode Interrupt Priority Level (low)
M_ICL1 EQU 7                   ; IRQC Mode Interrupt Priority Level (high)
M_ICL2 EQU 8                   ; IRQC Mode Trigger Mode
M_IDL EQU $E00                 ; IRQD Mode Mask
M_IDL0 EQU 9                   ; IRQD Mode Interrupt Priority Level (low)
M_IDL1 EQU 10                  ; IRQD Mode Interrupt Priority Level (high)
M_IDL2 EQU 11                  ; IRQD Mode Trigger Mode
M_D0L EQU $3000                ; DMA0 Interrupt priority Level Mask
M_D0L0 EQU 12                  ; DMA0 Interrupt Priority Level (low)
M_D0L1 EQU 13                  ; DMA0 Interrupt Priority Level (high)
M_D1L EQU $C000                ; DMA1 Interrupt Priority Level Mask
M_D1L0 EQU 14                  ; DMA1 Interrupt Priority Level (low)
M_D1L1 EQU 15                  ; DMA1 Interrupt Priority Level (high)
M_D2L EQU $30000               ; DMA2 Interrupt priority Level Mask
M_D2L0 EQU 16                  ; DMA2 Interrupt Priority Level (low)
M_D2L1 EQU 17                  ; DMA2 Interrupt Priority Level (high)
M_D3L EQU $C0000               ; DMA3 Interrupt Priority Level Mask
```

```
M_D3L0 EQU 18                  ; DMA3 Interrupt Priority Level (low)
M_D3L1 EQU 19                  ; DMA3 Interrupt Priority Level (high)
M_D4L EQU $300000              ; DMA4 Interrupt priority Level Mask
M_D4L0 EQU 20                  ; DMA4 Interrupt Priority Level (low)
M_D4L1 EQU 21                  ; DMA4 Interrupt Priority Level (high)
M_D5L EQU $C00000              ; DMA5 Interrupt priority Level Mask
M_D5L0 EQU 22                  ; DMA5 Interrupt Priority Level (low)
M_D5L1 EQU 23                  ; DMA5 Interrupt Priority Level (high)


;       Interrupt Priority Register Peripheral (IPRP)

M_HPL EQU $3                   ; Host Interrupt Priority Level Mask
M_HPL0 EQU 0                   ; Host Interrupt Priority Level (low)
M_HPL1 EQU 1                   ; Host Interrupt Priority Level (high)
M_S0L EQU $C                   ; SSI0 Interrupt Priority Level Mask
M_S0L0 EQU 2                   ; SSI0 Interrupt Priority Level (low)
M_S0L1 EQU 3                   ; SSI0 Interrupt Priority Level (high)
M_S1L EQU $30                  ; SSI1 Interrupt Priority Level Mask
M_S1L0 EQU 4                   ; SSI1 Interrupt Priority Level (low)
M_S1L1 EQU 5                   ; SSI1 Interrupt Priority Level (high)
M_SCL EQU $C0                  ; SCI  Interrupt Priority Level  Mask
M_SCL0 EQU 6                   ; SCI  Interrupt Priority Level  (low)
M_SCL1 EQU 7                   ; SCI  Interrupt Priority Level  (high)
M_T0L EQU $300                 ; TIMER Interrupt Priority Level Mask
M_T0L0 EQU 8                   ; TIMER Interrupt Priority Level (low)
M_T0L1 EQU 9                   ; TIMER Interrupt Priority Level (high)


;------------------------------------------------------------------------
;
;       EQUATES for TIMER
;
;------------------------------------------------------------------------

;       Register Addresses Of TIMER0

M_TCSR0 EQU $FFFF8F            ; Timer 0 Control/Status Register
M_TLR0 EQU  $FFFF8E            ; TIMER0 Load Reg
M_TCPR0 EQU $FFFF8D            ; TIMER0 Compare Register
M_TCR0 EQU  $FFFF8C            ; TIMER0 Count Register

;       Register Addresses Of TIMER1

M_TCSR1 EQU $FFFF8B            ; TIMER1 Control/Status Register
M_TLR1 EQU  $FFFF8A            ; TIMER1 Load Reg
M_TCPR1 EQU $FFFF89            ; TIMER1 Compare Register
M_TCR1 EQU  $FFFF88            ; TIMER1 Count Register


