



PRELIMINARY

## 80960JA/JF EMBEDDED 32-BIT MICROPROCESSOR

- Pin/Code Compatible with all 80960Jx Processors
- High-Performance Embedded Architecture
  - One Instruction/Clock Execution
  - Load/Store Programming Model
  - Sixteen 32-Bit Global Registers
  - Sixteen 32-Bit Local Registers (8 sets)
  - Nine Addressing Modes
  - User/Supervisor Protection Model
- Two-Way Set Associative Instruction Cache
  - 80960JA - 2 Kbyte
  - 80960JF - 4 Kbyte
  - Programmable Cache Locking Mechanism
- Direct Mapped Data Cache
  - 80960JA - 1 Kbyte
  - 80960JF - 2 Kbyte
  - Write Through Operation
- On-Chip Stack Frame Cache
  - Seven Register Sets Can Be Saved
  - Automatic Allocation on Call/Return
  - 0-7 Frames Reserved for High-Priority Interrupts
- On-Chip Data RAM
  - 1 Kbyte Critical Variable Storage
  - Single-Cycle Access
- High Bandwidth Burst Bus
  - 32-Bit Multiplexed Address/Data
  - Programmable Memory Configuration
  - Selectable 8-, 16-, 32-Bit Bus Widths
  - Supports Unaligned Accesses
  - Big or Little Endian Byte Ordering
- New Instructions
  - Conditional Add, Subtract and Select
  - Processor Management
- High-Speed Interrupt Controller
  - 31 Programmable Priorities
  - Eight Maskable Pins plus NMI
  - Up to 240 Vectors in Expanded Mode
- Two On-Chip Timers
  - Independent 32-Bit Counting
  - Clock Prescaling by 1, 2, 4 or 8
  - Internal Interrupt Sources
- Halt Mode for Low Power
- IEEE 1149.1 (JTAG) Boundary Scan Compatibility
- Packages
  - 132-Lead Pin Grid Array (PGA)
  - 132-Lead Plastic Quad Flat Pack (PQFP)

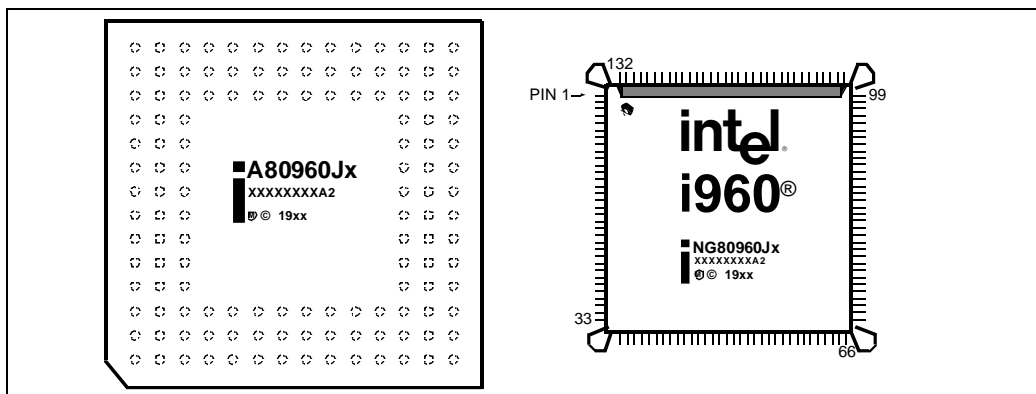


Figure 1. 80960JA/JF Microprocessors



## 80960JA/JF EMBEDDED 32-BIT MICROPROCESSOR

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## 1.0 PURPOSE

This document contains preliminary information for the 80960JA/JF microprocessor, including electrical characteristics and package pinout information. Detailed functional descriptions — other than parametric performance — are published in the *i960® Jx Microprocessor User's Guide (272483)*.

Throughout this data sheet, references to “80960Jx” indicate features which apply to all of the following:

- 80960JA — 5V, 2 Kbyte instruction cache, 1 Kbyte data cache
- 80960JF — 5V, 4 Kbyte instruction cache, 2 Kbyte data cache
- 80960JD — 5V, 4 Kbyte instruction cache, 2 Kbyte data cache and clock doubling
- 80L960JA — 3.3 V version of the 80960JA
- 80L960JF — 3.3 V version of the 80960JF

## 2.0 80960JA/JF OVERVIEW

The 80960JA/JF offers high performance to cost-sensitive 32-bit embedded applications. The 80960JA/JF is object code compatible with the 80960 Core Architecture and is capable of sustained execution at the rate of one instruction per clock. This processor's features include generous instruction cache, data cache and data RAM. It also boasts a fast interrupt mechanism, dual programmable timer units and new instructions.

Memory subsystems for cost-sensitive embedded applications often impose substantial wait state penalties. The 80960JA/JF integrates considerable storage resources on-chip to decouple CPU execution from the external bus.

The 80960JA/JF rapidly allocates and deallocates local register sets during context switches. The processor needs to flush a register set to the stack only when it saves more than seven sets to its local register cache.

A 32-bit multiplexed burst bus provides a high-speed interface to system memory and I/O. A full complement of control signals simplifies the connection of the 80960JA/JF to external components. The user programs physical and logical memory attributes through memory-mapped control registers (MMRs) — an extension not found on the i960 Kx, Sx or Cx processors. Physical and logical

configuration registers enable the processor to operate with all combinations of bus width and data object alignment. The processor supports a homogeneous byte ordering model.

This processor integrates two important peripherals: a timer unit and an interrupt controller. These and other hardware resources are programmed through memory-mapped control registers, an extension to the familiar 80960 architecture.

The timer unit (TU) offers two independent 32-bit timers for use as real-time system clocks and general-purpose system timing. These operate in either single-shot or auto-reload mode and can generate interrupts.

The interrupt controller unit (ICU) provides a flexible, low-latency means for requesting interrupts. The ICU provides full programmability of up to 240 interrupt sources into 31 priority levels. The ICU takes advantage of a cached priority table and optional routine caching to minimize interrupt latency. Local registers may be dedicated to high-priority interrupts to further reduce latency. Acting independently from the core, the ICU compares the priorities of posted interrupts with the current process priority, off-loading this task from the core. The ICU also supports the integrated timer interrupts.

The 80960JA/JF features a Halt mode designed to support applications where low power consumption is critical. The **halt** instruction shuts down instruction execution, resulting in a power savings of up to 90 percent.

The 80960JA/JF's testability features, including ONCE (On-Circuit Emulation) mode and Boundary Scan (JTAG), provide a powerful environment for design debug and fault diagnosis.

The *Solutions960®* program features a wide variety of development tools which support the i960 processor family. Many of these tools are developed by partner companies; some are developed by Intel, such as profile-driven optimizing compilers. For more information on these products, contact your local Intel representative.

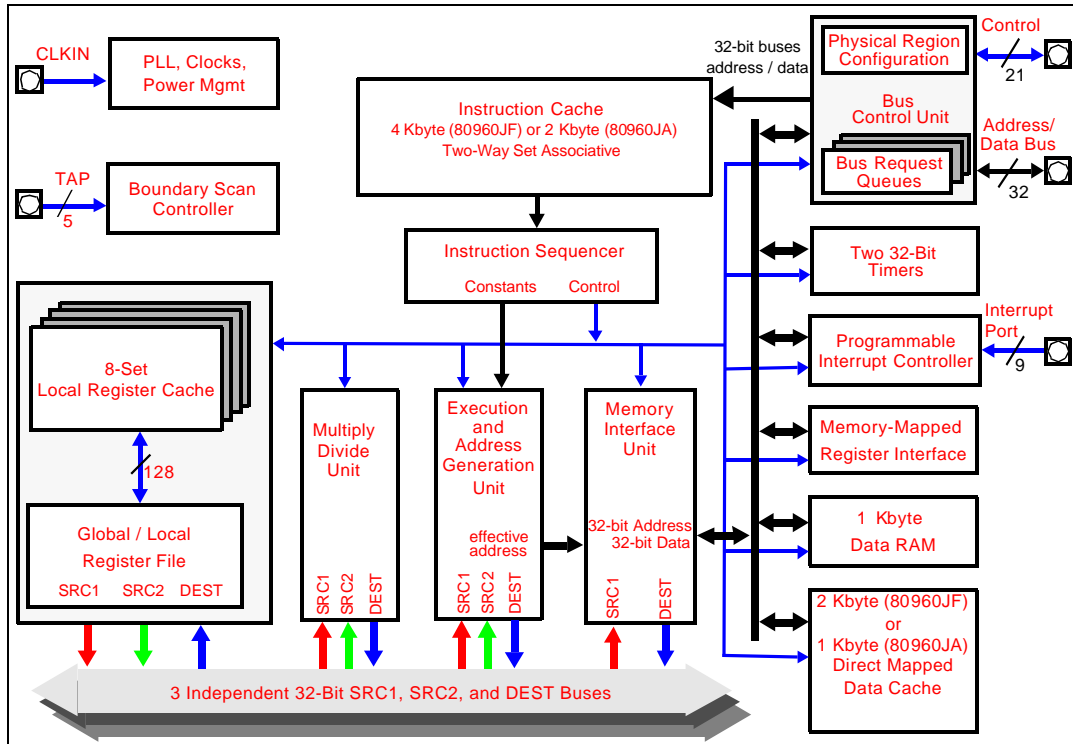


Figure 2. 80960JA/JF Block Diagram

## 2.1 80960 Processor Core

The 80960Jx family is a scalar implementation of the 80960 Core Architecture. Intel designed this processor core as a very high performance device that is also cost-effective. Factors that contribute to the core's performance include:

- Single-clock execution of most instructions
- Independent Multiply/Divide Unit
- Efficient instruction pipeline minimizes pipeline break latency
- Register and resource scoreboarding allow overlapped instruction execution
- 128-bit register bus speeds local register caching

- Two-way set associative, integrated instruction cache
- Direct-mapped, integrated data cache
- 1 Kbyte integrated data RAM delivers zero wait state program data

## 2.2 Burst Bus

A 32-bit high-performance bus controller interfaces the 80960JA/JF to external memory and peripherals. The BCU fetches instructions and transfers data at the rate of up to four 32-bit words per six clock cycles. The external address/data bus is multiplexed.

Users may configure the 80960JA/JF's bus controller to match an application's fundamental memory organization. Physical bus width is register-programmed for up to eight regions. Byte ordering and data caching are programmed through a group of logical memory templates and a defaults register.

The BCU's features include:

- Multiplexed external bus to minimize pin count
- 32-, 16- and 8-bit bus widths to simplify I/O interfaces
- External ready control for address-to-data, data-to-data and data-to-next-address wait state types
- Support for big or little endian byte ordering to facilitate the porting of existing program code
- Unaligned bus accesses performed transparently
- Three-deep load/store queue to decouple the bus from the core

Upon reset, the 80960JA/JF conducts an internal self test. Then, before executing its first instruction, it performs an external bus confidence test by performing a checksum on the first words of the initialization boot record (IBR).

The user may examine the contents of the caches at any time by executing special cache control instructions.

### 2.3 Timer Unit

The timer unit (TU) contains two independent 32-bit timers which are capable of counting at several clock rates and generating interrupts. Each is programmed by use of the TU registers. These memory-mapped registers are addressable on 32-bit boundaries. The timers have a single-shot mode and auto-reload capabilities for continuous operation. Each timer has an independent interrupt request to the interrupt controller. The TU can generate a fault when unauthorized writes from user mode are detected. Clock prescaling is supported.

### 2.4 Priority Interrupt Controller

A programmable interrupt controller manages up to 240 external sources through an 8-bit external interrupt port. Alternatively, the interrupt inputs may be configured for individual edge- or level-triggered

inputs. The interrupt unit (IU) also accepts interrupts from the two on-chip timer channels and a single Non-Maskable Interrupt (NMI) pin. Interrupts are serviced according to their priority levels relative to the current process priority.

Low interrupt latency is critical to many embedded applications. As part of its highly flexible interrupt mechanism, the 80960JA/JF exploits several techniques to minimize latency:

- Interrupt vectors and interrupt handler routines can be reserved on-chip
- Register frames for high-priority interrupt handlers can be cached on-chip
- The interrupt stack can be placed in cacheable memory space

### 2.5 Instruction Set Summary

The 80960JA/JF adds several new instructions to the i960 core architecture. The new instructions are:

- Conditional Move
- Conditional Add
- Conditional Subtract
- Byte Swap
- Halt
- Cache Control
- Interrupt Control

Table 1 identifies the instructions that the 80960Jx supports. Refer to *i960<sup>®</sup> Jx Microprocessor User's Guide (272483)* for a detailed description of each instruction.

### 2.6 Faults and Debugging

The 80960Jx employs a comprehensive fault model. The processor responds to faults by making implicit calls to a fault handling routine. Specific information collected for each fault allows the fault handler to diagnose exceptions and recover appropriately.

The processor also has built-in debug capabilities. In software, the 80960Jx may be configured to detect as many as seven different trace event types. Alternatively, **mark** and **fmark** instructions can generate

trace events explicitly in the instruction stream. Hardware breakpoint registers are also available to trap on execution and data addresses.

## 2.7 Low Power Operation

Intel fabricates the 80960Jx using an advanced sub-micron manufacturing process. The processor's sub-micron topology provides the circuit density for optimal cache size and high operating speeds while dissipating modest power. The processor also uses dynamic power management to turn off clocks to unused circuits.

Users may program the 80960Jx to enter Halt mode for maximum power savings. In Halt mode, the processor core stops completely while the integrated peripherals continue to function, reducing overall power requirements up to 90 percent. Processor execution resumes from internally or externally generated interrupts.

## 2.8 Test Features

The 80960Jx incorporates numerous features which enhance the user's ability to test both the processor and the system to which it is attached. These features include ONCE (On-Circuit Emulation) mode and Boundary Scan (JTAG).

The 80960Jx provides testability features compatible with IEEE Standard Test Access Port and Boundary Scan Architecture (IEEE Std. 1149.1).

One of the boundary scan instructions, **HIGHZ**, forces the processor to float all its output pins (ONCE mode). ONCE mode can also be initiated at reset without using the boundary scan mechanism.

ONCE mode is useful for board-level testing. This feature allows a mounted 80960JA/JF to electrically "remove" itself from a circuit board. This allows for system-level testing where a remote tester — such as an in-circuit emulator — can exercise the processor system.

The provided test logic does not interfere with component or circuit board behavior and ensures that components function correctly, connections

between various components are correct, and various components interact correctly on the printed circuit board.

The JTAG Boundary Scan feature is an attractive alternative to conventional "bed-of-nails" testing. It can examine connections which might otherwise be inaccessible to a test system.

## 2.9 Memory-Mapped Control Registers

The 80960JA/JF, though compliant with i960 series processor core, has the added advantage of memory-mapped, internal control registers not found on the i960 Kx, Sx or Cx processors. These give software the interface to easily read and modify internal control registers.

Each of these registers is accessed as a memory-mapped, 32-bit register. Access is accomplished through regular memory-format instructions. The processor ensures that these accesses do not generate external bus cycles.

## 2.10 Data Types and Memory Addressing Modes

As with all i960 family processors, the 80960JA/JF instruction set supports several data types and formats:

- Bit
- Bit fields
- Integer (8-, 16-, 32-, 64-bit)
- Ordinal (8-, 16-, 32-, 64-bit unsigned integers)
- Triple word (96 bits)
- Quad word (128 bits)

The 80960JA/JF provides a full set of addressing modes for C and assembly programming:

- Two Absolute modes
- Five Register Indirect modes
- Index with displacement
- IP with displacement



**Table 1. 80960Jx Instruction Set**

<b>Data Movement</b>	<b>Arithmetic</b>	<b>Logical</b>	<b>Bit, Bit Field and Byte</b>
Load Store Move *Conditional Select Load Address	Add Subtract Multiply Divide Remainder Modulo Shift Extended Shift Extended Multiply Extended Divide Add with Carry Subtract with Carry *Conditional Add *Conditional Subtract Rotate	And Not And And Not Or Exclusive Or Not Or Or Not Nor Exclusive Nor Not Nand	Set Bit Clear Bit Not Bit Alter Bit Scan For Bit Span Over Bit Extract Modify Scan Byte for Equal *Byte Swap
<b>Comparison</b>	<b>Branch</b>	<b>Call/Return</b>	<b>Fault</b>
Compare Conditional Compare Compare and Increment Compare and Decrement Test Condition Code Check Bit	Unconditional Branch Conditional Branch Compare and Branch	Call Call Extended Call System Return Branch and Link	Conditional Fault Synchronize Faults
<b>Debug</b>	<b>Processor Management</b>	<b>Atomic</b>	
Modify Trace Controls Mark Force Mark	Flush Local Registers Modify Arithmetic Controls Modify Process Controls *Halt System Control *Cache Control *Interrupt Control	Atomic Add Atomic Modify	

**NOTE:** Asterisk (\*) denotes new 80960Jx instructions unavailable on 80960CA/CF, 80960KA/KB and 80960SA/SB implementations.

### 3.0 PACKAGE INFORMATION

The 80960JA/JF will be offered in several speed and package types. The 132-pin Pin Grid Array (PGA) device will be specified for operation at  $V_{CC} = 5.0\text{ V} \pm 5\%$  over a case temperature range of  $0^\circ$  to  $100^\circ\text{C}$ :

- A80960JA/JF-33 (33 MHz)
- A80960JA/JF-25 (25 MHz)
- A80960JA/JF-16 (16 MHz)

The 132-pin Plastic Quad Flatpack (PQFP) devices will be specified for operation at  $V_{CC} = 5.0\text{ V} \pm 5\%$  over a case temperature range of  $0^\circ$  to  $100^\circ\text{C}$ :

- NG80960JA/JF-33 (33 MHz)
- NG80960JA/JF-25 (25 MHz)
- NG80960JA/JF-16 (16 MHz)

For complete package specifications and information, refer to Intel's Packaging Handbook (240800).

### 3.1 Pin Descriptions

This section describes the pins for the 80960JA/JF in the 132-pin ceramic Pin Grid Array (PGA) package and 132-lead Plastic Quad Flatpack Package (PQFP).

**Section 3.1.1, Functional Pin Definitions** describes pin function; **Section 3.1.2, 80960Jx 132-Lead PGA Pinout** and **Section 3.1.3, 80960Jx PQFP Pinout** define the signal and pin locations for the supported package types.

#### 3.1.1 Functional Pin Definitions

Table 2 presents the legend for interpreting the pin descriptions which follow. Pins associated with the bus interface are described in Table 3. Pins associated with basic control and test functions are described in Table 4. Pins associated with the Interrupt Unit are described in Table 5.

