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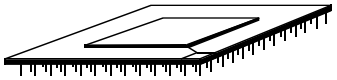
DSP56001

24-Bit General Purpose Digital Signal Processor

Pin Grid Array (PGA)
Available in an 88 pin ceramic through-hole package.



Ceramic Quad Flat Pack (CQFP)
Available in a 132 pin, small footprint, surface mount package.

Plastic Quad Flat Pack (PQFP)
Available in a 132 pin, small footprint, surface mount package.

The DSP56001 is a member of Motorola's family of HCMOS, low-power, general purpose Digital Signal Processors. The DSP56001 features 512 words of full speed, on-chip program RAM (PRAM) memory, two 256 word data RAMs, two preprogrammed data ROMs, and special on-chip bootstrap hardware to permit convenient loading of user programs into the program RAM. It is an off-the-shelf part since the program memory is user programmable. The core of the processor consists of three execution units operating in parallel — the data ALU, the address generation unit, and the program controller. The DSP56001 has MCU-style on-chip peripherals, program and data memory, as well as a memory expansion port. The MPU-style programming model and instruction set make writing efficient, compact code, straightforward.

The high throughput of the DSP56001 makes it well-suited for communication, high-speed control, numeric processing, computer and audio applications. The key features which facilitate this throughput are:

- **Speed** — At 16.5 million instructions per second (MIPS) with a 33 MHz clock, the DSP56001 can execute a 1024 point complex Fast Fourier Transform in1.98 milliseconds (66,240 clock cycles).
- **Precision** — The data paths are 24 bits wide thereby providing 144 dB of dynamic range; intermediate results held in the 56-bit accumulators can range over 336 dB.
- **Parallelism** — The data ALU, address arithmetic units, and program controller operate in parallel so that an instruction prefetch, a 24x24-bit multiplication, a 56-bit addition, two data moves, and two address pointer updates using one of three types of arithmetic (linear, modulo, or reverse carry) can be executed in a single instruction cycle. This parallelism allows a four coefficient Infinite Impulse Response (IIR) filter section to be executed in only four cycles, the theoretical minimum for a single multiplier architecture.
- **Integration** — In addition to the three independent execution units, the DSP56001 has six on-chip memories, three on-chip MCU style peripherals (Serial Communication Interface, Synchronous Serial Interface, and Host Interface), a clock generator and seven buses (three address and four data), making the overall system functionally complete and powerful, but also very low cost, low power, and compact.
- **Invisible Pipeline** — The three-stage instruction pipeline is essentially invisible to the programmer thus allowing straightforward program development in either assembly language or a high-level language such as ANSI C.
- **Instruction Set** — The 62 instruction mnemonics are MCU-like making the transition from programming microprocessors to programming the DSP56001 digital signal processor as easy as possible. The orthogonal syntax supports control of the parallel execution units. This syntax provides 12,808,830 different instruction variations using the 62 instruction mnemonics. The no-overhead DO instruction and the REPEAT (REP) instruction make writing straight-line code obsolete.
- **DSP56000/DSP56001 Compatibility** — The DSP56001 is identical to the DSP56000 except that it has 512x24-bits of on-chip program RAM instead of 3.75K of program ROM; a 32x24-bit bootstrap ROM for loading the program RAM from either a byte-wide memory mapped ROM or via the Host Interface; and the on-chip X and Y Data ROMs have been preprogrammed as positive Mu- and A-Law to linear expansion tables and a full, four quadrant sine wave table, respectively.
- **Low Power** — As a CMOS part, the DSP56001 is inherently very low power; however, three other features can reduce power consumption to an exceptionally low level.
  — The WAIT instruction shuts off the clock in the central processor portion of the DSP56001.
  — The STOP instruction halts the internal oscillator.
  — Power increases linearly (approximately) with frequency; thus, reducing the clock frequency reduces power consumption.