;       Register Addresses Of TIMER2

M_TCSR2 EQU $FFFF87            ; TIMER2 Control/Status Register
```

```
M_TLR2 EQU  $FFFF86                      ; TIMER2 Load Reg
M_TCPR2 EQU $FFFF85 ; TIMER2 Compare Register
M_TCR2 EQU  $FFFF84                      ; TIMER2 Count Register
M_TPLR EQU  $FFFF83                      ; TIMER Prescaler Load Register
M_TPCR EQU  $FFFF82                      ; TIMER Prescalar Count Register


;      Timer Control/Status Register Bit Flags

M_TE EQU 0           ; Timer Enable
M_TOIE EQU 1         ; Timer Overflow Interrupt Enable
M_TCIE EQU 2         ; Timer Compare Interrupt Enable
M_TC EQU $F0         ; Timer Control Mask (TC0-TC3)
M_INV EQU 8          ; Inverter Bit
M_TRM EQU 9          ; Timer Restart Mode
M_DIR EQU 11         ; Direction Bit
M_DI EQU 12          ; Data Input
M_DO EQU 13          ; Data Output
M_PCE EQU  15        ; Prescaled Clock Enable
M_TOF EQU 20         ; Timer Overflow Flag
M_TCF EQU 21         ; Timer Compare Flag

;       Timer Prescaler Register Bit Flags

M_PS EQU  $600000    ; Prescaler Source Mask
M_PS0 EQU  21
M_PS1 EQU  22

;          Timer Control Bits
M_TC0 EQU 4          ; Timer Control 0
M_TC1 EQU 5          ; Timer Control 1
M_TC2 EQU 6          ; Timer Control 2
M_TC3 EQU 7          ; Timer Control 3


;-------------------------------------------------------------------------
;
;       EQUATES for Direct Memory Access (DMA)
;
;-------------------------------------------------------------------------

;       Register Addresses Of DMA
M_DSTR EQU FFFFF4                        ; DMA Status Register
M_DOR0 EQU $FFFFF3   ; DMA Offset Register 0
M_DOR1 EQU $FFFFF2   ; DMA Offset Register 1
M_DOR2 EQU $FFFFF1   ; DMA Offset Register 2
M_DOR3 EQU $FFFFF0   ; DMA Offset Register 3


;       Register Addresses Of DMA0

M_DSR0 EQU $FFFFEF   ; DMA0 Source Address Register
M_DDR0 EQU $FFFFEE   ; DMA0 Destination Address Register
```

```
M_DCO0 EQU $FFFFED   ; DMA0 Counter
M_DCR0 EQU $FFFFEC   ; DMA0 Control Register

;       Register Addresses Of DMA1

M_DSR1 EQU $FFFFEB   ; DMA1 Source Address Register
M_DDR1 EQU $FFFFEA   ; DMA1 Destination Address Register
M_DCO1 EQU $FFFFE9   ; DMA1 Counter
M_DCR1 EQU $FFFFE8   ; DMA1 Control Register

;       Register Addresses Of DMA2

M_DSR2 EQU $FFFFE7   ; DMA2 Source Address Register
M_DDR2 EQU $FFFFE6   ; DMA2 Destination Address Register
M_DCO2 EQU $FFFFE5   ; DMA2 Counter
M_DCR2 EQU $FFFFE4   ; DMA2 Control Register

;       Register Addresses Of DMA4

M_DSR3 EQU $FFFFE3   ; DMA3 Source Address Register
M_DDR3 EQU $FFFFE2   ; DMA3 Destination Address Register
M_DCO3 EQU $FFFFE1   ; DMA3 Counter
M_DCR3 EQU $FFFFE0   ; DMA3 Control Register

;       Register Addresses Of DMA4


M_DSR4 EQU $FFFFDF   ; DMA4 Source Address Register
M_DDR4 EQU $FFFFDE   ; DMA4 Destination Address Register
M_DCO4 EQU $FFFFDD   ; DMA4 Counter
M_DCR4 EQU $FFFFDC   ; DMA4 Control Register

;       Register Addresses Of DMA5

M_DSR5 EQU $FFFFDB   ; DMA5 Source Address Register
M_DDR5 EQU $FFFFDA   ; DMA5 Destination Address Register
M_DCO5 EQU $FFFFD9   ; DMA5 Counter
M_DCR5 EQU $FFFFD8   ; DMA5 Control Register