Table 2. Pin Description Nomenclature

Symbol	Description
I	Input pin only.
O	Output pin only.
I/O	Pin can be either an input or output.
–	Pin must be connected as described.
S	Synchronous. Inputs must meet setup and hold times relative to CLKIN for proper operation. S(E) Edge sensitive input S(L) Level sensitive input
A (...)	Asynchronous. Inputs may be asynchronous relative to CLKIN. A(E) Edge sensitive input A(L) Level sensitive input
R (...)	While the processor's $\overline{\text{RESET}}$ pin is asserted, the pin: R(1) is driven to $V_{CC}$ R(0) is driven to $V_{SS}$ R(Q) is a valid output R(X) is driven to unknown state R(H) is pulled up to $V_{CC}$
H (...)	While the processor is in the hold state, the pin: H(1) is driven to $V_{CC}$ H(0) is driven to $V_{SS}$ H(Q) Maintains previous state or continues to be a valid output H(Z) Floats
P (...)	While the processor is halted, the pin: P(1) is driven to $V_{CC}$ P(0) is driven to $V_{SS}$ P(Q) Maintains previous state or continues to be a valid output

Table 3. Pin Description — External Bus Signals (Sheet 1 of 4)

NAME	TYPE	DESCRIPTION															
AD31:0	I/O S(L) R(X) H(Z) P(Q)	<p><b>ADDRESS / DATA BUS</b> carries 32-bit physical addresses and 8-, 16- or 32-bit data to and from memory. During an address (<math>T_a</math>) cycle, bits 31:2 contain a physical word address (bits 0-1 indicate SIZE; see below). During a data (<math>T_d</math>) cycle, read or write data is present on one or more contiguous bytes, comprising AD31:24, AD23:16, AD15:8 and AD7:0. During write operations, unused pins are driven to determinate values.</p> <p>SIZE, which comprises bits 0-1 of the AD lines during a <math>T_a</math> cycle, specifies the number of data transfers during the bus transaction.</p> <table border="1"> <thead> <tr> <th>AD1</th> <th>AD0</th> <th>Bus Transfers</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1 Transfer</td> </tr> <tr> <td>0</td> <td>1</td> <td>2 Transfers</td> </tr> <tr> <td>1</td> <td>0</td> <td>3 Transfers</td> </tr> <tr> <td>1</td> <td>1</td> <td>4 Transfers</td> </tr> </tbody> </table> <p>When the processor enters Halt mode, if the previous bus operation was a:</p> <ul style="list-style-type: none"> <li>• write — AD31:2 are driven with the last data value on the AD bus.</li> <li>• read — AD31:4 are driven with the last address value on the AD bus; AD3:2 are driven with the value of A3:2 from the last data cycle.</li> </ul> <p>Typically, AD1:0 reflect the SIZE information of the last bus transaction (either instruction fetch or load/store) that was executed before entering Halt mode.</p>	AD1	AD0	Bus Transfers	0	0	1 Transfer	0	1	2 Transfers	1	0	3 Transfers	1	1	4 Transfers
AD1	AD0	Bus Transfers															
0	0	1 Transfer															
0	1	2 Transfers															
1	0	3 Transfers															
1	1	4 Transfers															
ALE	O R(0) H(Z) P(0)	<p><b>ADDRESS LATCH ENABLE</b> indicates the transfer of a physical address. ALE is asserted during a <math>T_a</math> cycle and deasserted before the beginning of the <math>T_d</math> state. It is active HIGH and floats to a high impedance state during a hold cycle (<math>T_H</math>).</p>															
$\overline{\text{ALE}}$	O R(1) H(Z) P(1)	<p><b>ADDRESS LATCH ENABLE</b> indicates the transfer of a physical address. <math>\overline{\text{ALE}}</math> is the inverted version of ALE. This signal gives the 80960JA/JF a high degree of compatibility with existing 80960Kx systems.</p>															
$\overline{\text{ADS}}$	O R(1) H(Z) P(1)	<p><b>ADDRESS STROBE</b> indicates a valid address and the start of a new bus access. The processor asserts <math>\overline{\text{ADS}}</math> for the entire <math>T_a</math> cycle. External bus control logic typically samples <math>\overline{\text{ADS}}</math> at the end of the cycle.</p>															
A3:2	O R(X) H(Z) P(Q)	<p><b>ADDRESS3:2</b> comprise a partial demultiplexed address bus.</p> <p><i>32-bit memory accesses:</i> the processor asserts address bits A3:2 during <math>T_a</math>. The partial word address increments with each assertion of RDYRCV during a burst.</p> <p><i>16-bit memory accesses:</i> the processor asserts address bits A3:1 during <math>T_a</math> with A1 driven on the <math>\overline{\text{BE1}}</math> pin. The partial short word address increments with each assertion of RDYRCV during a burst.</p> <p><i>8-bit memory accesses:</i> the processor asserts address bits A3:0 during <math>T_a</math>, with A1:0 driven on <math>\overline{\text{BE1:0}}</math>. The partial byte address increments with each assertion of RDYRCV during a burst.</p>															

Table 3. Pin Description — External Bus Signals (Sheet 2 of 4)

NAME	TYPE	DESCRIPTION															
<b>BE3:0</b>	O R(1) H(Z) P(1)	<p><b>BYTE ENABLES</b> select which of up to four data bytes on the bus participate in the current bus access. Byte enable encoding is dependent on the bus width of the memory region accessed:</p> <p><i>32-bit bus:</i></p> <p><math>\overline{\text{BE}}3</math> enables data on AD31:24  <math>\overline{\text{BE}}2</math> enables data on AD23:16  <math>\overline{\text{BE}}1</math> enables data on AD15:8  <math>\overline{\text{BE}}0</math> enables data on AD7:0</p> <p><i>16-bit bus:</i></p> <p><math>\overline{\text{BE}}3</math> becomes Byte High Enable (enables data on AD15:8)  <math>\overline{\text{BE}}2</math> is not used (state is high)  <math>\overline{\text{BE}}1</math> becomes Address Bit 1 (A1)  <math>\overline{\text{BE}}0</math> becomes Byte Low Enable (enables data on AD7:0)</p> <p><i>8-bit bus:</i></p> <p><math>\overline{\text{BE}}3</math> is not used (state is high)  <math>\overline{\text{BE}}2</math> is not used (state is high)  <math>\overline{\text{BE}}1</math> becomes Address Bit 1 (A1)  <math>\overline{\text{BE}}0</math> becomes Address Bit 0 (A0)</p> <p>The processor asserts byte enables, byte high enable and byte low enable during <math>T_a</math>. Since unaligned bus requests are split into separate bus transactions, these signals do not toggle during a burst. They remain active through the last <math>T_d</math> cycle.</p> <p>For accesses to 8- and 16-bit memory, the processor asserts the address bits in conjunction with A3:2 described above.</p>															
<b>WIDTH/ HLTD1:0</b>	O R(0) H(Z) P(1)	<p><b>WIDTH/HALTED</b> signals denote the physical memory attributes for a bus transaction:</p> <table border="0"> <tr> <td>WIDTH/HLTD1</td> <td>WIDTH/HLTD0</td> <td></td> </tr> <tr> <td>0</td> <td>0</td> <td>8 Bits Wide</td> </tr> <tr> <td>0</td> <td>1</td> <td>16 Bits Wide</td> </tr> <tr> <td>1</td> <td>0</td> <td>32 Bits Wide</td> </tr> <tr> <td>1</td> <td>1</td> <td>Processor Halted</td> </tr> </table> <p>The processor floats the WIDTH/HLTD pins whenever it relinquishes the bus in response to a HOLD request, regardless of prior operating state.</p>	WIDTH/HLTD1	WIDTH/HLTD0		0	0	8 Bits Wide	0	1	16 Bits Wide	1	0	32 Bits Wide	1	1	Processor Halted
WIDTH/HLTD1	WIDTH/HLTD0																
0	0	8 Bits Wide															
0	1	16 Bits Wide															
1	0	32 Bits Wide															
1	1	Processor Halted															
<b>D/C</b>	O R(X) H(Z) P(Q)	<p><b>DATA/CODE</b> indicates that a bus access is a data access (1) or an instruction access (0). D/C has the same timing as W/R.</p> <p>0 = instruction access  1 = data access</p>															
<b>W/R</b>	O R(0) H(Z) P(Q)	<p><b>WRITE/READ</b> specifies, during a <math>T_a</math> cycle, whether the operation is a write (1) or read (0). It is latched on-chip and remains valid during <math>T_d</math> cycles.</p> <p>0 = read  1 = write</p>															

Table 3. Pin Description — External Bus Signals (Sheet 3 of 4)

NAME	TYPE	DESCRIPTION
<b>DT/R</b>	<b>O</b> R(0) H(Z) P(Q)	<b>DATA TRANSMIT / RECEIVE</b> indicates the direction of data transfer to and from the address/data bus. It is low during $T_a$ and $T_w/T_d$ cycles for a read; it is high during $T_a$ and $T_w/T_d$ cycles for a write. DT/R never changes state when $\overline{DEN}$ is asserted. 0 = receive 1 = transmit
<b>DEN</b>	<b>O</b> R(1) H(Z) P(1)	<b>DATA ENABLE</b> indicates data transfer cycles during a bus access. $\overline{DEN}$ is asserted at the start of the first data cycle in a bus access and deasserted at the end of the last data cycle. DEN is used with DT/R to provide control for data transceivers connected to the data bus. 0 = data cycle 1 = not data cycle
<b>BLAST</b>	<b>O</b> R(1) H(Z) P(1)	<b>BURST LAST</b> indicates the last transfer in a bus access. $\overline{BLAST}$ is asserted in the last data transfer of burst and non-burst accesses. $\overline{BLAST}$ remains active as long as wait states are inserted via the RDYRCV pin. $\overline{BLAST}$ becomes inactive after the final data transfer in a bus cycle. 0 = last data transfer 1 = not last data transfer
<b>RDYRCV</b>	<b>I</b> S(L)	<b>READY/RECOVER</b> indicates that data on AD lines can be sampled or removed. When RDYRCV is not asserted during a $T_d$ cycle, the $T_d$ cycle is extended to the next cycle by inserting a wait state ( $T_w$ ). 0 = sample data 1 = don't sample data  The RDYRCV pin has another function during the recovery ( $T_r$ ) state. The processor continues to insert additional recovery states until it samples the pin HIGH. This function gives slow external devices sufficient time to float their buffers before the processor begins to drive address again. 0 = insert wait states 1 = recovery complete
<b>LOCK/ONCE</b>	<b>I/O</b> S(L) R(H) H(Z) P(1)	<b>BUS LOCK</b> indicates that an atomic read-modify-write operation is in progress. The $\overline{LOCK}$ output is asserted in the first clock of an atomic operation and deasserted in the last data transfer of the sequence. The processor does not grant HOLDA while it is asserting $\overline{LOCK}$ . This prevents external agents from accessing memory involved in semaphore operations. 0 = Atomic read-modify-write in progress 1 = Atomic read-modify-write not in progress  <b>ONCE MODE:</b> The processor samples the $\overline{ONCE}$ input during reset. When it is asserted LOW at the end of reset, the processor enters ONCE mode. In ONCE mode, the processor stops all clocks and floats all output pins. The pin has a weak internal pullup which is active during reset to ensure normal operation when the pin is left unconnected. 0 = ONCE mode enabled 1 = ONCE mode not enabled

Table 3. Pin Description — External Bus Signals (Sheet 4 of 4)

NAME	TYPE	DESCRIPTION
<b>HOLD</b>	I S(L)	<b>HOLD</b> : A request from an external bus master to acquire the bus. When the processor receives HOLD and grants bus control to another master, it asserts <b>HOLDA</b> , floats the address/data and control lines and enters the $T_h$ state. When HOLD is deasserted, the processor deasserts <b>HOLDA</b> and enters either the $T_i$ or $T_a$ state, resuming control of the address/data and control lines.  0 = no hold request 1 = hold request
<b>HOLDA</b>	O R(Q) H(1) P(Q)	<b>HOLD ACKNOWLEDGE</b> indicates to an external bus master that the processor has relinquished control of the bus. The processor can grant HOLD requests and enter the $T_h$ state during reset and while halted as well as during regular operation.  0 = hold not acknowledged 1 = hold acknowledged
<b>BSTAT</b>	O R(0) H(Q) P(0)	<b>BUS STATUS</b> indicates that the processor may soon stall unless it has sufficient access to the bus; see <i>i960<sup>®</sup> Jx Microprocessor User's Guide (272483)</i> . Arbitration logic can examine this signal to determine when an external bus master should acquire/relinquish the bus.  0 = no potential stall 1 = potential stall

Table 4. Pin Description — Processor Control Signals, Test Signals and Power (Sheet 1 of 2)

NAME	TYPE	DESCRIPTION
<b>CLKIN</b>	I	<b>CLOCK INPUT</b> provides the processor's fundamental time base; both the processor core and the external bus run at the CLKIN rate. All input and output timings are specified relative to a rising CLKIN edge.
<b>RESET</b>	I A(L)	<b>RESET</b> initializes the processor and clears its internal logic. During reset, the processor places the address/data bus and control output pins in their idle (inactive) states.  During reset, the input pins are ignored with the exception of $\overline{\text{LOCK/ONCE}}$ , $\overline{\text{STEST}}$ and $\overline{\text{HOLD}}$ .  The $\overline{\text{RESET}}$ pin has an internal synchronizer. To ensure predictable processor initialization during power up, $\overline{\text{RESET}}$ must be asserted a minimum of 10,000 CLKIN cycles with $V_{CC}$ and CLKIN stable. On a warm reset, $\overline{\text{RESET}}$ should be asserted for a minimum of 15 cycles.
<b>STEST</b>	I S(L)	<b>SELF TEST</b> enables or disables the processor's internal self-test feature at initialization. $\overline{\text{STEST}}$ is examined at the end of reset. When $\overline{\text{STEST}}$ is asserted, the processor performs its internal self-test and the external bus confidence test. When $\overline{\text{STEST}}$ is deasserted, the processor performs only the external bus confidence test.  0 = self test disabled 1 = self test enabled

Table 4. Pin Description — Processor Control Signals, Test Signals and Power (Sheet 2 of 2)

NAME	TYPE	DESCRIPTION
$\overline{\text{FAIL}}$	O R(0) H(Q) P(1)	<p><b>FAIL</b> indicates a failure of the processor's built-in self-test performed during initialization. FAIL is asserted immediately upon reset and toggles during self-test to indicate the status of individual tests:</p> <ul style="list-style-type: none"> <li>When self-test passes, the processor deasserts <math>\overline{\text{FAIL}}</math> and begins operation from user code.</li> <li>When self-test fails, the processor asserts <math>\overline{\text{FAIL}}</math> and then stops executing.</li> </ul> <p>0 = self test failed 1 = self test passed</p>
TCK	I	<p><b>TEST CLOCK</b> is a CPU input which provides the clocking function for IEEE 1149.1 Boundary Scan Testing (JTAG). State information and data are clocked into the processor on the rising edge; data is clocked out of the processor on the falling edge.</p>
TDI	I S(L)	<p><b>TEST DATA INPUT</b> is the serial input pin for JTAG. TDI is sampled on the rising edge of TCK, during the SHIFT-IR and SHIFT-DR states of the Test Access Port.</p>
TDO	O R(Q) H(Q) P(Q)	<p><b>TEST DATA OUTPUT</b> is the serial output pin for JTAG. TDO is driven on the falling edge of TCK during the SHIFT-IR and SHIFT-DR states of the Test Access Port. At other times, TDO floats. TDO does not float during ONCE mode.</p>
$\overline{\text{TRST}}$	I A(L)	<p><b>TEST RESET</b> asynchronously resets the Test Access Port (TAP) controller function of IEEE 1149.1 Boundary Scan testing (JTAG). When using the Boundary Scan feature, connect a pulldown resistor between this pin and <math>V_{SS}</math>. When TAP is not used, this pin must be connected to <math>V_{SS}</math>; however, no resistor is required. See Section 4.3, Connection Recommendations (pg. 22).</p>
TMS	I S(L)	<p><b>TEST MODE SELECT</b> is sampled at the rising edge of TCK to select the operation of the test logic for IEEE 1149.1 Boundary Scan testing.</p>
$V_{CC}$	–	<p><b>POWER</b> pins intended for external connection to a <math>V_{CC}</math> board plane.</p>
$V_{CCPLL}$	–	<p><b>PLL POWER</b> is a separate <math>V_{CC}</math> supply pin for the phase lock loop clock generator. It is intended for external connection to the <math>V_{CC}</math> board plane. In noisy environments, add a simple bypass filter circuit to reduce noise-induced clock jitter and its effects on timing relationships.</p>
$V_{SS}$	–	<p><b>GROUND</b> pins intended for external connection to a <math>V_{SS}</math> board plane.</p>
NC	–	<p><b>NO CONNECT</b> pins. Do not make any system connections to these pins.</p>

Table 5. Pin Description — Interrupt Unit Signals

NAME	TYPE	DESCRIPTION
<u>XINT7:0</u>	I A(E/L)	<p><b>EXTERNAL INTERRUPT</b> pins are used to request interrupt service. The <u>XINT7:0</u> pins can be configured in three modes:</p> <p><b>Dedicated Mode:</b> Each pin is assigned a dedicated interrupt level. Dedicated inputs can be programmed to be level (low) or edge (falling) sensitive.</p> <p><b>Expanded Mode:</b> All eight pins act as a vectored interrupt source. The interrupt pins are level sensitive in this mode.</p> <p><b>Mixed Mode:</b> The <u>XINT7:5</u> pins act as dedicated sources and the <u>XINT4:0</u> pins act as the five most significant bits of a vectored source. The least significant bits of the vectored source are set to 010<sub>2</sub> internally.</p> <p>Unused external interrupt pins should be connected to V<sub>CC</sub>.</p>
<u>NMI</u>	I A(E)	<p><b>NON-MASKABLE INTERRUPT</b> causes a non-maskable interrupt event to occur. NMI is the highest priority interrupt source and is falling edge-triggered. If NMI is unused, it should be connected to V<sub>CC</sub>.</p>





3.1.2 80960Jx 132-Lead PGA Pinout

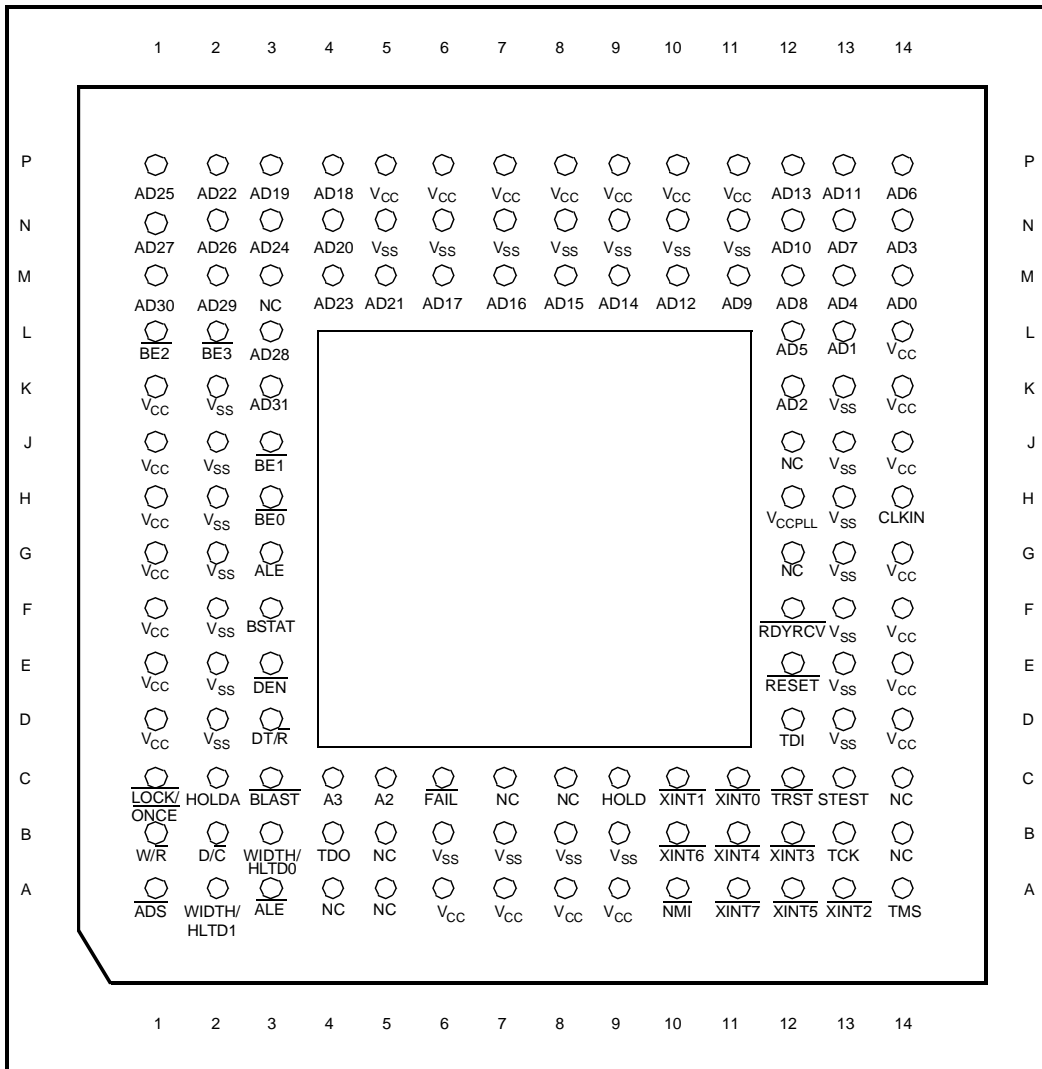


Figure 3. 132-Lead Pin Grid Array Bottom View - Pins Facing Up

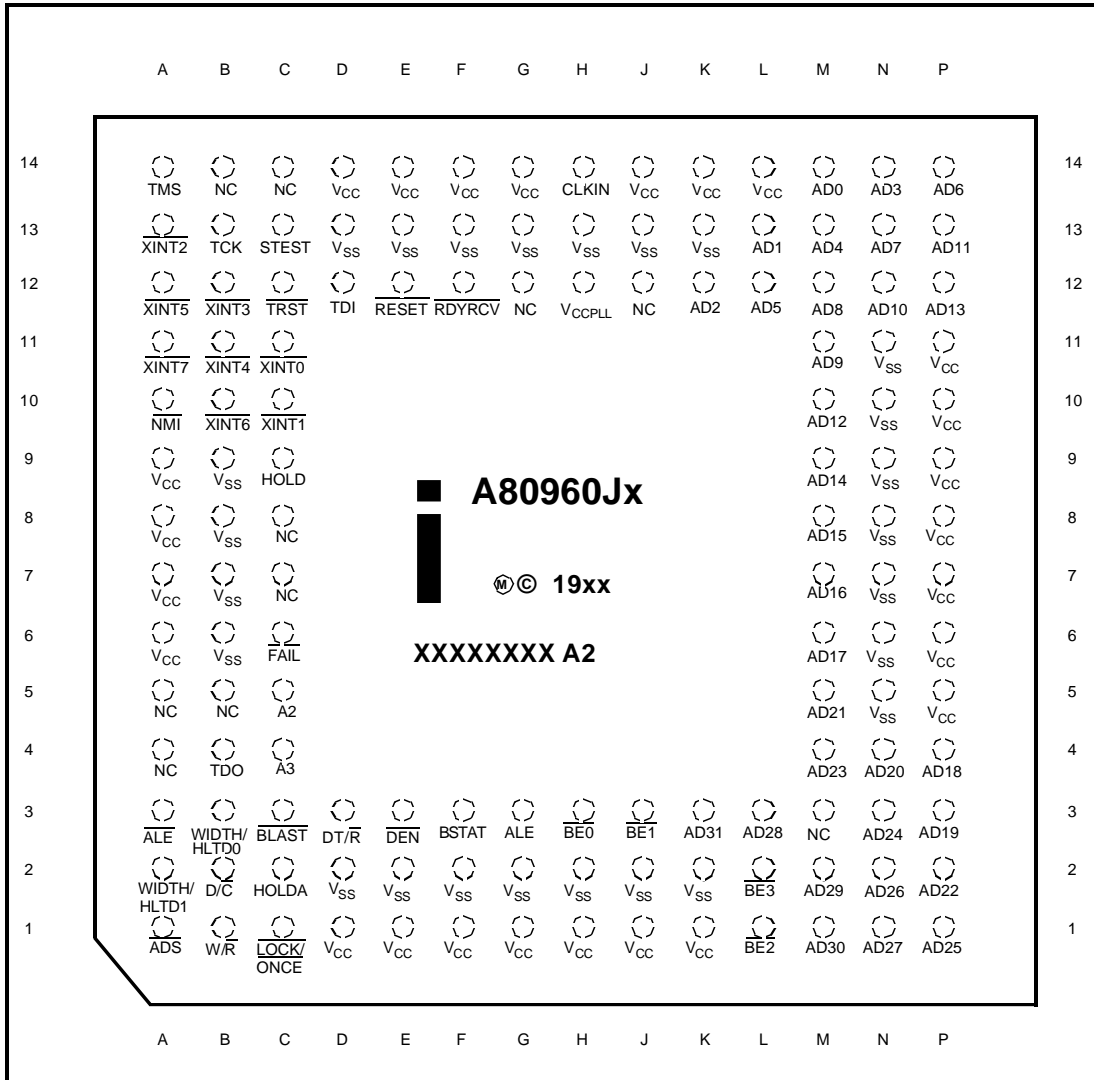


Figure 4. 132-Lead Pin Grid Array Top View - Pins Facing Down

Table 6. 132-Lead PGA Pinout — In Signal Order

Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin
A2	C5	AD31	K3	TDI	D12	V <sub>SS</sub>	B9
A3	C4	ADS	A1	TDO	B4	V <sub>SS</sub>	D2
AD0	M14	ALE	G3	TMS	A14	V <sub>SS</sub>	D13
AD1	L13	ALE	A3	TRST	C12	V <sub>SS</sub>	E2
AD2	K12	BE0	H3	V <sub>CC</sub>	A6	V <sub>SS</sub>	E13
AD3	N14	BE1	J3	V <sub>CC</sub>	A7	V <sub>SS</sub>	F2
AD4	M13	BE2	L1	V <sub>CC</sub>	A8	V <sub>SS</sub>	F13
AD5	L12	BE3	L2	V <sub>CC</sub>	A9	V <sub>SS</sub>	G2
AD6	P14	BLAST	C3	V <sub>CC</sub>	D1	V <sub>SS</sub>	G13
AD7	N13	BSTAT	F3	V <sub>CC</sub>	D14	V <sub>SS</sub>	H2
AD8	M12	CLKIN	H14	V <sub>CC</sub>	E1	V <sub>SS</sub>	H13
AD9	M11	D/C	B2	V <sub>CC</sub>	E14	V <sub>SS</sub>	J2
AD10	N12	DEN	E3	V <sub>CC</sub>	F1	V <sub>SS</sub>	J13
AD11	P13	DT/R	D3	V <sub>CC</sub>	F14	V <sub>SS</sub>	K2
AD12	M10	FAIL	C6	V <sub>CC</sub>	G1	V <sub>SS</sub>	K13
AD13	P12	HOLD	C9	V <sub>CC</sub>	G14	V <sub>SS</sub>	N5
AD14	M9	HOLDA	C2	V <sub>CC</sub>	H1	V <sub>SS</sub>	N6
AD15	M8	LOCK/ONCE	C1	V <sub>CC</sub>	J1	V <sub>SS</sub>	N7
AD16	M7	NC	A4	V <sub>CC</sub>	J14	V <sub>SS</sub>	N8
AD17	M6	NC	A5	V <sub>CC</sub>	K1	V <sub>SS</sub>	N9
AD18	P4	NC	B5	V <sub>CC</sub>	K14	V <sub>SS</sub>	N10
AD19	P3	NC	B14	V <sub>CC</sub>	L14	V <sub>SS</sub>	N11
AD20	N4	NC	C7	V <sub>CC</sub>	P5	W/R	B1
AD21	M5	NC	C8	V <sub>CC</sub>	P6	WIDTH/HLTD0	B3
AD22	P2	NC	C14	V <sub>CC</sub>	P7	WIDTH/HLTD1	A2
AD23	M4	NC	G12	V <sub>CC</sub>	P8	XINT0	C11
AD24	N3	NC	J12	V <sub>CC</sub>	P9	XINT1	C10
AD25	P1	NC	M3	V <sub>CC</sub>	P10	XINT2	A13
AD26	N2	NMI	A10	V <sub>CC</sub>	P11	XINT3	B12
AD27	N1	RDYRCV	F12	V <sub>CCPLL</sub>	H12	XINT4	B11
AD28	L3	RESET	E12	V <sub>SS</sub>	B6	XINT5	A12
AD29	M2	STEST	C13	V <sub>SS</sub>	B7	XINT6	B10
AD30	M1	TCK	B13	V <sub>SS</sub>	B8	XINT7	A11

NOTE: Do not connect any external logic to pins marked NC (no connect pins).

Table 7. 132-Lead PGA Pinout — In Pin Order

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
A1	ADS	C6	FAIL	H1	V <sub>CC</sub>	M10	AD12
A2	WIDTH/HLTD1	C7	NC	H2	V <sub>SS</sub>	M11	AD9
A3	ALE	C8	NC	H3	BE0	M12	AD8
A4	NC	C9	HOLD	H12	V <sub>CCPLL</sub>	M13	AD4
A5	NC	C10	XINT1	H13	V <sub>SS</sub>	M14	AD0
A6	V <sub>CC</sub>	C11	XINT0	H14	CLKIN	N1	AD27
A7	V <sub>CC</sub>	C12	TRST	J1	V <sub>CC</sub>	N2	AD26
A8	V <sub>CC</sub>	C13	STEST	J2	V <sub>SS</sub>	N3	AD24
A9	V <sub>CC</sub>	C14	NC	J3	BE1	N4	AD20
A10	NMI	D1	V <sub>CC</sub>	J12	NC	N5	V <sub>SS</sub>
A11	XINT7	D2	V <sub>SS</sub>	J13	V <sub>SS</sub>	N6	V <sub>SS</sub>
A12	XINT5	D3	DT/R	J14	V <sub>CC</sub>	N7	V <sub>SS</sub>
A13	XINT2	D12	TDI	K1	V <sub>CC</sub>	N8	V <sub>SS</sub>
A14	TMS	D13	V <sub>SS</sub>	K2	V <sub>SS</sub>	N9	V <sub>SS</sub>
B1	W/R	D14	V <sub>CC</sub>	K3	AD31	N10	V <sub>SS</sub>
B2	D/C	E1	V <sub>CC</sub>	K12	AD2	N11	V <sub>SS</sub>
B3	WIDTH/HLTD0	E2	V <sub>SS</sub>	K13	V <sub>SS</sub>	N12	AD10
B4	TDO	E3	DEN	K14	V <sub>CC</sub>	N13	AD7
B5	NC	E12	RESET	L1	BE2	N14	AD3
B6	V <sub>SS</sub>	E13	V <sub>SS</sub>	L2	BE3	P1	AD25
B7	V <sub>SS</sub>	E14	V <sub>CC</sub>	L3	AD28	P2	AD22
B8	V <sub>SS</sub>	F1	V <sub>CC</sub>	L12	AD5	P3	AD19
B9	V <sub>SS</sub>	F2	V <sub>SS</sub>	L13	AD1	P4	AD18
B10	XINT6	F3	BSTAT	L14	V <sub>CC</sub>	P5	V <sub>CC</sub>
B11	XINT4	F12	RDYRCV	M1	AD30	P6	V <sub>CC</sub>
B12	XINT3	F13	V <sub>SS</sub>	M2	AD29	P7	V <sub>CC</sub>
B13	TCK	F14	V <sub>CC</sub>	M3	NC	P8	V <sub>CC</sub>
B14	NC	G1	V <sub>CC</sub>	M4	AD23	P9	V <sub>CC</sub>
C1	LOCK/ONCE	G2	V <sub>SS</sub>	M5	AD21	P10	V <sub>CC</sub>
C2	HOLDA	G3	ALE	M6	AD17	P11	V <sub>CC</sub>
C3	BLAST	G12	NC	M7	AD16	P12	AD13
C4	A3	G13	V <sub>SS</sub>	M8	AD15	P13	AD11
C5	A2	G14	V <sub>CC</sub>	M9	AD14	P14	AD6

**NOTE:** Do not connect any external logic to pins marked NC (no connect pins).



Table 8. 132-Lead PQFP Pinout — In Signal Order

Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin
AD31	60	$\overline{\text{ALE}}$	24	$V_{CC}$ (Core)	47	$V_{SS}$ (I/O)	10
AD30	61	$\overline{\text{ADS}}$	36	$V_{CC}$ (Core)	59	$V_{SS}$ (I/O)	27
AD29	62	A3	33	$V_{CC}$ (Core)	74	$V_{SS}$ (I/O)	40
AD28	63	A2	32	$V_{CC}$ (Core)	92	$V_{SS}$ (I/O)	48
AD27	66	$\overline{\text{BE3}}$	55	$V_{CC}$ (Core)	113	$V_{SS}$ (I/O)	56
AD26	68	$\overline{\text{BE2}}$	54	$V_{CC}$ (Core)	115	$V_{SS}$ (I/O)	64
AD25	69	$\overline{\text{BE1}}$	53	$V_{CC}$ (Core)	123	$V_{SS}$ (I/O)	71
AD24	70	$\overline{\text{BE0}}$	52	$V_{CC}$ (I/O)	9	$V_{SS}$ (I/O)	79
AD23	75	WIDTH/HLTD1	28	$V_{CC}$ (I/O)	26	$V_{SS}$ (I/O)	85
AD22	76	WIDTH/HLTD0	31	$V_{CC}$ (I/O)	41	$V_{SS}$ (I/O)	93
AD21	77	$\overline{\text{D/C}}$	35	$V_{CC}$ (I/O)	49	$V_{SS}$ (I/O)	97
AD20	78	$\overline{\text{W/R}}$	37	$V_{CC}$ (I/O)	57	$V_{SS}$ (I/O)	106
AD19	81	$\overline{\text{DT/R}}$	42	$V_{CC}$ (I/O)	65	$V_{SS}$ (I/O)	112
AD18	82	$\overline{\text{DEN}}$	43	$V_{CC}$ (I/O)	72	$V_{SS}$ (I/O)	131
AD17	83	$\overline{\text{BLAST}}$	34	$V_{CC}$ (I/O)	80	NC	18
AD16	84	$\overline{\text{RDYRCV}}$	132	$V_{CC}$ (I/O)	86	NC	19
AD15	87	$\overline{\text{LOCK/ONCE}}$	50	$V_{CC}$ (I/O)	94	NC	20
AD14	88	HOLD	4	$V_{CC}$ (I/O)	98	NC	21
AD13	89	HOLDA	44	$V_{CC}$ (I/O)	105	NC	22
AD12	90	BSTAT	51	$V_{CC}$ (I/O)	111	NC	67
AD11	95	CLKIN	117	$V_{CC}$ (I/O)	129	NC	121
AD10	96	$\overline{\text{RESET}}$	125	$V_{CCPLL}$	119	NC	122
AD9	99	STEST	128	$V_{SS}$ (CLK)	118	NC	126
AD8	100	$\overline{\text{FAIL}}$	23	$V_{SS}$ (Core)	17	NC	127
AD7	101	TCK	2	$V_{SS}$ (Core)	30	$\overline{\text{XINT7}}$	14
AD6	102	TDI	130	$V_{SS}$ (Core)	38	$\overline{\text{XINT6}}$	13
AD5	103	TDO	25	$V_{SS}$ (Core)	46	$\overline{\text{XINT5}}$	12
AD4	104	$\overline{\text{TRST}}$	1	$V_{SS}$ (Core)	58	$\overline{\text{XINT4}}$	11
AD3	107	TMS	3	$V_{SS}$ (Core)	73	$\overline{\text{XINT3}}$	8
AD2	108	$V_{CC}$ (CLK)	120	$V_{SS}$ (Core)	91	$\overline{\text{XINT2}}$	7
AD1	109	$V_{CC}$ (Core)	16	$V_{SS}$ (Core)	114	$\overline{\text{XINT1}}$	6
AD0	110	$V_{CC}$ (Core)	29	$V_{SS}$ (Core)	116	$\overline{\text{XINT0}}$	5
ALE	45	$V_{CC}$ (Core)	39	$V_{SS}$ (Core)	124	$\overline{\text{NMI}}$	15

**NOTE:** Do not connect any external logic to pins marked NC (no connect pins).

Table 9. 132-Lead PQFP Pinout — In Pin Order

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	TRST	34	BLAST	67	NC	100	AD8
2	TCK	35	D/C	68	AD26	101	AD7
3	TMS	36	ADS	69	AD25	102	AD6
4	HOLD	37	W/R	70	AD24	103	AD5
5	XINT0	38	V <sub>SS</sub> (Core)	71	V <sub>SS</sub> (I/O)	104	AD4
6	XINT1	39	V <sub>CC</sub> (Core)	72	V <sub>CC</sub> (I/O)	105	V <sub>CC</sub> (I/O)
7	XINT2	40	V <sub>SS</sub> (I/O)	73	V <sub>SS</sub> (Core)	106	V <sub>SS</sub> (I/O)
8	XINT3	41	V <sub>CC</sub> (I/O)	74	V <sub>CC</sub> (Core)	107	AD3
9	V <sub>CC</sub> (I/O)	42	DT/R	75	AD23	108	AD2
10	V <sub>SS</sub> (I/O)	43	DEN	76	AD22	109	AD1
11	XINT4	44	HOLDA	77	AD21	110	AD0
12	XINT5	45	ALE	78	AD20	111	V <sub>CC</sub> (I/O)
13	XINT6	46	V <sub>SS</sub> (Core)	79	V <sub>SS</sub> (I/O)	112	V <sub>SS</sub> (I/O)
14	XINT7	47	V <sub>CC</sub> (Core)	80	V <sub>CC</sub> (I/O)	113	V <sub>CC</sub> (Core)
15	NMI	48	V <sub>SS</sub> (I/O)	81	AD19	114	V <sub>SS</sub> (Core)
16	V <sub>CC</sub> (Core)	49	V <sub>CC</sub> (I/O)	82	AD18	115	V <sub>CC</sub> (Core)
17	V <sub>SS</sub> (Core)	50	LOCK/ONCE	83	AD17	116	V <sub>SS</sub> (Core)
18	NC	51	BSTAT	84	AD16	117	CLKIN
19	NC	52	BE0	85	V <sub>SS</sub> (I/O)	118	V <sub>SS</sub> (CLK)
20	NC	53	BE1	86	V <sub>CC</sub> (I/O)	119	V <sub>CC</sub> PLL
21	NC	54	BE2	87	AD15	120	V <sub>CC</sub> (CLK)
22	NC	55	BE3	88	AD14	121	NC
23	FAIL	56	V <sub>SS</sub> (I/O)	89	AD13	122	NC
24	ALE	57	V <sub>CC</sub> (I/O)	90	AD12	123	V <sub>CC</sub> (Core)
25	TDO	58	V <sub>SS</sub> (Core)	91	V <sub>SS</sub> (Core)	124	V <sub>SS</sub> (Core)
26	V <sub>CC</sub> (I/O)	59	V <sub>CC</sub> (Core)	92	V <sub>CC</sub> (Core)	125	RESET
27	V <sub>SS</sub> (I/O)	60	AD31	93	V <sub>SS</sub> (I/O)	126	NC
28	WIDTH/HLTD1	61	AD30	94	V <sub>CC</sub> (I/O)	127	NC
29	V <sub>CC</sub> (Core)	62	AD29	95	AD11	128	STEST
30	V <sub>SS</sub> (Core)	63	AD28	96	AD10	129	V <sub>CC</sub> (I/O)
31	WIDTH/HLTD0	64	V <sub>SS</sub> (I/O)	97	V <sub>SS</sub> (I/O)	130	TDI
32	A2	65	V <sub>CC</sub> (I/O)	98	V <sub>CC</sub> (I/O)	131	V <sub>SS</sub> (I/O)
33	A3	66	AD27	99	AD9	132	RDYRCV

NOTE: Do not connect any external logic to pins marked NC (no connect pins).

### 3.2 Package Thermal Specifications

The 80960JA/JF is specified for operation when  $T_C$  (case temperature) is within the range of  $0^\circ\text{C}$  to  $100^\circ\text{C}$ . Case temperature may be measured in any environment to determine whether the 80960JA/JF is within specified operating range. The case temperature should be measured at the center of the top surface, opposite the pins.

$\theta_{CA}$  is the thermal resistance from case to ambient. Use the following equation to calculate  $T_A$ , the maximum ambient temperature to conform to a particular case temperature:

$$T_A = T_C - P (\theta_{CA})$$

Junction temperature ( $T_J$ ) is commonly used in reliability calculations.  $T_J$  can be calculated from  $\theta_{JC}$  (thermal resistance from junction to case) using the following equation:

$$T_J = T_C + P (\theta_{JC})$$

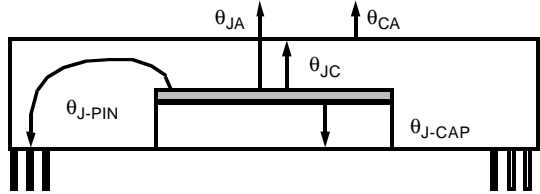
Similarly, if  $T_A$  is known, the corresponding case temperature ( $T_C$ ) can be calculated as follows:

$$T_C = T_A + P (\theta_{CA})$$

Compute  $P$  by multiplying  $I_{CC}$  from Table 14 and  $V_{CC}$ . Values for  $\theta_{JC}$  and  $\theta_{CA}$  are given in Table 10 for the PGA package and Table 11 for the PQFP package. For high speed operation, the processor's  $\theta_{JA}$  may be significantly reduced by adding a heatsink and/or by increasing airflow.

**Table 10. 132-Lead PGA Package Thermal Characteristics**

Thermal Resistance — $^\circ\text{C}/\text{Watt}$						
Parameter	Airflow — ft./min (m/sec)					
	0 (0)	200 (1.01)	400 (2.03)	600 (3.04)	800 (4.06)	1000 (5.08)
$\theta_{JC}$ (Junction-to-Case)	3	3	3	3	3	3
$\theta_{CA}$ (Case-to-Ambient) (No Heatsink)	18	15	12	11	11	11
$\theta_{CA}$ (Case-to-Ambient) (Omnidirectional Heatsink)	15	12	9	8	8	8
$\theta_{CA}$ (Case-to-Ambient) (Unidirectional Heatsink)	14	11	8	7	7	7

**NOTES:**

1. This table applies to a PGA device plugged into a socket or soldered directly into a board.
2.  $\theta_{JA} = \theta_{JC} + \theta_{CA}$
3.  $\theta_{J-CAP} = 4^\circ\text{C}/\text{W}$  (approx.)
4.  $\theta_{J-PIN} = 4^\circ\text{C}/\text{W}$  (inner pins) (approx.)
5.  $\theta_{J-PIN} = 8^\circ\text{C}/\text{W}$  (outer pins) (approx.)



Table 11. 132-Lead PQFP Package Thermal Characteristics

Thermal Resistance — °C/Watt							
Parameter	Airflow — ft./min (m/sec)						
	0 (0)	50 (0.25)	100 (0.50)	200 (1.01)	400 (2.03)	600 (3.04)	800 (4.06)
$\theta_{JC}$ (Junction-to-Case)	6	7	7	7	7	7	7
$\theta_{CA}$ (Case-to-Ambient; No Heatsink)	23	20	18	14	10	9	8

**NOTES:**

1. This table applies to a PQFP device soldered directly into board.
2.  $\theta_{JA} = \theta_{JC} + \theta_{CA}$
3.  $\theta_{JL} = 18^\circ\text{C/W}$  (approx.)
4.  $\theta_{JB} = 18^\circ\text{C/W}$  (approx.)

## 4.0 ELECTRICAL SPECIFICATIONS

### 4.1 Absolute Maximum Ratings

Parameter	Maximum Rating
Storage Temperature	-65 °C to +150 °C
Case Temperature Under Bias	-65 °C to +110 °C
Supply Voltage wrt. $V_{SS}$	-0.5V to +4.6V
Voltage on Other Pins wrt. $V_{SS}$	-0.5V to $V_{CC} + 0.5V$

**NOTICE:** This data sheet contains preliminary information on new products in production. The specifications are subject to change without notice.

**WARNING:** Stressing the device beyond the “Absolute Maximum Ratings” may cause permanent damage. These are stress ratings only. Operation beyond the “Operating Conditions” is not recommended and extended exposure beyond the “Operating Conditions” may affect device reliability.

### 4.2 Operating Conditions

Table 12. 80960JA/JF Operating Conditions

Symbol	Parameter	Min	Max	Units	Notes
$V_{CC}$	Supply Voltage			V	
	80960JA/JF-33	4.75	5.25		
	80960JA/JF-25	4.75	5.25		
	80960JA/JF-16	4.75	5.25		
$f_{CLKIN}$	Input Clock Frequency			MHz	
	80960JA/JF-33	8	33.33		
	80960JA/JF-25	8	25		
	80960JA/JF-16	8	16.67		
$T_C$	Operating Case Temperature			°C	
	A80960JA/JF-33 (132 PGA)	0	100		
	A80960JA/JF-25 (132 PGA)	0	100		
	A80960JA/JF-16 (132 PGA)	0	100		
	NG80960JA/JF-33 (132 PQFP)	0	100		
	NG80960JA/JF-25 (132 PQFP)	0	100		
	NG80960JA/JF-16 (132 PQFP)	0	100		

### 4.3 Connection Recommendations

For clean on-chip power distribution,  $V_{CC}$  and  $V_{SS}$  pins separately feed the device’s functional units. Power and ground connections must be made to all 80960JA/JF power and ground pins. On the circuit board, every  $V_{CC}$  pin should connect to a power plane and every  $V_{SS}$  pin should connect to a ground plane. Place liberal decoupling capacitance near the 80960JA/JF, since the processor can cause transient power surges.