;         DMA Control Register

M_DSS EQU $3         ; DMA Source Space Mask (DSS0-Dss1)
M_DSS0 EQU 0         ; DMA Source Memory space 0
M_DSS1 EQU 1         ; DMA Source Memory space 1
M_DDS EQU $C         ; DMA Destination Space Mask (DDS-DDS1)
M_DDS0 EQU 2         ; DMA Destination Memory Space 0
M_DDS1 EQU 3         ; DMA Destination Memory Space 1
M_DAM EQU $3f0       ; DMA Address Mode Mask (DAM5-DAM0)
M_DAM0  EQU 4        ; DMA Address Mode 0
M_DAM1  EQU 5        ; DMA Address Mode 1
M_DAM2  EQU 6        ; DMA Address Mode 2
M_DAM3  EQU 7        ; DMA Address Mode 3
M_DAM4  EQU 8        ; DMA Address Mode 4
```

```
M_DAM5  EQU 9        ; DMA Address Mode 5
M_D3D EQU 10         ; DMA Three Dimensional Mode
M_DRS EQU $F800      ; DMA Request Source Mask (DRS0-DRS4)
M_DCON EQU 16        ; DMA Continuous Mode
M_DPR EQU $60000     ; DMA Channel Priority
M_DPR0 EQU 17        ; DMA Channel Priority Level (low)
M_DPR1 EQU 18        ; DMA Channel Priority Level (high)
M_DTM EQU $380000    ; DMA Transfer Mode Mask (DTM2-DTM0)
M_DTM0 EQU 19        ; DMA Transfer Mode 0
M_DTM1 EQU 20        ; DMA Transfer Mode 1
M_DTM2 EQU 21        ; DMA Transfer Mode 2
M_DIE EQU 22         ; DMA Interrupt Enable bit
M_DE EQU 23          ; DMA Channel Enable bit

;       DMA Status Register

M_DTD EQU $3F        ; Channel Transfer Done Status MASK (DTD0-DTD5)
M_DTD0 EQU 0         ; DMA Channel Transfer Done Status 0
M_DTD1 EQU 1         ; DMA Channel Transfer Done Status 1
M_DTD2 EQU 2         ; DMA Channel Transfer Done Status 2
M_DTD3 EQU 3         ; DMA Channel Transfer Done Status 3
M_DTD4 EQU 4         ; DMA Channel Transfer Done Status 4
M_DTD5 EQU 5         ; DMA Channel Transfer Done Status 5
M_DACT EQU  8        ; DMA Active State
M_DCH EQU  $E00      ; DMA Active Channel Mask (DCH0-DCH2)
M_DCH0 EQU  9        ; DMA Active Channel 0
M_DCH1 EQU  10       ; DMA Active Channel 1
M_DCH2 EQU  11       ; DMA Active Channel 2


;------------------------------------------------------------------------
;
;       EQUATES for Phase Locked Loop (PLL)
;
;------------------------------------------------------------------------

;       Register Addresses Of PLL

M_PCTL EQU $FFFFFD         ; PLL Control Register

;       PLL Control Register

M_MF EQU $FFF        : Multiplication Factor Bits Mask (MF0-MF11)
M_DF EQU $7000       ; Division Factor Bits Mask (DF0-DF2)
M_XTLR EQU 15        ; XTAL Range select bit
M_XTLD EQU 16        ; XTAL Disable Bit
M_PSTP EQU 17        ; STOP Processing State Bit
M_PEN EQU 18         ; PLL Enable Bit
M_PCOD EQU 19        ; PLL Clock Output Disable Bit
M_PD EQU $F00000     ; PreDivider Factor Bits Mask (PD0-PD3)
```

```
;--------------------------------------------------------------------------
;
;       EQUATES for BIU
;
;--------------------------------------------------------------------------

;       Register Addresses Of BIU


M_BCR EQU $FFFFFB    ; Bus Control Register
M_DCR EQU $FFFFFA    ; DRAM Control Register
M_AAR0 EQU $FFFFF9   ; Address Attribute Register 0
M_AAR1 EQU $FFFFF8   ; Address Attribute Register 1
M_AAR2 EQU $FFFFF7   ; Address Attribute Register 2
M_AAR3 EQU $FFFFF6   ; Address Attribute Register 3
M_IDR EQU  $FFFFF5   ; ID Register

;       Bus Control Register

M_BA0W EQU $1F       ; Area 0 Wait Control Mask (BA0W0-BA0W4)
M_BA1W EQU $3E0      ; Area 1 Wait Control Mask (BA1W0-BA14)
M_BA2W EQU $1C00     ; Area 2 Wait Control Mask (BA2W0-BA2W2)
M_BA3W EQU $E000     ; Area 3 Wait Control Mask (BA3W0-BA3W3)
M_BDFW EQU $1F0000   ; Default Area Wait Control Mask (BDFW0-BDFW4)
M_BBS EQU 21         ; Bus State
M_BLH EQU 22         ; Bus Lock Hold
M_BRH EQU 23         ; Bus Request Hold