Pay special attention to the Test Reset ( $\overline{TRST}$ ) pin. It is essential that the JTAG Boundary Scan Test Access Port (TAP) controller initializes to a known state whether it will be used or not. If the JTAG Boundary Scan function will be used, connect a pulldown resistor between the  $\overline{TRST}$  pin and  $V_{SS}$ . If the JTAG Boundary Scan function will not be used (even for board-level testing), connect the  $\overline{TRST}$  pin to  $V_{SS}$ . Also, do not connect the TDI, TDO, and TCK pins if the TAP Controller will not be used.

**Pins identified as NC must not be connected in the system.**

#### 4.4 DC Specifications

**Table 13. 80960JA/JF DC Characteristics**

Symbol	Parameter	Min	Typ	Max	Units	Notes
$V_{IL}$	Input Low Voltage	-0.3		0.8	V	
$V_{IH}$	Input High Voltage	2.0		$V_{CC} + 0.3$	V	
$V_{OL}$	Output Low Voltage			0.45	V	$I_{OL} = 5 \text{ mA}$
$V_{OH}$	Output High Voltage	2.4 $V_{CC} - 0.5$			V	$I_{OH} = -1 \text{ mA}$ $I_{OH} = -200 \mu\text{A}$
$V_{OLP}$	Output Ground Bounce		< 0.8		V	(1,2)
$C_{IN}$	Input Capacitance PGA PQFP			12 10	pF	$f_{CLKIN} = f_{MIN} (2)$
$C_{OUT}$	I/O or Output Capacitance PGA PQFP			12 10	pF	$f_{CLKIN} = f_{MIN} (2)$
$C_{CLK}$	CLKIN Capacitance PGA PQFP			12 10	pF	$f_{CLKIN} = f_{MIN} (2)$

**NOTES:**

1. Typical is measured with  $V_{CC} = 5.0\text{V}$  and temperature = 25 °C.
2. Not tested.

**Table 14. 80960JA/JF  $I_{CC}$  Characteristics** (Sheet 1 of 2)

Symbol	Parameter	Typ	Max	Units	Notes
$I_{LI1}$	Input Leakage Current for each pin except TCK, TDI, TRST and TMS		$\pm 1$	$\mu\text{A}$	$0 \leq V_{IN} \leq V_{CC}$
$I_{LI2}$	Input Leakage Current for TCK, TDI, TRST and TMS	-140	-250	$\mu\text{A}$	$V_{IN} = 0.45\text{V} (1)$
$I_{LO}$	Output Leakage Current		$\pm 1$	$\mu\text{A}$	$0.4 \leq V_{OUT} \leq V_{CC}$
$I_{CC}$ Active (Power Supply)	80960JA/JF-33		515	mA	(2,3)
	80960JA/JF-25		390		(2,3)
	80960JA/JF-16		245		(2,3)
$I_{CC}$ Active (Thermal)	80960JA/JF-33	420		mA	(2,4)
	80960JA/JF-25	325			(2,4)
	80960JA/JF-16	205			(2,4)

Table 14. 80960JA/JF  $I_{CC}$  Characteristics (Sheet 2 of 2)

Symbol	Parameter	Typ	Max	Units	Notes
$I_{CC}$ Test (Power modes)	Reset mode				
	80960JA/JF-33		380	mA	(5)
	80960JA/JF-25		300		(5)
	80960JA/JF-16		210		(5)
	Halt mode				
	80960JA/JF-33		40		(5)
	80960JA/JF-25		30		(5)
	80960JA/JF-16		20		(5)
	ONCE mode			10	

**NOTES:**

1. These pins have internal pullup devices. Typical leakage current is not tested.
2. Measured with device operating and outputs loaded to the test condition in Figure 6, AC Test Load (pg. 32).
3.  $I_{CC}$  Active (Power Supply) value is provided for selecting your system's power supply. It is measured using one of the worst case instruction mixes with  $V_{CC} = 5.3V$ . This parameter is characterized but not tested.
4.  $I_{CC}$  Active (Thermal) value is provided for your system's thermal management. Typical  $I_{CC}$  is measured with  $V_{CC} = 5.0V$  and temperature = 25° C. This parameter is characterized but not tested.
5.  $I_{CC}$  Test (Power modes) refers to the  $I_{CC}$  values that are tested when the 80960JA/JF is in Reset mode, Halt mode or ONCE mode with  $V_{CC} = 5.3V$ .

#### 4.5 AC Specifications

The 80960JA/JF AC timings are based upon device characterization.

**Table 15. 80960JA/JF AC Characteristics (33 MHz) (Sheet 1 of 2)**

Symbol	Parameter	Min	Max	Units	Notes
<b>INPUT CLOCK TIMINGS</b>					
$T_F$	CLKIN Frequency	8	33.33	MHz	
$T_C$	CLKIN Period	30	62.5	ns	
$T_{CS}$	CLKIN Period Stability		$\pm 250$	ps	(1, 2)
$T_{CH}$	CLKIN High Time	12		ns	Measured at 1.5 V (1)
$T_{CL}$	CLKIN Low Time	12		ns	Measured at 1.5 V (1)
$T_{CR}$	CLKIN Rise Time		4	ns	0.8 V to 2.0 V (1)
$T_{CF}$	CLKIN Fall Time		4	ns	2.0 V to 0.8 V (1)
<b>SYNCHRONOUS OUTPUT TIMINGS</b>					
$T_{OV1}$	Output Valid Delay, Except $\overline{\text{ALE}}/\overline{\text{ALE}}$ Inactive and $\overline{\text{DT}}/\overline{\text{R}}$	3.5	15	ns	(3)
$T_{OV2}$	Output Valid Delay, $\overline{\text{DT}}/\overline{\text{R}}$	$0.5T_C + 3.5$	$0.5T_C + 15$	ns	
$T_{OF}$	Output Float Delay	3.5	13	ns	(4)
<b>SYNCHRONOUS INPUT TIMINGS</b>					
$T_{IS1}$	Input Setup to CLKIN — AD31:0, NMI, XINT7:0	6		ns	(5)
$T_{IH1}$	Input Hold from CLKIN — AD31:0, NMI, XINT7:0	2		ns	(5)
$T_{IS2}$	Input Setup to CLKIN — $\overline{\text{RDYRCV}}$ and HOLD	7.5		ns	(6)
$T_{IH2}$	Input Hold from CLKIN — $\overline{\text{RDYRCV}}$ and HOLD	1		ns	(6)
$T_{IS3}$	Input Setup to CLKIN — $\overline{\text{RESET}}$	6		ns	(7)
$T_{IH3}$	Input Hold from CLKIN — $\overline{\text{RESET}}$	2		ns	(7)
$T_{IS4}$	Input Setup to $\overline{\text{RESET}}$ — ONCE, STEST	6		ns	(8)
$T_{IH4}$	Input Hold from $\overline{\text{RESET}}$ — ONCE, STEST	2		ns	(8)

**NOTE:** See Table 16 on page 27 for note definitions for this table.

Table 15. 80960JA/JF AC Characteristics (33 MHz) (Sheet 2 of 2)

Symbol	Parameter	Min	Max	Units	Notes
<b>RELATIVE OUTPUT TIMINGS</b>					
$T_{LXL}$	ALE/ALE Width	$0.5T_C - 7$		ns	(9)
$T_{LXA}$	Address Hold from ALE/ALE Inactive				Equal Loading (9)
$T_{DXD}$	DT/R Valid to DEN Active				Equal Loading (9)
<b>BOUNDARY SCAN TEST SIGNAL TIMINGS</b>					
$T_{BSF}$	TCK Frequency		$0.5T_F$	MHz	
$T_{BSCH}$	TCK High Time	15		ns	Measured at 1.5 V (1)
$T_{BSCL}$	TCK Low Time	15		ns	Measured at 1.5 V (1)
$T_{BSCR}$	TCK Rise Time		5	ns	0.8 V to 2.0 V (1)
$T_{BSCF}$	TCK Fall Time		5	ns	2.0 V to 0.8 V (1)
$T_{BSIS1}$	Input Setup to TCK — TDI, TMS	4		ns	
$T_{BSIH1}$	Input Hold from TCK — TDI, TMS	6		ns	
$T_{BSOV1}$	TDO Valid Delay	3	30	ns	(1, 10)
$T_{BSOF1}$	TDO Float Delay	3	30	ns	(1, 10)
$T_{BSOV2}$	All Outputs (Non-Test) Valid Delay	3	30	ns	(1, 10)
$T_{BSOF2}$	All Outputs (Non-Test) Float Delay	3	30	ns	(1, 10)
$T_{BSIS2}$	Input Setup to TCK — All Inputs (Non-Test)	4		ns	
$T_{BSIH2}$	Input Hold from TCK — All Inputs (Non-Test)	6		ns	

**NOTE:** See Table 16 on page 27 for note definitions for this table.

**Table 16. Note Definitions for Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25)**

NOTES:	
1.	Not tested.
2.	To ensure a 1:1 relationship between the amplitude of the input jitter and the internal clock, the jitter frequency spectrum should not have any power peaking between 500 KHz and 1/3 of the CLKIN frequency.
3.	Inactive ALE/ $\overline{\text{ALE}}$ refers to the falling edge of ALE and the rising edge of $\overline{\text{ALE}}$ . For inactive ALE/ $\overline{\text{ALE}}$ timings, refer to Relative Output Timings in this table.
4.	A float condition occurs when the output current becomes less than $I_{LO}$ . Float delay is not tested, but is designed to be no longer than the valid delay.
5.	AD31:0 are synchronous inputs. Setup and hold times must be met for proper processor operation. $\overline{\text{NMI}}$ and XINT7:0 may be synchronous or asynchronous. Meeting setup and hold time guarantees recognition at a particular clock edge. For asynchronous operation, NMI and XINT7:0 must be asserted for a minimum of two CLKIN periods to guarantee recognition.
6.	$\overline{\text{RDYRCV}}$ and HOLD are synchronous inputs. Setup and hold times must be met for proper processor operation.
7.	$\overline{\text{RESET}}$ may be synchronous or asynchronous. Meeting setup and hold time guarantees recognition at a particular clock edge.
8.	ONCE and STEST must be stable at the rising edge of $\overline{\text{RESET}}$ for proper operation.
9.	Guaranteed by design. May not be 100% tested.
10.	Relative to falling edge of TCK.

**Table 17. 80960JA/JF AC Characteristics (25 MHz) (Sheet 1 of 3)**

Symbol	Parameter	Min	Max	Units	Notes
<b>INPUT CLOCK TIMINGS</b>					
$T_F$	CLKIN Frequency	8	25	MHz	
$T_C$	CLKIN Period	40	62.5	ns	
$T_{CS}$	CLKIN Period Stability		$\pm 250$	ps	(1, 2)
$T_{CH}$	CLKIN High Time	16		ns	Measured at 1.5 V (1)
$T_{CL}$	CLKIN Low Time	16		ns	Measured at 1.5 V (1)
$T_{CR}$	CLKIN Rise Time		5	ns	0.8 V to 2.0 V (1)
$T_{CF}$	CLKIN Fall Time		5	ns	2.0 V to 0.8 V (1)
<b>SYNCHRONOUS OUTPUT TIMINGS</b>					
$T_{OV1}$	Output Valid Delay, Except ALE/ $\overline{\text{ALE}}$ Inactive and DT/ $\overline{\text{R}}$	3.5	17	ns	(3)
$T_{OV2}$	Output Valid Delay, DT/ $\overline{\text{R}}$	$0.5T_C + 3.5$	$0.5T_C + 17$	ns	
$T_{OF}$	Output Float Delay	3.5	15	ns	(4)

Table 17. 80960JA/JF AC Characteristics (25 MHz) (Sheet 2 of 3)

Symbol	Parameter	Min	Max	Units	Notes
<b>SYNCHRONOUS INPUT TIMINGS</b>					
T <sub>IS1</sub>	Input Setup to CLKIN — AD31:0, NMI, XINT7:0	8		ns	(5)
T <sub>IH1</sub>	Input Hold from CLKIN — AD31:0, NMI, XINT7:0	2		ns	(5)
T <sub>IS2</sub>	Input Setup to CLKIN — RDYRCV and HOLD	8		ns	(6)
T <sub>IH2</sub>	Input Hold from CLKIN — RDYRCV and HOLD	1		ns	(6)
T <sub>IS3</sub>	Input Setup to CLKIN — RESET	8		ns	(7)
T <sub>IH3</sub>	Input Hold from CLKIN — RESET	2		ns	(7)
T <sub>IS4</sub>	Input Setup to RESET — ONCE, STEST	8		ns	(8)
T <sub>IH4</sub>	Input Hold from RESET — ONCE, STEST	2		ns	(8)
<b>RELATIVE OUTPUT TIMINGS</b>					
T <sub>LXL</sub>	ALE/ALE Width	0.5T <sub>C</sub> - 7.5		ns	(9)
T <sub>LXA</sub>	Address Hold from ALE/ALE Inactive				Equal Loading (9)
T <sub>DXD</sub>	DT/R Valid to DEN Active				Equal Loading (9)
<b>BOUNDARY SCAN TEST SIGNAL TIMINGS</b>					
T <sub>BSF</sub>	TCK Frequency		0.5T <sub>F</sub>	MHz	
T <sub>BSCH</sub>	TCK High Time	15		ns	Measured at 1.5 V (1)
T <sub>BSCCL</sub>	TCK Low Time	15		ns	Measured at 1.5 V (1)
T <sub>BSCR</sub>	TCK Rise Time		5	ns	0.8 V to 2.0 V (1)
T <sub>BSCF</sub>	TCK Fall Time		5	ns	2.0 V to 0.8 V (1)
T <sub>BISIS1</sub>	Input Setup to TCK — TDI, TMS	4		ns	
T <sub>BSIH1</sub>	Input Hold from TCK — TDI, TMS	6		ns	
T <sub>BSOV1</sub>	TDO Valid Delay	3	30	ns	(1, 10)
T <sub>BSOF1</sub>	TDO Float Delay	3	30	ns	(1, 10)



Table 17. 80960JA/JF AC Characteristics (25 MHz) (Sheet 3 of 3)

Symbol	Parameter	Min	Max	Units	Notes
T <sub>BSOV2</sub>	All Outputs (Non-Test) Valid Delay	3	30	ns	(1, 10)
T <sub>BSOF2</sub>	All Outputs (Non-Test) Float Delay	3	30	ns	(1, 10)
T <sub>BSIS2</sub>	Input Setup to TCK — All Inputs (Non-Test)	4		ns	
T <sub>BSIH2</sub>	Input Hold from TCK — All Inputs (Non-Test)	6		ns	

**NOTES:**

- Not tested.
- To ensure a 1:1 relationship between the amplitude of the input jitter and the internal clock, the jitter frequency spectrum should not have any power peaking between 500 KHz and 1/3 of the CLKIN frequency.
- Inactive ALE/ $\overline{\text{ALE}}$  refers to the falling edge of ALE and the rising edge of  $\overline{\text{ALE}}$ . For inactive ALE/ $\overline{\text{ALE}}$  timings, refer to Relative Output Timings in this table.
- A float condition occurs when the output current becomes less than  $I_{LO}$ . Float delay is not tested, but is designed to be no greater than the valid delay.
- AD31:0 are synchronous inputs. Setup and hold times must be met for proper processor operation.  $\overline{\text{NMI}}$  and XINT7:0 may be synchronous or asynchronous. Meeting setup and hold time guarantees recognition at a particular clock edge. For asynchronous operation,  $\overline{\text{NMI}}$  and XINT7:0 must be asserted for a minimum of two CLKIN periods to guarantee recognition.
- RDYRCV and HOLD are synchronous inputs. Setup and hold times must be met for proper processor operation.
- RESET may be synchronous or asynchronous. Meeting setup and hold time guarantees recognition at a particular clock edge.
- ONCE and STEST must be stable at the rising edge of  $\overline{\text{RESET}}$  for proper operation.
- Guaranteed by design. May not be 100% tested.
- Relative to falling edge of TCK.

Table 18. 80960JA/JF AC Characteristics (16 MHz) (Sheet 1 of 3)

Symbol	Parameter	Min	Max	Units	Notes
<b>INPUT CLOCK TIMINGS</b>					
T <sub>F</sub>	CLKIN Frequency	8	16.67	MHz	
T <sub>C</sub>	CLKIN Period	60	62.5	ns	
T <sub>CS</sub>	CLKIN Period Stability		± 250	ps	(1, 2)
T <sub>CH</sub>	CLKIN High Time	24		ns	Measured at 1.5 V (1)
T <sub>CL</sub>	CLKIN Low Time	24		ns	Measured at 1.5 V (1)
T <sub>CR</sub>	CLKIN Rise Time		8	ns	0.8 V to 2.0 V (1)
T <sub>CF</sub>	CLKIN Fall Time		8	ns	2.0 V to 0.8 V (1)

Table 18. 80960JA/JF AC Characteristics (16 MHz) (Sheet 2 of 3)

Symbol	Parameter	Min	Max	Units	Notes
<b>SYNCHRONOUS OUTPUT TIMINGS</b>					
$T_{OV1}$	Output Valid Delay, Except $\overline{\text{ALE}}/\overline{\text{ALE}}$ Inactive and $\overline{\text{DT}}/\overline{\text{R}}$	3.5	18	ns	(3)
$T_{OV2}$	Output Valid Delay, $\overline{\text{DT}}/\overline{\text{R}}$	$0.5T_C + 3.5$	$0.5T_C + 18$	ns	
$T_{OF}$	Output Float Delay	3.5	16	ns	(4)
<b>SYNCHRONOUS INPUT TIMINGS</b>					
$T_{IS1}$	Input Setup to CLKIN — AD31:0, NMI, XINT7:0	8		ns	(5)
$T_{IH1}$	Input Hold from CLKIN — AD31:0, NMI, XINT7:0	2		ns	(5)
$T_{IS2}$	Input Setup to CLKIN — RDYRCV and HOLD	8		ns	(6)
$T_{IH2}$	Input Hold from CLKIN — RDYRCV and HOLD	1		ns	(6)
$T_{IS3}$	Input Setup to CLKIN — $\overline{\text{RESET}}$	8		ns	(7)
$T_{IH3}$	Input Hold from CLKIN — $\overline{\text{RESET}}$	2		ns	(7)
$T_{IS4}$	Input Setup to $\overline{\text{RESET}}$ — $\overline{\text{ONCE}}$ , STEST	8		ns	(8)
$T_{IH4}$	Input Hold from $\overline{\text{RESET}}$ — $\overline{\text{ONCE}}$ , STEST	2		ns	(8)
<b>RELATIVE OUTPUT TIMINGS</b>					
$T_{LXL}$	$\overline{\text{ALE}}/\overline{\text{ALE}}$ Width	$0.5T_C - 8$		ns	(9)
$T_{LXA}$	Address Hold from $\overline{\text{ALE}}/\overline{\text{ALE}}$ Inactive				Equal Loading (9)
$T_{DXD}$	$\overline{\text{DT}}/\overline{\text{R}}$ Valid to $\overline{\text{DEN}}$ Active				Equal Loading (9)
<b>BOUNDARY SCAN TEST SIGNAL TIMINGS</b>					
$T_{BSF}$	TCK Frequency		$0.5T_F$	MHz	
$T_{BSCH}$	TCK High Time	15		ns	Measured at 1.5 V (1)
$T_{BSCL}$	TCK Low Time	15		ns	Measured at 1.5 V (1)
$T_{BSCR}$	TCK Rise Time		5	ns	0.8 V to 2.0 V (1)
$T_{BSCF}$	TCK Fall Time		5	ns	2.0 V to 0.8 V (1)
$T_{BSIS1}$	Input Setup to TCK — TDI, TMS	4		ns	

Table 18. 80960JA/JF AC Characteristics (16 MHz) (Sheet 3 of 3)

Symbol	Parameter	Min	Max	Units	Notes
T <sub>BSIH1</sub>	Input Hold from TCK — TDI, TMS	6		ns	
T <sub>BSOV1</sub>	TDO Valid Delay	3	30	ns	(1, 10)
T <sub>BSOF1</sub>	TDO Float Delay	3	36	ns	(1, 10)
T <sub>BSOV2</sub>	All Outputs (Non-Test) Valid Delay	3	30	ns	(1, 10)
T <sub>BSOF2</sub>	All Outputs (Non-Test) Float Delay	3	36	ns	(1, 10)
T <sub>BSIS2</sub>	Input Setup to TCK — All Inputs (Non-Test)	4		ns	
T <sub>BSIH2</sub>	Input Hold from TCK — All Inputs (Non-Test)	6		ns	

**NOTES:**

1. Not tested.
2. To ensure a 1:1 relationship between the amplitude of the input jitter and the internal clock, the jitter frequency spectrum should not have any power peaking between 500 KHz and 1/3 of the CLKIN frequency.
3. Inactive ALE/ $\overline{\text{ALE}}$  refers to the falling edge of ALE and the rising edge of  $\overline{\text{ALE}}$ . For inactive ALE/ $\overline{\text{ALE}}$  timings, refer to Relative Output Timings in this table.
4. A float condition occurs when the output current becomes less than I<sub>LO</sub>. Float delay is not tested, but is designed to be no greater than the valid delay.
5. AD31:0 are synchronous inputs. Setup and hold times must be met for proper processor operation.  $\overline{\text{NMI}}$  and  $\overline{\text{XINT7:0}}$  may be synchronous or asynchronous. Meeting setup and hold time guarantees recognition at a particular clock edge. For asynchronous operation,  $\overline{\text{NMI}}$  and  $\overline{\text{XINT7:0}}$  must be asserted for a minimum of two CLKIN periods to guarantee recognition.
6. RDYRCV and HOLD are synchronous inputs. Setup and hold times must be met for proper processor operation.
7. RESET may be synchronous or asynchronous. Meeting setup and hold time guarantees recognition at a particular clock edge.
8. ONCE and STEST must be stable at the rising edge of  $\overline{\text{RESET}}$  for proper operation.
9. Guaranteed by design. May not be 100% tested.
10. Relative to falling edge of TCK.

#### 4.5.1 AC Test Conditions and Derating Curves

The AC Specifications in **Section 4.5, AC Specifications** are tested with the 50 pF load indicated in Figure 6. Figure 7 shows how timings vary with load capacitance; Figure 8 shows how output rise and fall times vary with load capacitance.

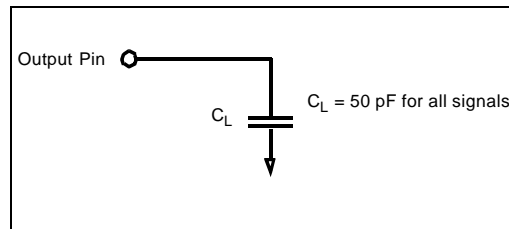


Figure 6. AC Test Load

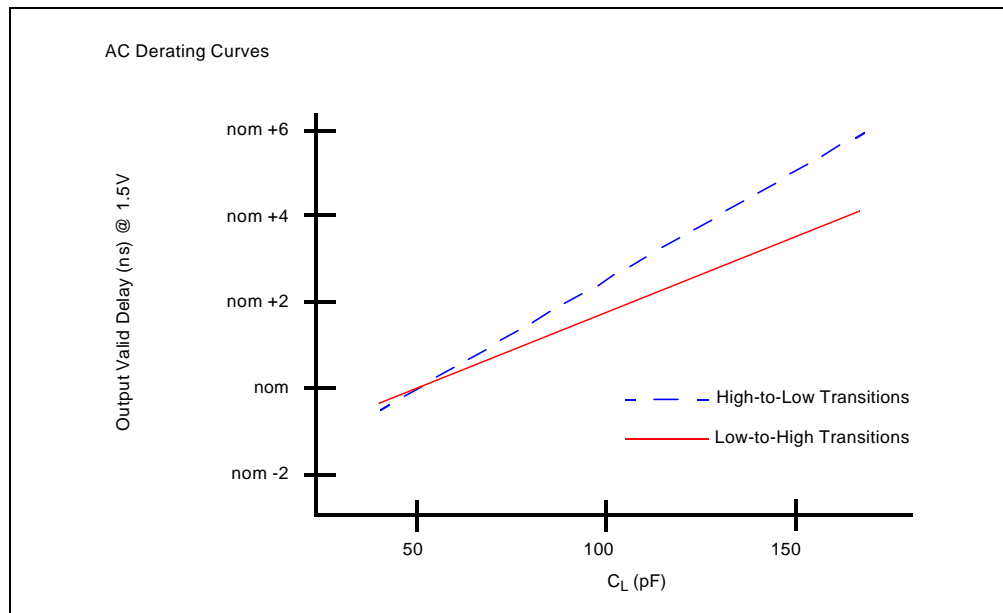


Figure 7. Output Delay or Hold vs. Load Capacitance

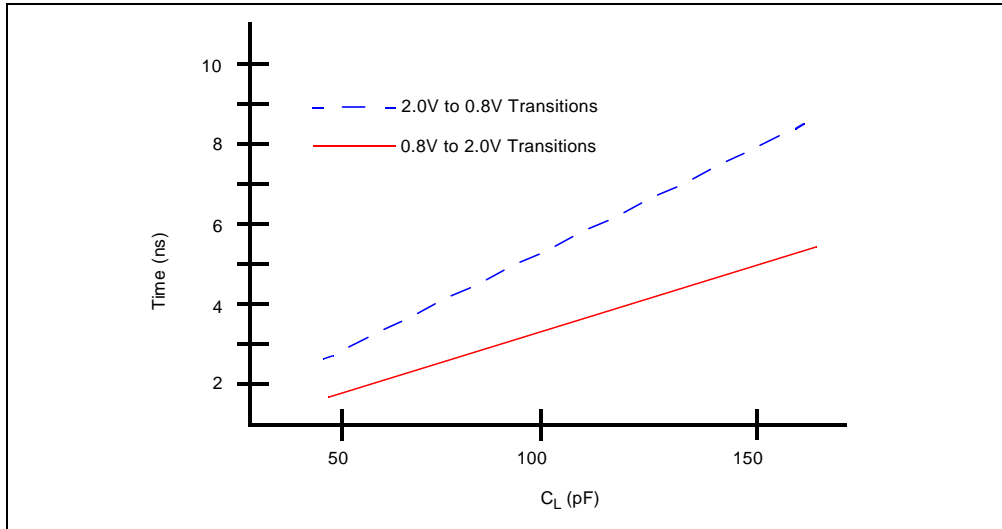


Figure 8. Rise and Fall Time Derating

4.5.2 AC Timing Waveforms

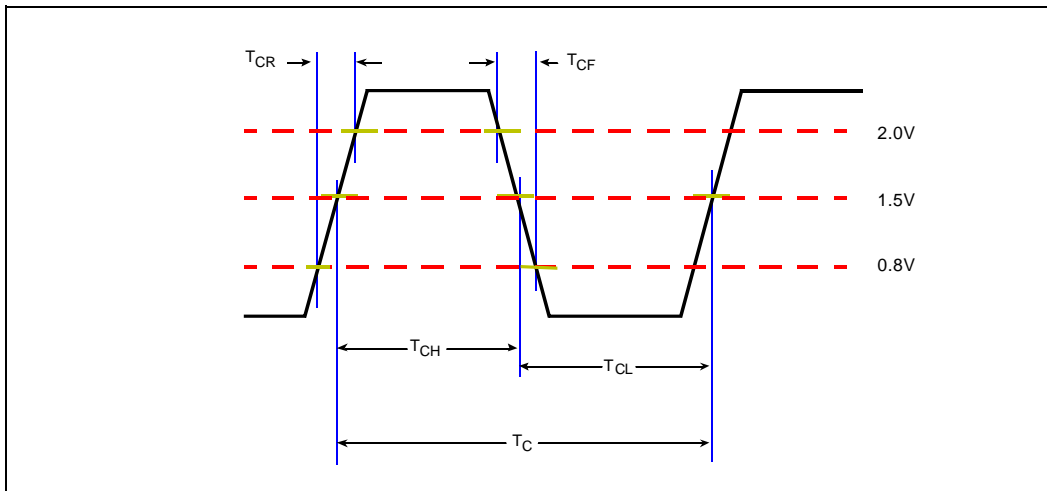


Figure 9. CLKIN Waveform

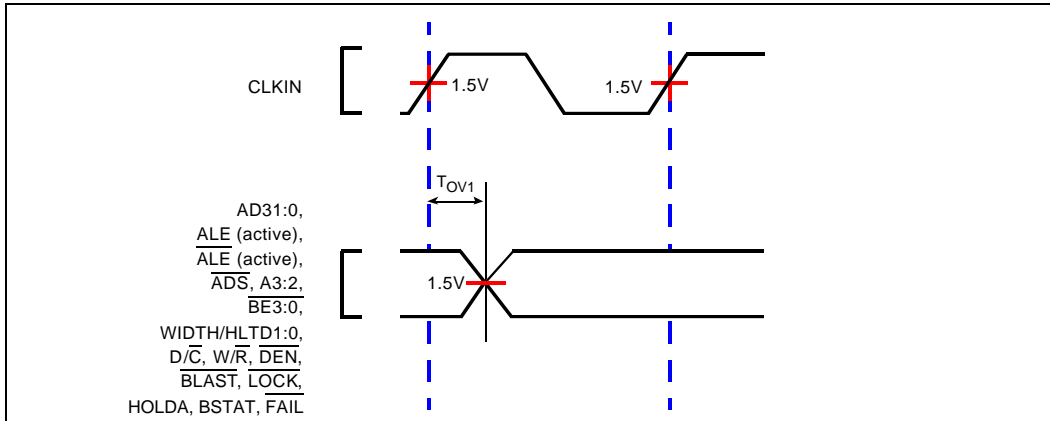


Figure 10. Output Delay Waveform for  $T_{OV1}$

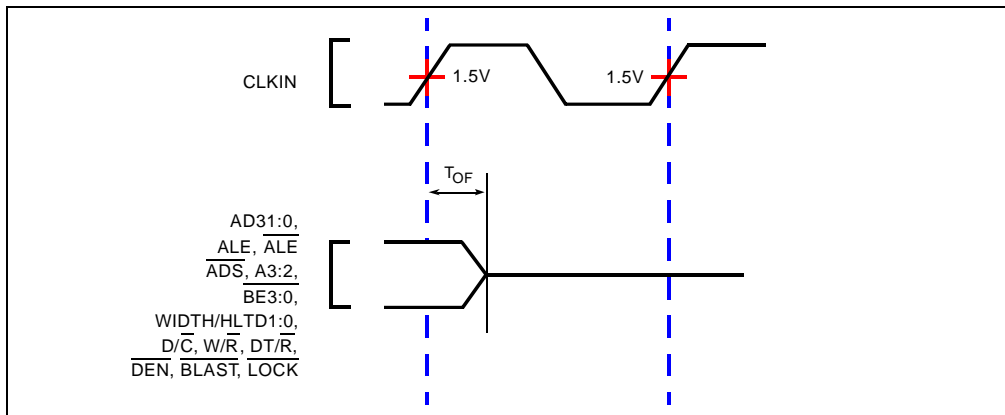


Figure 11. Output Float Waveform for  $T_{OF}$



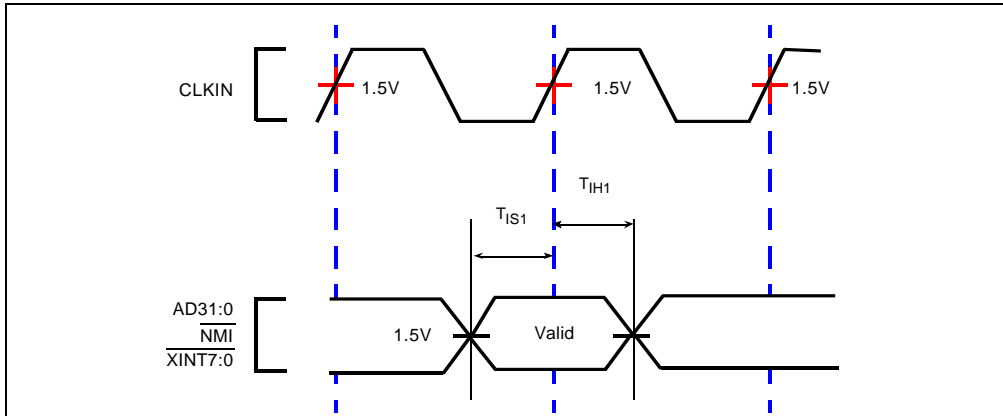


Figure 12. Input Setup and Hold Waveform for  $T_{IS1}$  and  $T_{IH1}$

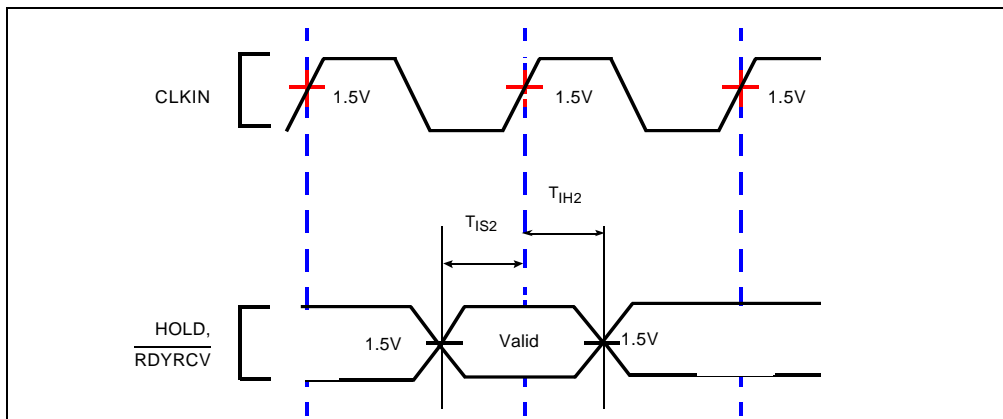


Figure 13. Input Setup and Hold Waveform for  $T_{IS2}$  and  $T_{IH2}$

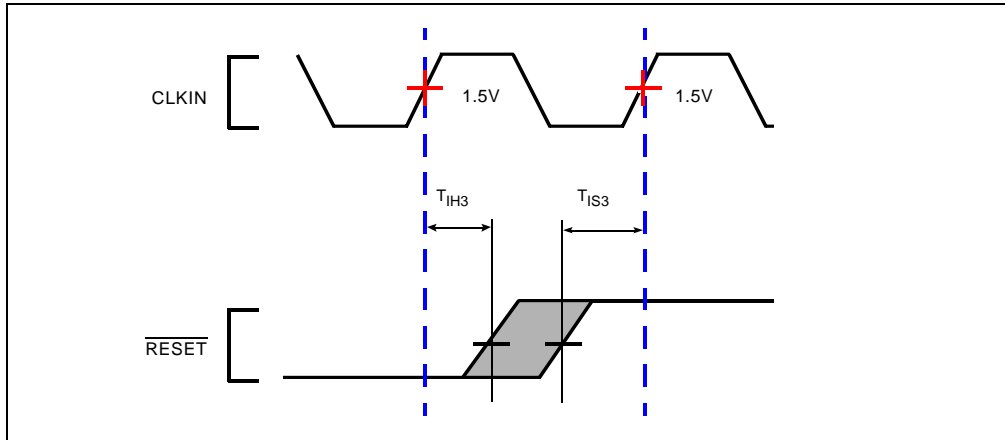


Figure 14. Input Setup and Hold Waveform for  $T_{IS3}$  and  $T_{IH3}$

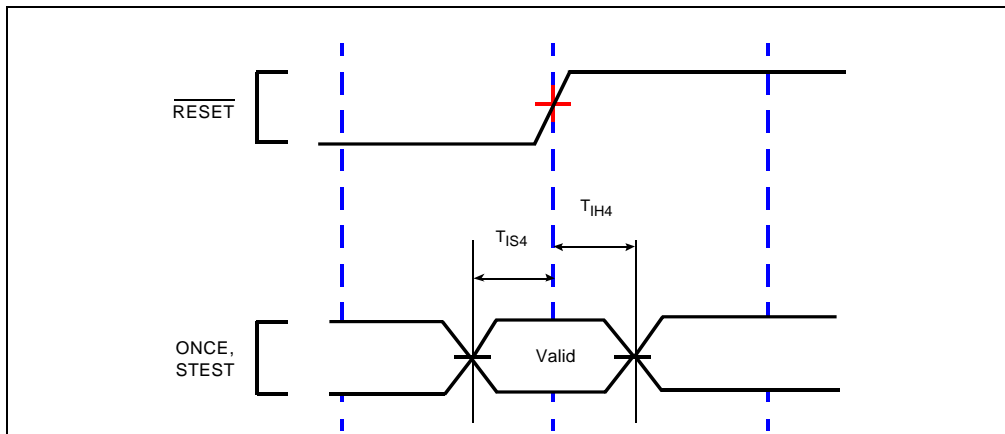


Figure 15. Input Setup and Hold Waveform for  $T_{IS4}$  and  $T_{IH4}$



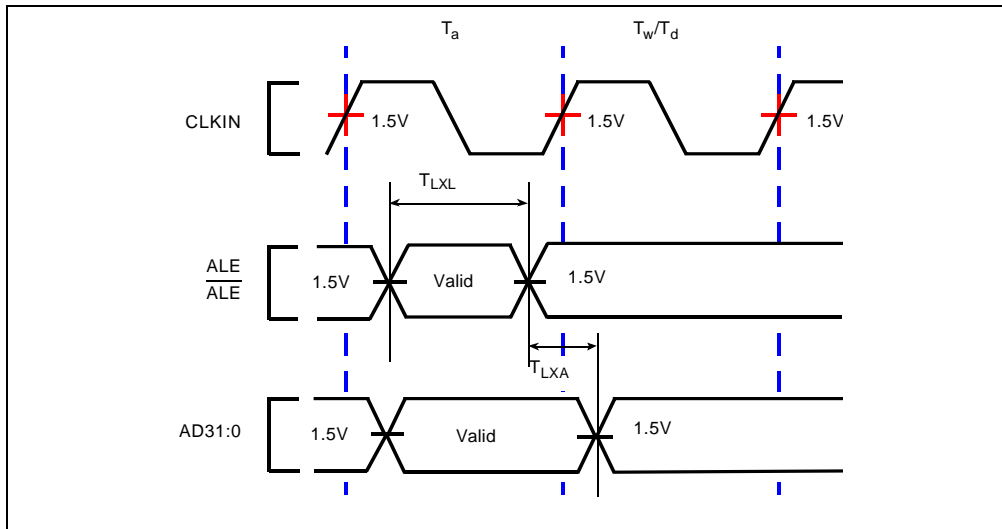


Figure 16. Relative Timings Waveform for  $T_{LXL}$  and  $T_{LXA}$

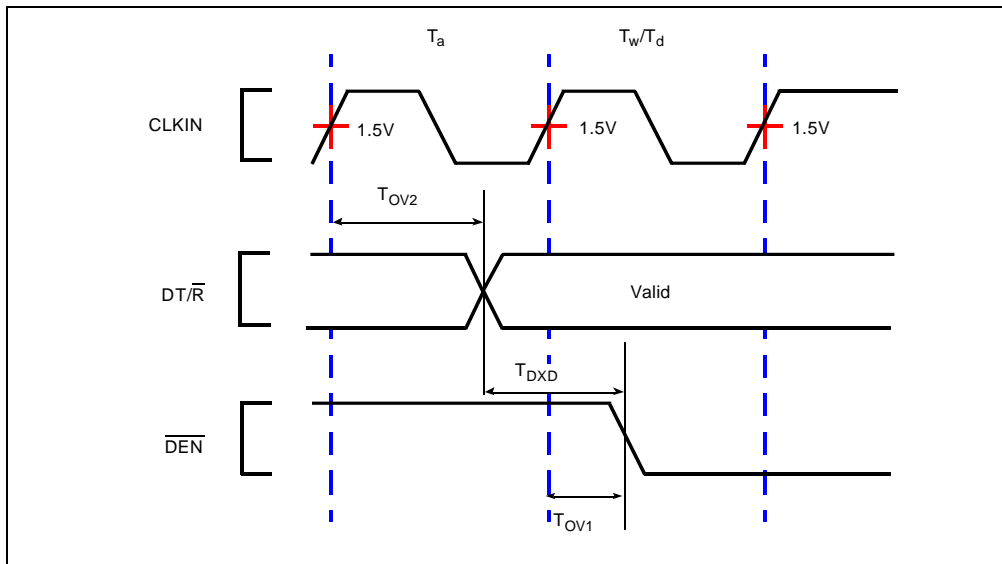


Figure 17.  $\overline{DT/R}$  and  $\overline{DEN}$  Timings Waveform

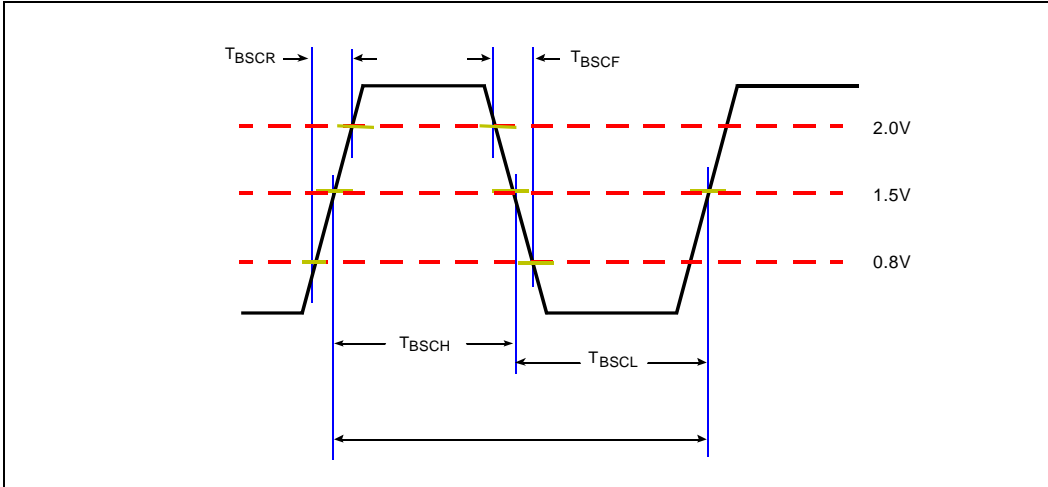


Figure 18. TCK Waveform

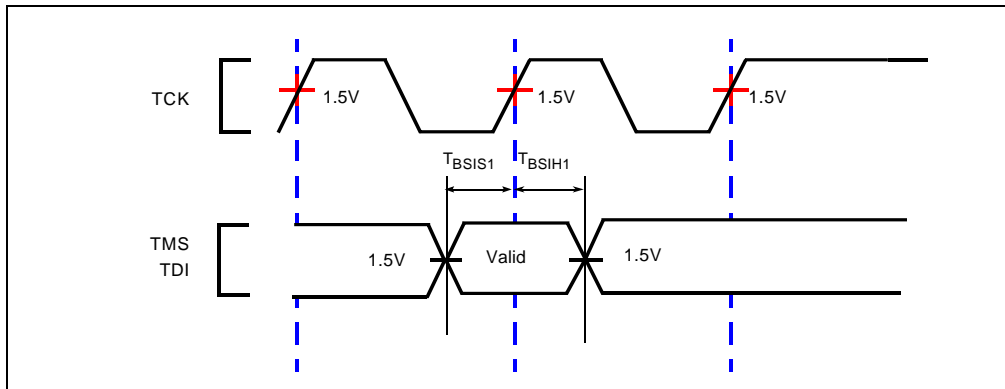


Figure 19. Input Setup and Hold Waveforms for  $T_{BSI1}$  and  $T_{BSIH1}$

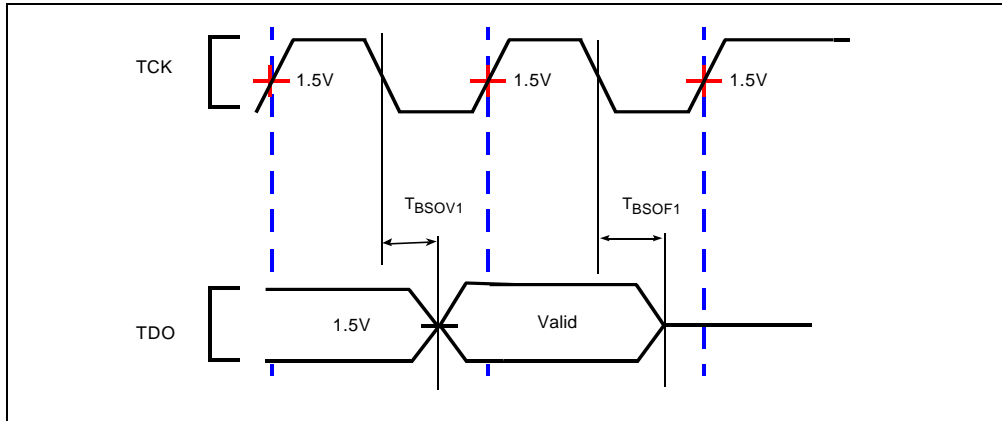


Figure 20. Output Delay and Output Float Waveform for  $T_{BSOV1}$  AND  $T_{BSOF1}$