;       DRAM Control Register

M_BCW EQU $3         ; In Page Wait States Bits Mask (BCW0-BCW1)
M_BRW EQU $C         ; Out Of Page Wait States Bits Mask (BRW0-BRW1)
M_BPS EQU $300       ; DRAM Page Size Bits Mask (BPS0-BPS1)
M_BPLE EQU 11        ; Page Logic Enable
M_BME EQU 12         ; Mastership Enable
M_BRE EQU 13         ; Refresh Enable
M_BSTR EQU 14        ; Software Triggered Refresh
M_BRF EQU $7F8000    ; Refresh Rate Bits Mask (BRF0-BRF7)
M_BRP EQU 23         ; Refresh prescaler

;       Address Attribute Registers

M_BAT EQU $3         ; Ext. Access Type and Pin Def. Bits Mask (BAT0-BAT1)
M_BAAP EQU 2         ; Address Attribute Pin Polarity
M_BPEN EQU 3         ; Program Space Enable
M_BXEN EQU 4         ; X Data Space Enable
M_BYEN EQU 5         ; Y Data Space Enable
M_BAM EQU 6          ; Address Muxing
M_BPAC EQU 7         ; Packing Enable
M_BNC EQU $F00       ; Number of Address Bits to Compare Mask (BNC0-BNC3)
M_BAC EQU $FFF000    ; Address to Compare Bits Mask (BAC0-BAC11)
```

```
;       control and status bits in SR

M_CP EQU $c00000     ; mask for CORE-DMA priority bits in SR
M_CA EQU 0           ; Carry
M_V EQU 1            ; Overflow
M_Z EQU 2            ; Zero
M_N EQU 3            ; Negative
M_U EQU 4            ; Unnormalized
M_E EQU 5            ; Extension
M_L EQU 6            ; Limit
M_S EQU 7            ; Scaling Bit
M_I0 EQU 8           ; Interupt Mask Bit 0
M_I1 EQU 9           ; Interupt Mask Bit 1
M_S0 EQU 10          ; Scaling Mode Bit 0
M_S1 EQU 11          ; Scaling Mode Bit 1
M_SC EQU 13          ; Sixteen_Bit Compatibility
M_DM EQU 14          ; Double Precision Multiply
M_LF EQU 15          ; DO-Loop Flag
M_FV EQU 16          ; DO-Forever Flag
M_SA EQU 17          ; Sixteen-Bit Arithmetic
M_CE EQU 19          ; Instruction Cache Enable
M_SM EQU 20          ; Arithmetic Saturation
M_RM EQU 21          ; Rounding Mode
M_CP0 EQU 22         ; bit 0 of priority bits in SR
M_CP1 EQU 23         ; bit 1 of priority bits in SR

;       control and status bits in OMR
M_CDP EQU $300       ; mask for CORE-DMA priority bits in OMR
M_MA    equ0         ; Operating Mode A
M_MB   equ1          ; Operating Mode B
M_MC    equ2         ; Operating Mode C
M_MD    equ3         ; Operating Mode D
M_EBD EQU 4          ; External Bus Disable bit in OMR
M_SD EQU 6           ; Stop Delay
M_MS EQU 7           ; Memory Switch bit in OMR
M_CDP0 EQU 8         ; bit 0 of priority bits in OMR
M_CDP1 EQU 9         ; bit 1 of priority bits in OMR
M_BEN   EQU 10       ; Burst Enable
M_TAS  EQU 11        ; TA Synchronize Select
M_BRT  EQU 12        ; Bus Release Timing
M_ATE EQU 15         ; Address Tracing Enable bit in OMR.
M_XYS EQU 16         ; Stack Extension space select bit in OMR.
M_EUN EQU 17         ; Extensed stack UNderflow flag in OMR.
M_EOV EQU 18         ; Extended stack OVerflow flag in OMR.
M_WRP EQU 19         ; Extended WRaP flag in OMR.
M_SEN EQU 20         ; Stack Extension Enable bit in OMR.
```