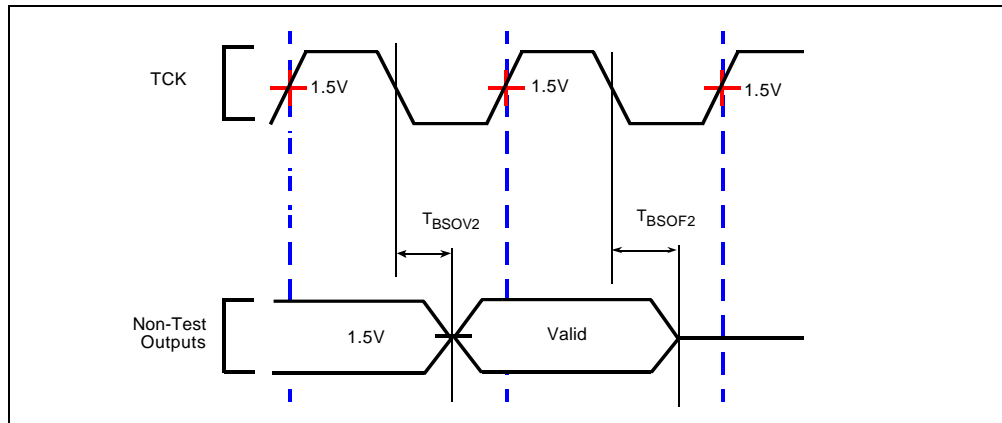


Figure 21. Output Delay and Output Float Waveform for  $T_{BSOV2}$  and  $T_{BSOF2}$

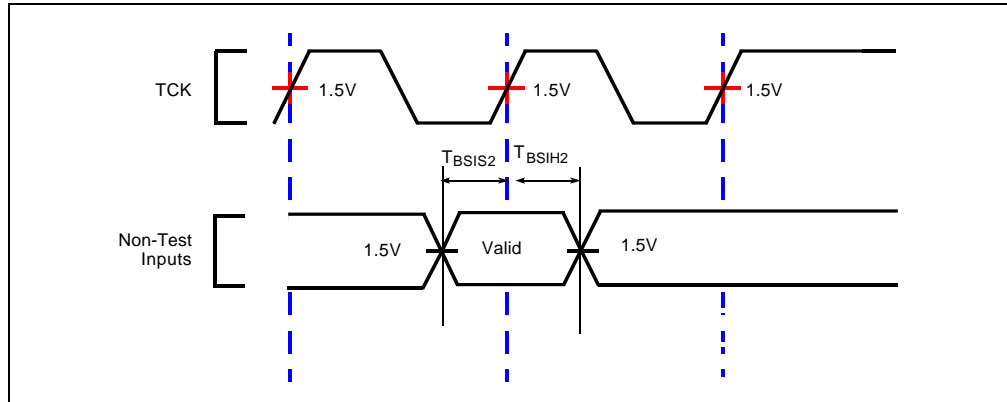


Figure 22. Input Setup and Hold Waveform for  $T_{BSIS2}$  and  $T_{BSIH2}$

## 5.0 BUS FUNCTIONAL WAVEFORMS

Figures 23 through 28 illustrate typical 80960JA/JF bus transactions. Figure 29 depicts the bus arbitration sequence. Figure 30 illustrates the processor reset sequence from the time power is applied to the device. Figure 31 illustrates the processor reset sequence when the processor is in operation. Figure 32 illustrates the processor ONCE sequence from the time power is applied to the device. Figures 33 and 34 also show accesses on 32-bit buses. Tables 19 through 22 summarize all possible combinations of bus accesses across 8-, 16-, and 32-bit buses according to data alignment.

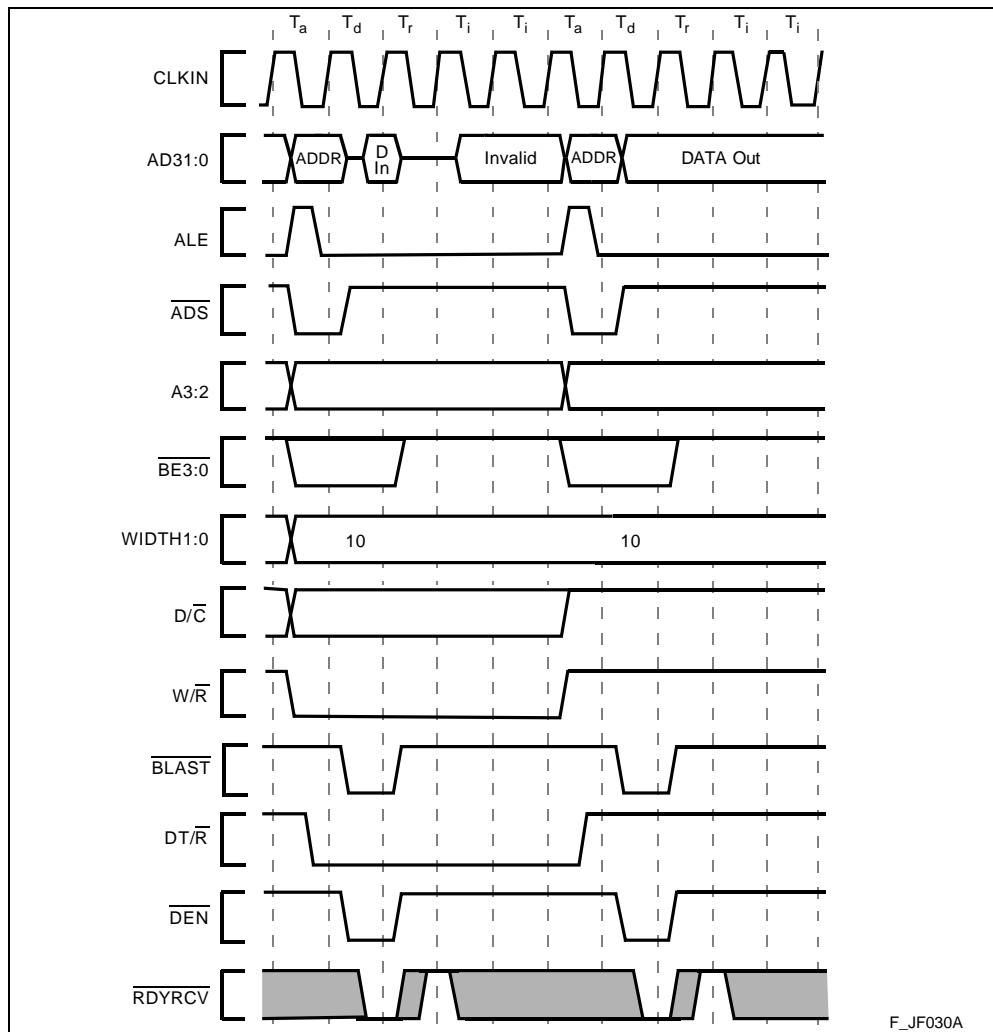


Figure 23. Non-Burst Read and Write Transactions Without Wait States, 32-Bit Bus

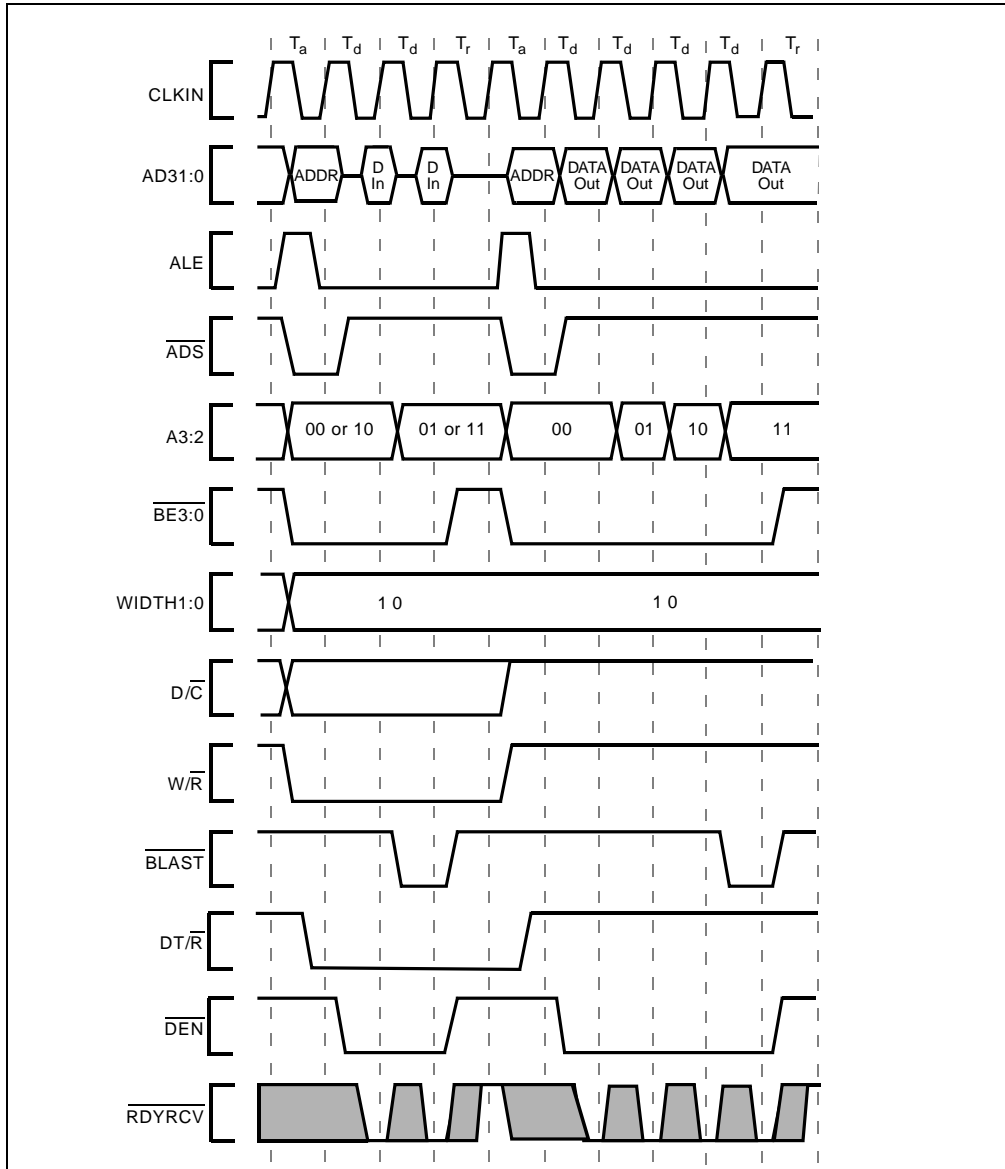


Figure 24. Burst Read and Write Transactions Without Wait States, 32-Bit Bus

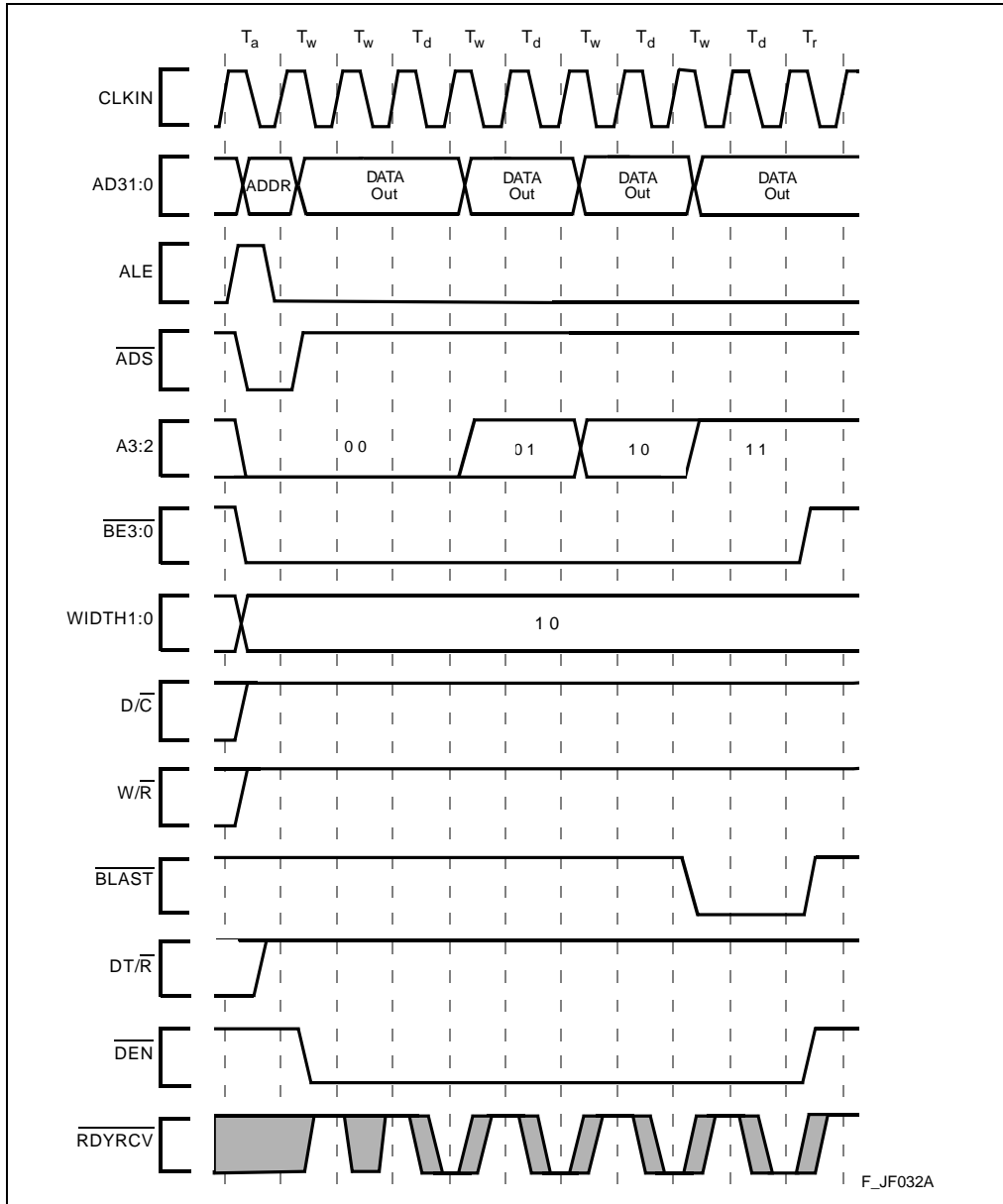


Figure 25. Burst Write Transactions With 2,1,1,1 Wait States, 32-Bit Bus

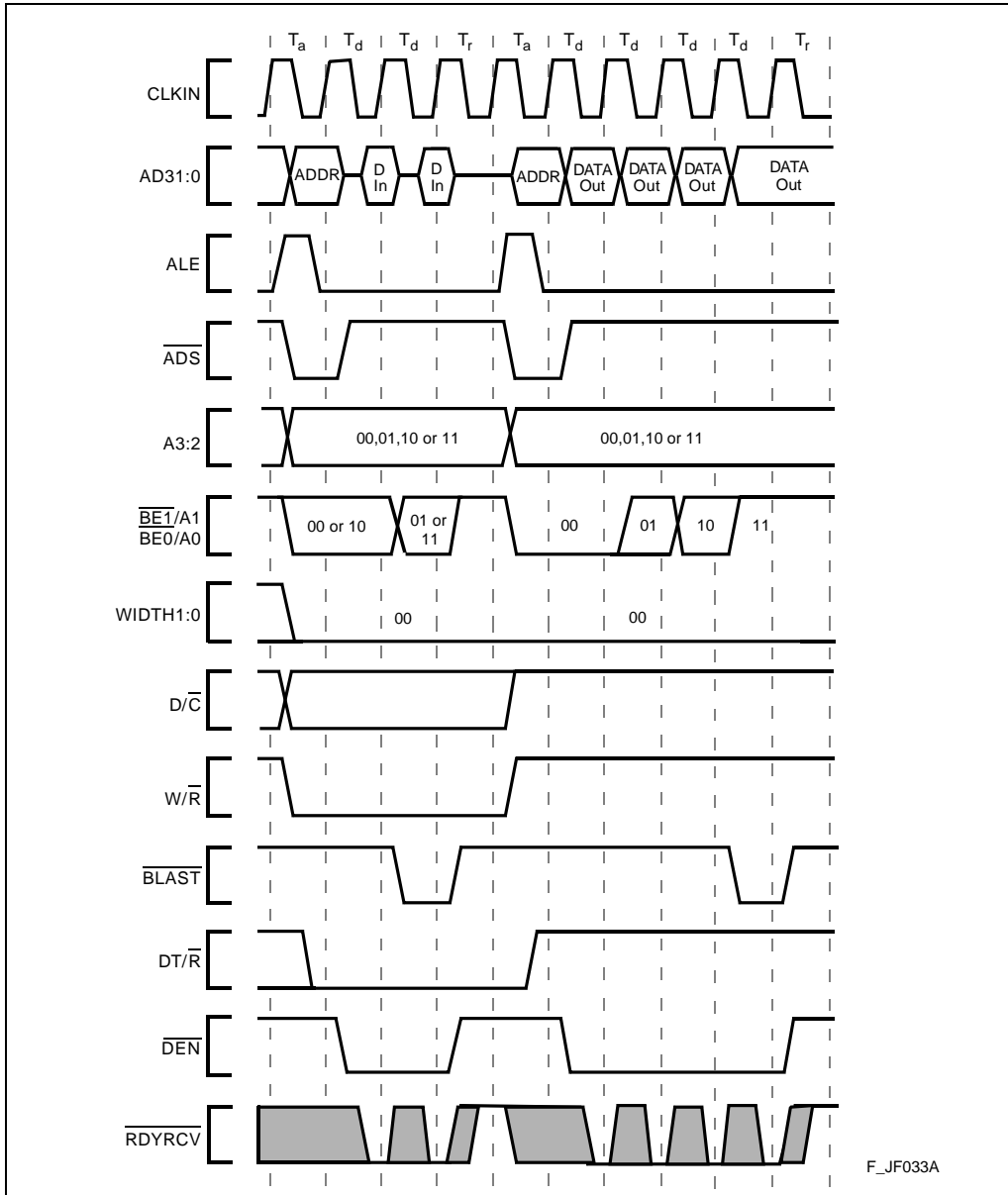


Figure 26. Burst Read and Write Transactions Without Wait States, 8-Bit Bus



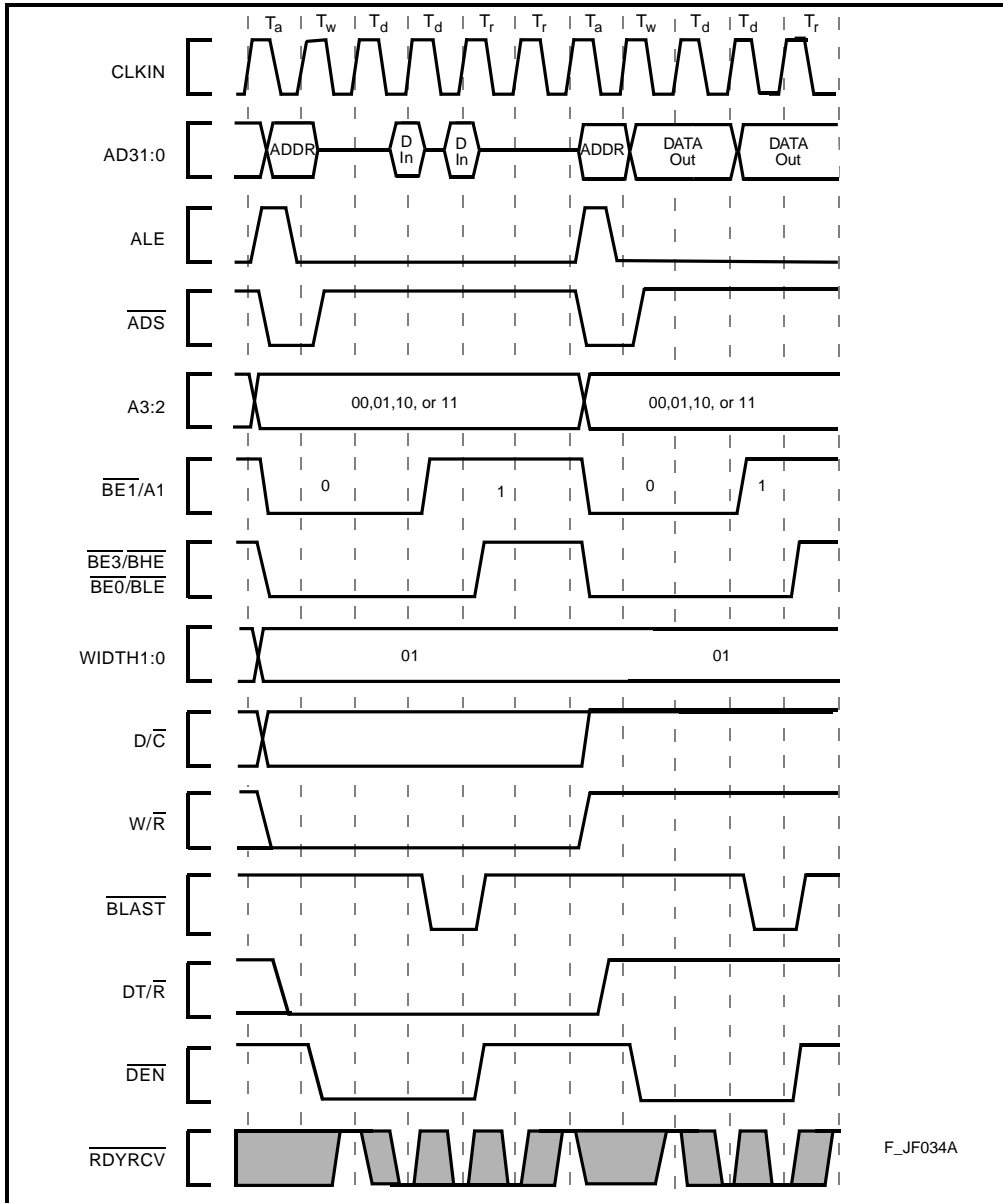


Figure 27. Burst Read and Write Transactions With 1, 0 Wait States and Extra  $T_r$  State on Read, 16-Bit Bus

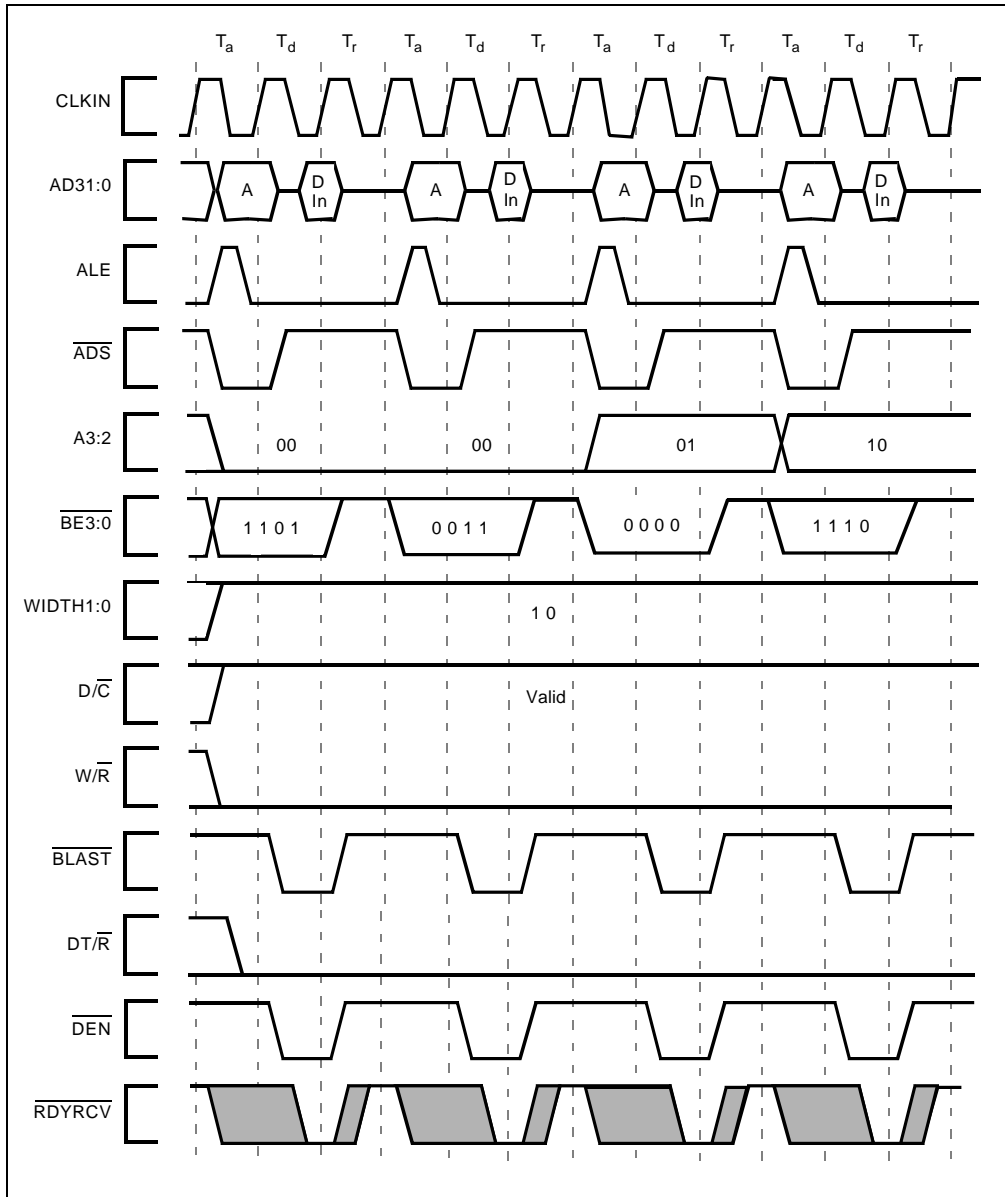


Figure 28. Bus Transactions Generated by Double Word Read Bus Request, Misaligned One Byte From Quad Word Boundary, 32-Bit Bus, Little Endian

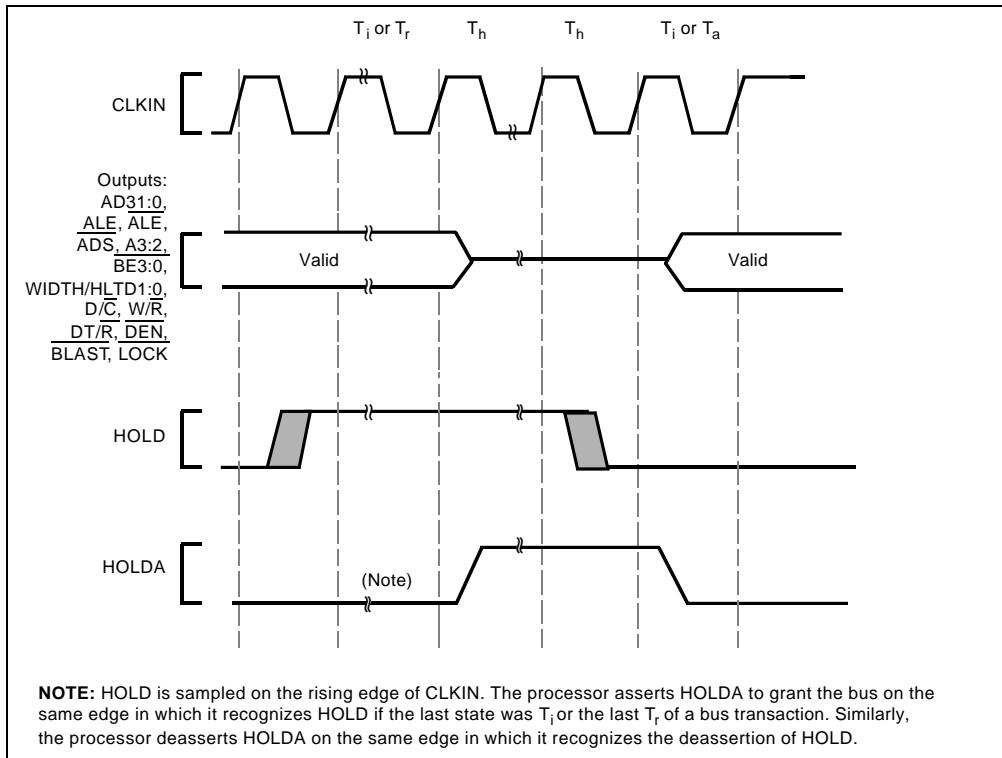


Figure 29. HOLD/HOLDA Waveform For Bus Arbitration

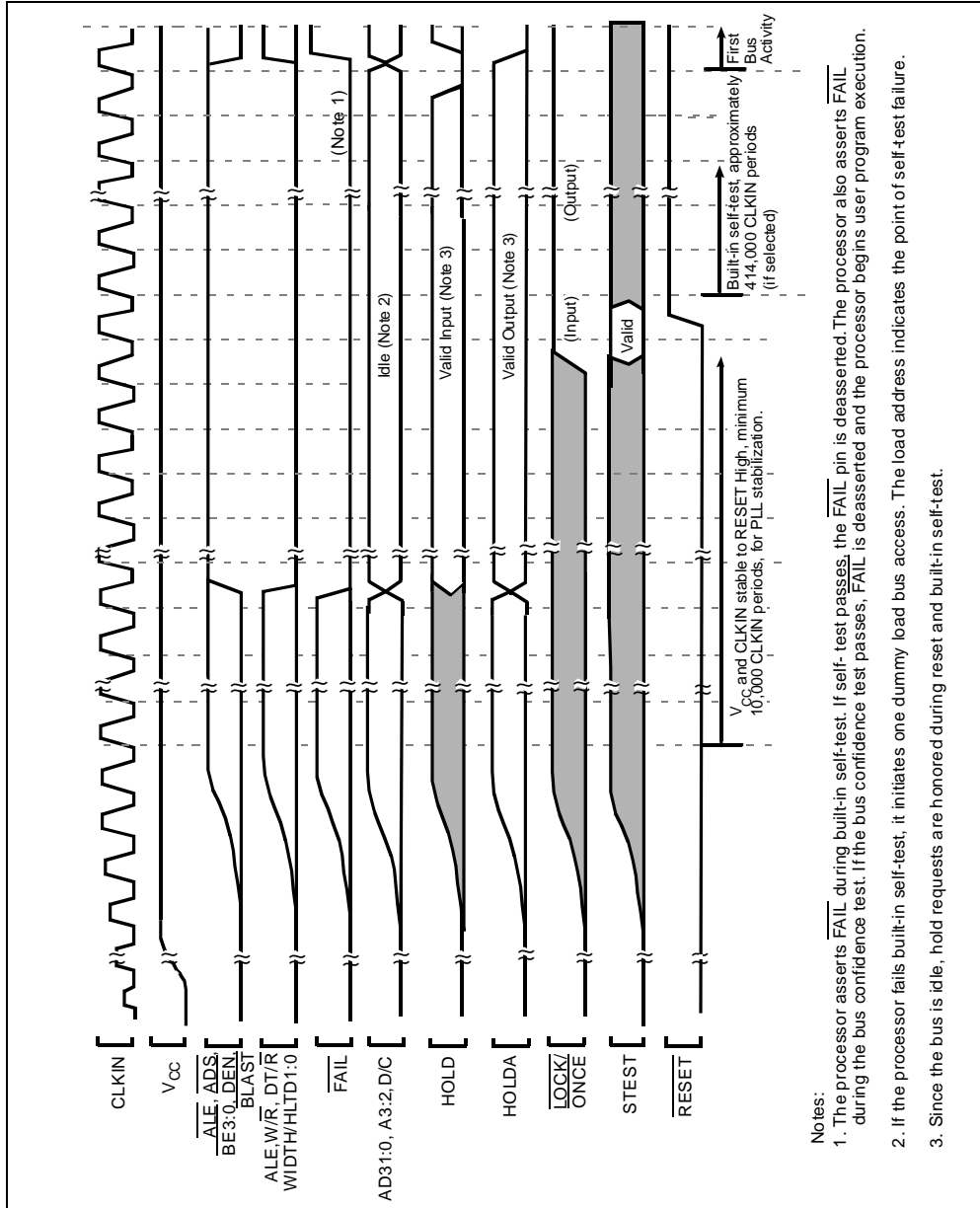


Figure 30. Cold Reset Waveform

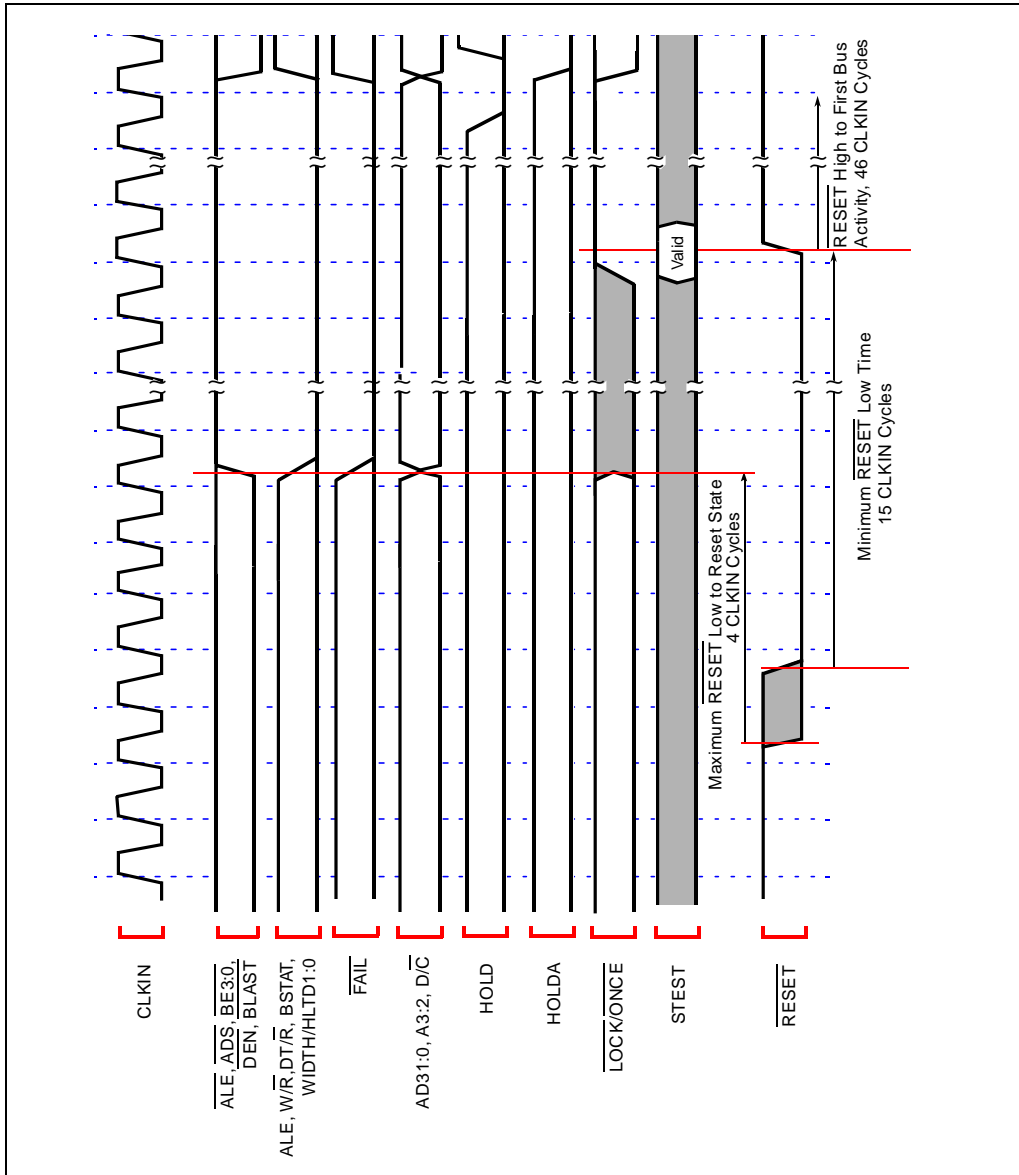


Figure 31. Warm Reset Waveform

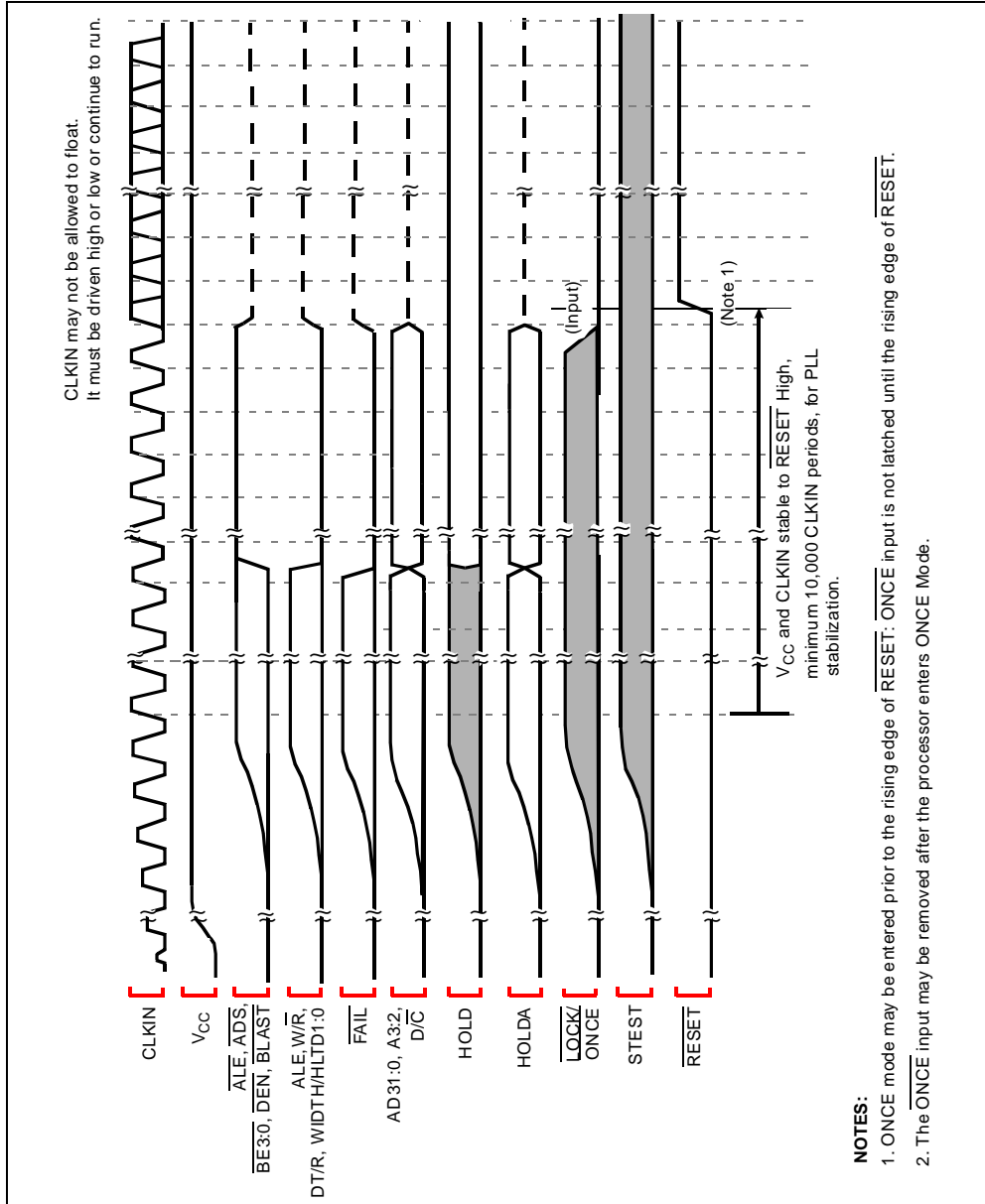


Figure 32. Entering the ONCE State

**Table 19. Natural Boundaries for Load and Store Accesses**

Data Width	Natural Boundary (Bytes)
Byte	1
Short Word	2
Word	4
Double Word	8
Triple Word	16
Quad Word	16