```
;*************************************************************************
;
;      EQUATES for DSP56304 interrupts
;
;      Last update: June 11 1995
;
;*************************************************************************

          page      132,55,0,0,0
          opt       mex

intequ  ident   1,0

          if        @DEF(I_VEC)
          ;leave user definition as is.
          else
I_VEC EQU $0
          endif

;------------------------------------------------------------------------
; Non-Maskable interrupts
;------------------------------------------------------------------------
I_RESET EQU I_VEC+$00          ; Hardware RESET
I_STACK EQU I_VEC+$02          ; Stack Error
I_ILL EQU I_VEC+$04            ; Illegal Instruction
I_DBG EQU I_VEC+$06            ; Debug Request
I_TRAP EQU I_VEC+$08           ; Trap
I_NMI EQU I_VEC+$0A            ; Non Maskable Interrupt

;------------------------------------------------------------------------
; Interrupt Request Pins
;------------------------------------------------------------------------
I_IRQA EQU I_VEC+$10           ; IRQA
I_IRQB EQU I_VEC+$12           ; IRQB
I_IRQC EQU I_VEC+$14           ; IRQC
I_IRQD EQU I_VEC+$16           ; IRQD

;------------------------------------------------------------------------
; DMA Interrupts
;------------------------------------------------------------------------
I_DMA0 EQU I_VEC+$18           ; DMA Channel 0
I_DMA1 EQU I_VEC+$1A           ; DMA Channel 1
I_DMA2 EQU I_VEC+$1C           ; DMA Channel 2
I_DMA3 EQU I_VEC+$1E           ; DMA Channel 3
I_DMA4 EQU I_VEC+$20           ; DMA Channel 4
I_DMA5 EQU I_VEC+$22           ; DMA Channel 5

;------------------------------------------------------------------------
; Timer Interrupts
;------------------------------------------------------------------------
I_TIM0C EQU I_VEC+$24          ; TIMER 0 compare
```

```
I_TIM0OF EQU I_VEC+$26          ; TIMER 0 overflow
I_TIM1C EQU I_VEC+$28           ; TIMER 1 compare
I_TIM1OF EQU I_VEC+$2A          ; TIMER 1 overflow
I_TIM2C EQU I_VEC+$2C           ; TIMER 2 compare
I_TIM2OF EQU I_VEC+$2E          ; TIMER 2 overflow

;-------------------------------------------------------------------------
; ESSI Interrupts
;-------------------------------------------------------------------------
I_SI0RD EQU I_VEC+$30           ; ESSI0 Receive Data
I_SI0RDE EQU I_VEC+$32          ; ESSI0 Receive Data w/ exception Status
I_SI0RLS EQU I_VEC+$34          ; ESSI0 Receive last slot
I_SI0TD EQU I_VEC+$36           ; ESSI0 Transmit data
I_SI0TDE EQU I_VEC+$38          ; ESSI0 Transmit Data w/ exception Status
I_SI0TLS EQU I_VEC+$3A          ; ESSI0 Transmit last slot
I_SI1RD EQU I_VEC+$40           ; ESSI1 Receive Data
I_SI1RDE EQU I_VEC+$42          ; ESSI1 Receive Data w/ exception Status
I_SI1RLS EQU I_VEC+$44          ; ESSI1 Receive last slot
I_SI1TD EQU I_VEC+$46           ; ESSI1 Transmit data
I_SI1TDE EQU I_VEC+$48          ; ESSI1 Transmit Data w/ exception Status
I_SI1TLS EQU I_VEC+$4A          ; ESSI1 Transmit last slot

;-------------------------------------------------------------------------
; SCI Interrupts
;-------------------------------------------------------------------------
I_SCIRD EQU I_VEC+$50           ; SCI Receive Data
I_SCIRDE EQU I_VEC+$52          ; SCI Receive Data With Exception Status
I_SCITD EQU I_VEC+$54           ; SCI Transmit Data
I_SCIIL EQU I_VEC+$56           ; SCI Idle Line
I_SCITM EQU I_VEC+$58           ; SCI Timer

;-------------------------------------------------------------------------
; HOST Interrupts
;-------------------------------------------------------------------------
I_HRDF EQU I_VEC+$60            ; Host Receive Data Full
I_HTDE EQU I_VEC+$62            ; Host Transmit Data Empty
I_HC EQU I_VEC+$64              ; Default Host Command

;-------------------------------------------------------------------------
; INTERRUPT ENDING ADDRESS
;-------------------------------------------------------------------------
I_INTEND EQU I_VEC+$FF          ; last address of interrupt vector space
```

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Preliminary Data

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