**Table 20. Summary of Byte Load and Store Accesses**

Address Offset from Natural Boundary (in Bytes)	Accesses on 8-Bit Bus (WIDTH1:0=00)	Accesses on 16-Bit Bus (WIDTH1:0=01)	Accesses on 32-Bit Bus (WIDTH1:0=10)
+0 (aligned)	• byte access	• byte access	• byte access

**Table 21. Summary of Short Word Load and Store Accesses**

Address Offset from Natural Boundary (in Bytes)	Accesses on 8-Bit Bus (WIDTH1:0=00)	Accesses on 16-Bit Bus (WIDTH1:0=01)	Accesses on 32-Bit Bus (WIDTH1:0=10)
+0 (aligned)	• burst of 2 bytes	• short-word access	• short-word access
+1	• 2 byte accesses	• 2 byte accesses	• 2 byte accesses

Table 22. Summary of  $n$ -Word Load and Store Accesses ( $n = 1, 2, 3, 4$ )

Address Offset from Natural Boundary in Bytes	Accesses on 8-Bit Bus (WIDTH1:0=00)	Accesses on 16-Bit Bus (WIDTH1:0=01)	Accesses on 32-Bit Bus (WIDTH1:0=10)
+0 (aligned) ( $n=1, 2, 3, 4$ )	<ul style="list-style-type: none"> <li><math>n</math> burst(s) of 4 bytes</li> </ul>	<ul style="list-style-type: none"> <li>case <math>n=1</math>: burst of 2 short words</li> <li>case <math>n=2</math>: burst of 4 short words</li> <li>case <math>n=3</math>: burst of 4 short words burst of 2 short words</li> <li>case <math>n=4</math>: 2 bursts of 4 short words</li> </ul>	<ul style="list-style-type: none"> <li>burst of <math>n</math> word(s)</li> </ul>
+1 ( $n=1, 2, 3, 4$ ) +5 ( $n=2, 3, 4$ ) +9 ( $n=3, 4$ ) +13 ( $n=3, 4$ )	<ul style="list-style-type: none"> <li>byte access</li> <li>burst of 2 bytes</li> <li><math>n-1</math> burst(s) of 4 bytes</li> <li>byte access</li> </ul>	<ul style="list-style-type: none"> <li>byte access</li> <li>short-word access</li> <li><math>n-1</math> burst(s) of 2 short words</li> <li>byte access</li> </ul>	<ul style="list-style-type: none"> <li>byte access</li> <li>short-word access</li> <li><math>n-1</math> word access(es)</li> <li>byte access</li> </ul>
+2 ( $n=1, 2, 3, 4$ ) +6 ( $n=2, 3, 4$ ) +10 ( $n=3, 4$ ) +14 ( $n=3, 4$ )	<ul style="list-style-type: none"> <li>burst of 2 bytes</li> <li><math>n-1</math> burst(s) of 4 bytes</li> <li>burst of 2 bytes</li> </ul>	<ul style="list-style-type: none"> <li>short-word access</li> <li><math>n-1</math> burst(s) of 2 short words</li> <li>short-word access</li> </ul>	<ul style="list-style-type: none"> <li>short-word access</li> <li><math>n-1</math> word access(es)</li> <li>short-word access</li> </ul>
+3 ( $n=1, 2, 3, 4$ ) +7 ( $n=2, 3, 4$ ) +11 ( $n=3, 4$ ) +15 ( $n=3, 4$ )	<ul style="list-style-type: none"> <li>byte access</li> <li><math>n-1</math> burst(s) of 4 bytes</li> <li>burst of 2 bytes</li> <li>byte access</li> </ul>	<ul style="list-style-type: none"> <li>byte access</li> <li><math>n-1</math> burst(s) of 2 short words</li> <li>short-word access</li> <li>byte access</li> </ul>	<ul style="list-style-type: none"> <li>byte access</li> <li><math>n-1</math> word access(es)</li> <li>short-word access</li> <li>byte access</li> </ul>
+4 ( $n=2, 3, 4$ ) +8 ( $n=3, 4$ ) +12 ( $n=3, 4$ )	<ul style="list-style-type: none"> <li><math>n</math> burst(s) of 4 bytes</li> </ul>	<ul style="list-style-type: none"> <li><math>n</math> burst(s) of 2 short words</li> </ul>	<ul style="list-style-type: none"> <li><math>n</math> word access(es)</li> </ul>



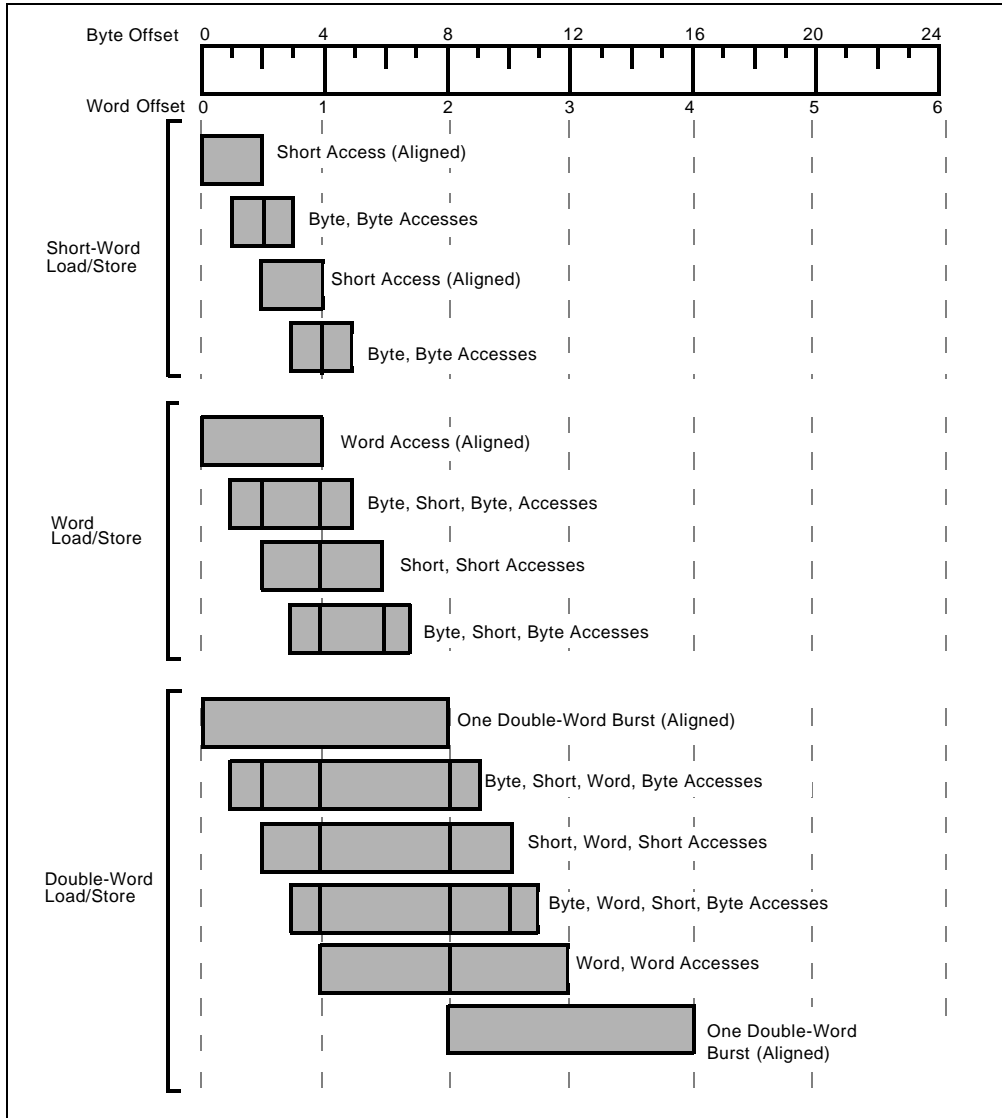


Figure 33. Summary of Aligned and Unaligned Accesses (32-Bit Bus)

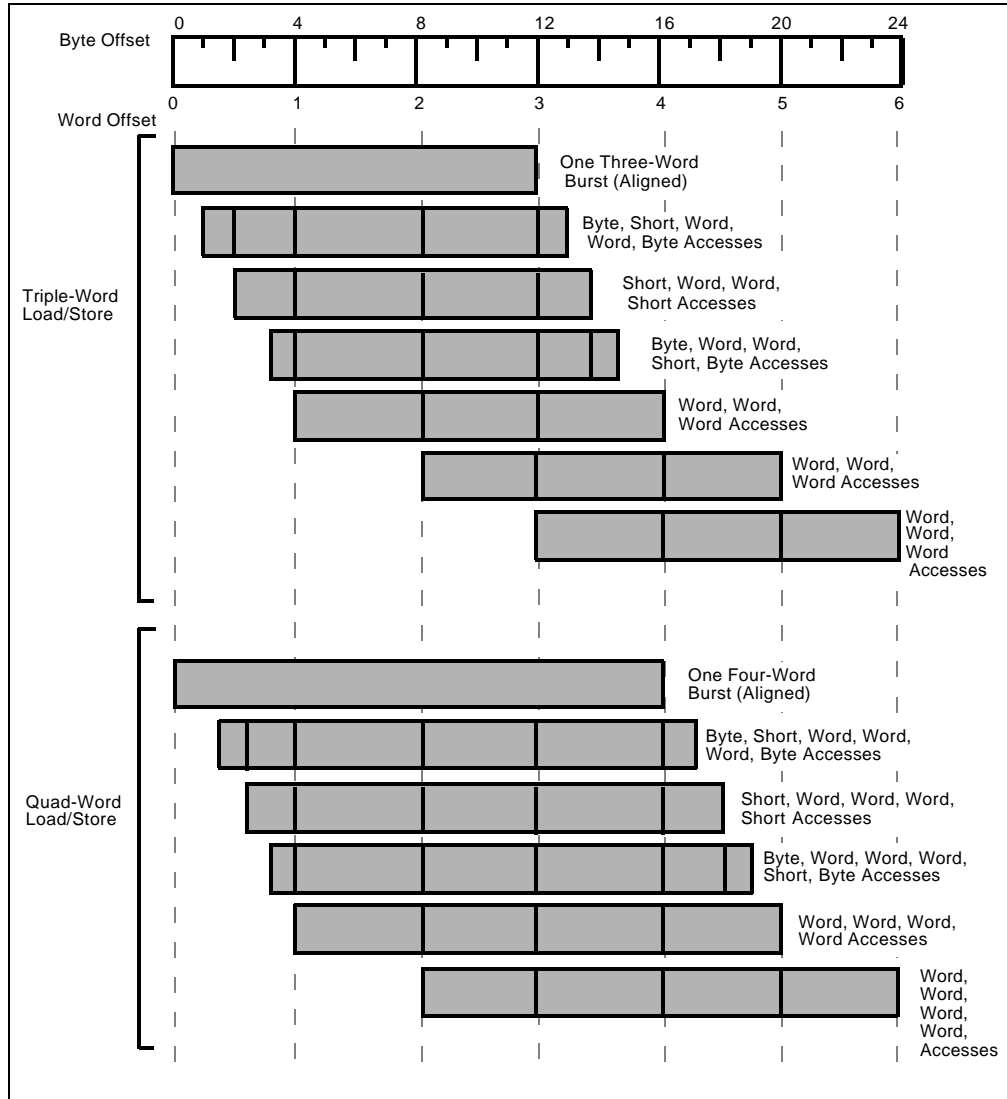


Figure 34. Summary of Aligned and Unaligned Accesses (32-Bit Bus) (Continued)

## 6.0 DEVICE IDENTIFICATION

80960JA/JF processors may be identified electrically according to device type and stepping (see Table 23). The 32-bit identifier is accessible in three ways:

- Upon reset, the identifier is placed into the g0 register.
- The identifier may be accessed from supervisor mode at any time by reading the DEVICEID register at address FF008710H.
- The IEEE Standard 1149.1 Test Access Port may select the DEVICE ID register through the IDCODE instruction.

The device and stepping letter is also printed on the top side of the product package.

**Table 23. 80960JA/JF Die and Stepping Reference**

Device and Stepping	Version Number	Part Number	Manufacturer	X	Complete ID (Hex)
80960JA A, A2	0000	1000 1000 0010 0001	0000 0001 001	1	08821013
80960JF A, A2	0000	1000 1000 0010 0000	0000 0001 001	1	08820013

**NOTE:** This data sheet applies to the 80960JA/JF A and 80960JA/JF A2 steppings.

## 7.0 REVISION HISTORY

This data sheet supersedes revision 272504-003. Table 24 indicates significant changes since that revision. Table 24, Table 24, and Table 24 detail changes which occurred prior to revision 272504-004.

**Table 24. Data Sheet Version -003 to -004 Revision History (Sheet 1 of 2)**

Section	Description
Table 13, 80960JA/JF DC Characteristics (pg. 23)	Removed I <sub>CC</sub> characteristics. Added V <sub>OLP</sub> (output ground bounce) specification.
Table 13, 80960JA/JF DC Characteristics (pg. 23)	New table for comprehensible I <sub>CC</sub> characteristics. Added I <sub>CC</sub> 's for reset mode. ONCE I <sub>CC</sub> Improved from 30 mA to 10 mA.
Section 4.5, AC Specifications (pg. 25)	Grouped AC Specifications tables by frequency. Added 25 MHz and 16 MHz AC specifications.
Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25) Section INPUT CLOCK TIMINGS	T <sub>CS</sub> (max) improved from ±0.1% to ±250 ps
Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25) Section SYNCHRONOUS OUTPUT TIMINGS	T <sub>OV1</sub> (min) improved from 3.0 ns to 3.5 ns. T <sub>OV2</sub> (min) improved from 0.5T <sub>C</sub> + 3.0 ns to 0.5T <sub>C</sub> + 3.5 ns. T <sub>oF</sub> (min) improved from 3.0 ns to 3.5 ns.

**Table 24. Data Sheet Version -003 to -004 Revision History** (Sheet 2 of 2)

Section	Description
Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25) Section SYNCHRONOUS INPUT TIMINGS	$T_{IS2}$ (min) improved from 8 ns to 7.5 ns
Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25) Section RELATIVE OUTPUT TIMINGS	$T_{LXL}$ , $T_{LXA}$ , and $T_{DXD}$ (min) improved from $0.5T_C - 3$ ns to $0.5T_C - 7$ ns.
Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25) Section BOUNDARY SCAN TEST SIGNAL TIMINGS	$T_{BSF}$ (max) improved from 8 MHz to $0.5T_F$ $T_{BSIS1}$ (min) improved from 8 ns to 4 ns. $T_{BSIH1}$ (min) improved from 10 ns to 6 ns. $T_{BSIS2}$ (min) improved from 8 ns to 4 ns. $T_{BSIH2}$ (min) improved from 10 ns to 6 ns.

**Table 25. Data Sheet Version -002 to -003 Revision History**

Section	Description
Section 4.3, Connection Recommendations (pg. 22)	Added precaution to drive $\overline{TRST}$ pin low to reset the TAP controller, even if the JTAG Boundary Scan function will not be used.
Table 13, 80960JA/JF DC Characteristics (pg. 23)	Changed $I_{L1}$ specification to $I_{L11}$ and added new specification $I_{L12}$ to denote leakage for TAP controller pins. $I_{CC}$ ONCE mode now indicated as 19mA (typ.) and 30 mA (max.).
Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25)	Minimum CLKIN frequency now specified as 8 MHz.
Table 16, Targeted 80960JA/JF Synchronous Input Timings (pg. 24)	$T_{IS1}$ and $T_{IH1}$ now applicable to $\overline{NMI}$ and $\overline{XINT7:0}$ signals with setup time (min.) improved from 7 to 6 ns and hold time (min.) improved from 3 to 2 ns. $T_{IH2}$ (min.) improved from 2 to 1 ns. $T_{IS4}$ (min.) improved from 7 to 6 ns and $T_{IH4}$ (min.) improved from 3 to 2 ns, with $T_{IS4}$ and $T_{IH4}$ now measured from the inactive edge of RESET.
Figure 7, Output Delay or Hold vs. Load Capacitance (pg. 32) Figure 8, Rise and Fall Time Derating (pg. 33)	Inserted data.
Figure 12, Input Setup and Hold Waveform for $T_{IS1}$ and $T_{IH1}$ (pg. 35) Figure 15, Input Setup and Hold Waveform for $T_{IS4}$ and $T_{IH4}$ (pg. 36)	Figures redrawn to correspond to changes in setup and hold specifications for $\overline{NMI}$ , $\overline{XINT7:0}$ , ONCE and STEST.

**Table 26. Data Sheet Version -001 to -002 Revision History** (Sheet 1 of 2)

Section	Description
Figure 2, 80960JA/JF Block Diagram (pg. 2)	Added 80960JA product version, which includes 2 Kbyte instruction cache and 1 Kbyte data cache.
Table 1, 80960Jx Instruction Set (pg. 5)	Renamed Conditional Move instruction to Conditional Select instruction.
Table 3, Pin Description — External Bus Signals (pg. 7)	Clarified description of unused AD31:0 pins during write operations. Corrected description of AD31:0 pins during HALT mode. Renamed ADS pin from Address/Data Status to Address Strobe (pin function unchanged). Corrected description of BE3:2 pins to indicate high state when pin(s) unused.
Table 4, Pin Description — Processor Control Signals, Test Signals and Power (pg. 10)	Added note that TDO does not float during ONCE Mode. Added note to ground TRST if TAP unused.
Figure 3, 132-Lead Pin Grid Array Bottom View - Pins Facing Up (pg. 13) Figure 4, 132-Lead Pin Grid Array Top View - Pins Facing Down (pg. 14) Table 6, 132-Lead PGA Pinout — In Signal Order (pg. 15) Table 7, 132-Lead PGA Pinout — In Pin Order (pg. 16)	New figures and tables. Pin C8 changed from $V_{CC}$ (previously published elsewhere) to NC. Processor operates correctly in a system with either connection.
Figure 5, 132-Lead PQFP - Top View (pg. 17) Table 8, 132-Lead PQFP Pinout — In Signal Order (pg. 18) Table 9, 132-Lead PQFP Pinout — In Pin Order (pg. 19)	New figure and tables. Lead 19 changed from $V_{CC(I/O)}$ (previously published elsewhere) to NC. Processor operates correctly in a system with either connection.
Section 3.2, Package Thermal Specifications (pg. 20)	New section with tables of thermal characteristics.
Section 4.0, ELECTRICAL SPECIFICATIONS (pg. 21)	New section with targeted operating conditions, targeted DC characteristics, targeted AC specifications and AC timing waveforms.
Figure 29, HOLD/HOLDA Waveform For Bus Arbitration (pg. 47)	Improved figure.

**Table 26. Data Sheet Version -001 to -002 Revision History** (Sheet 2 of 2)

Section	Description
Table 19, Natural Boundaries for Load and Store Accesses (pg. 51) Table 20, Summary of Byte Load and Store Accesses (pg. 51) Table 21, Summary of Short Word Load and Store Accesses (pg. 51) Table 22, Summary of n-Word Load and Store Accesses (n = 1, 2, 3, 4) (pg. 52) Figure 33, Summary of Aligned and Unaligned Accesses (32-Bit Bus) (pg. 53)	New tables and figures to explain bus access alignment.
Figure 30, Cold Reset Waveform (pg. 48)	New figure.
Section 6.0, DEVICE IDENTIFICATION (pg. 55)	New section.

**Table 27. Data Sheet Version -002 to -003 Revision History** (Sheet 1 of 2)

Section	Description
Section 4.3, Connection Recommendations (pg. 22)	Added precaution to drive $\overline{\text{TRST}}$ pin low to reset the TAP controller, even if the JTAG Boundary Scan function will not be used.
Table 13, 80960JA/JF DC Characteristics (pg. 23)	Changed $I_{L1}$ specification to $I_{L11}$ and added new specification $I_{L12}$ to denote leakage for TAP controller pins. $I_{CC}$ ONCE mode now indicated as 19mA (typ.) and 30 mA (max.).
Table 15, 80960JA/JF AC Characteristics (33 MHz) (pg. 25)	Minimum CLKIN frequency now specified as 8 MHz.
Table 16, Targeted 80960JA/JF Synchronous Input Timings (pg. 24)	$T_{IS1}$ and $T_{IH1}$ now applicable to $\overline{\text{NMI}}$ and $\overline{\text{XINT7:0}}$ signals with setup time (min.) improved from 7 to 6 ns and hold time (min.) improved from 3 to 2 ns. $T_{IH2}$ (min.) improved from 2 to 1 ns. $T_{IS4}$ (min.) improved from 7 to 6 ns and $T_{IH4}$ (min.) improved from 3 to 2 ns, with $T_{IS4}$ and $T_{IH4}$ now measured from the inactive edge of RESET.
Figure 7, Output Delay or Hold vs. Load Capacitance (pg. 32) Figure 8, Rise and Fall Time Derating (pg. 33)	Inserted data.

**Table 27. Data Sheet Version -002 to -003 Revision History** (Sheet 2 of 2)

<b>Section</b>	<b>Description</b>
Figure 12, Input Setup and Hold Waveform for $T_{IS1}$ and $T_{IH1}$ (pg. 35) Figure 15, Input Setup and Hold Waveform for $T_{IS4}$ and $T_{IH4}$ (pg. 36)	Figures redrawn to correspond to changes in setup and hold specifications for NMI, XINT7:0, ONCE and STEST.