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

Rev. 3
September 19, 1996

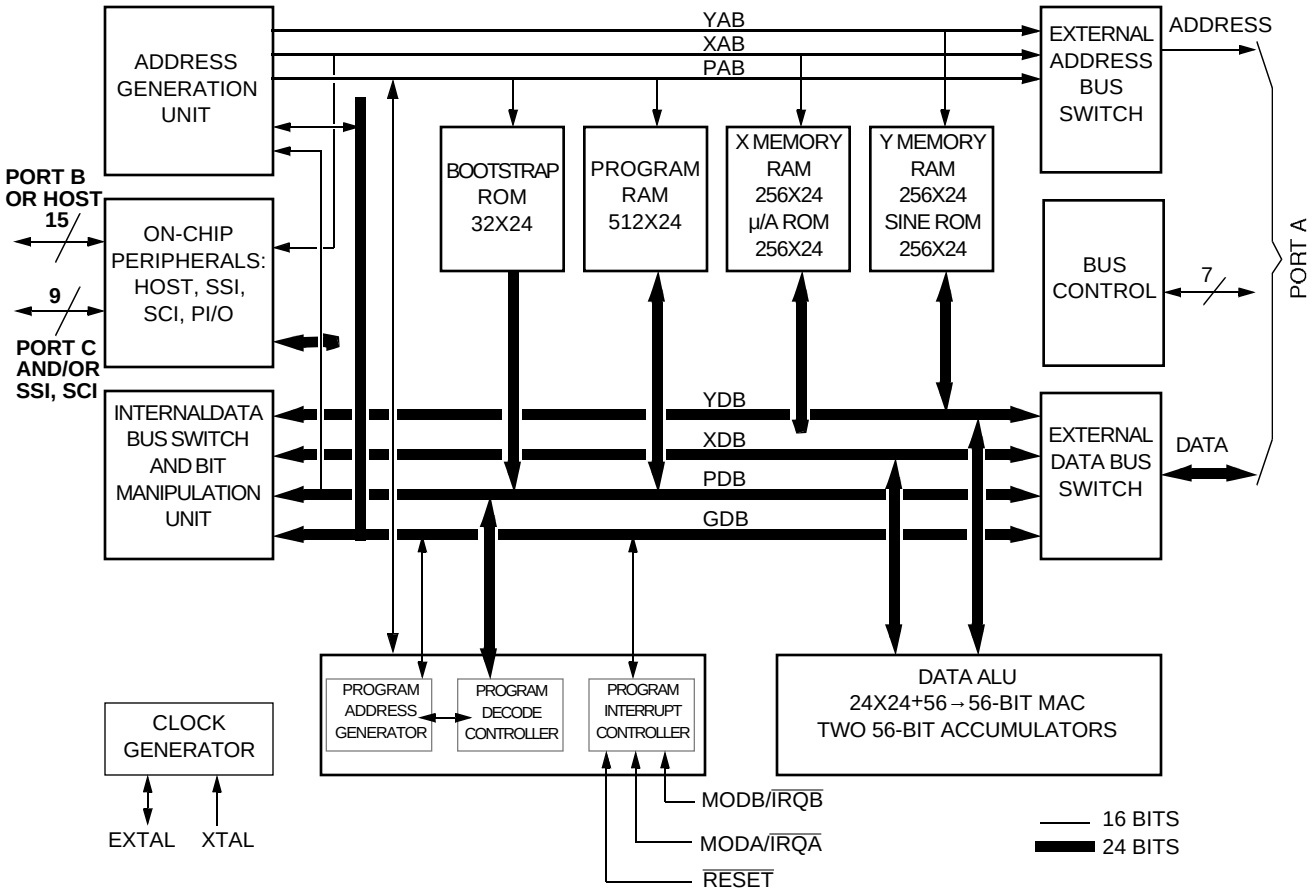


Figure 1. DSP56001 Block Diagram

In the USA:
For technical assistance call:
DSP Applications Helpline (512) 891-3230

For availability and literature call your local Motorola Sales Office or Authorized Motorola Distributor.

For free application software and information call the Dr. BuB electronic bulletin board:
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(8 data bits, no parity, 1 stop)

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Contact your regional sales office or Motorola distributor.

SIGNAL DESCRIPTION

The DSP56001 is available in 132 pin surface mount (CQFP and PQFP) or an 88-pin pin-grid array packaging. Its input and output signals are organized into seven functional groups which are listed below and shown in Figure 1.

Port A Address and Data Buses
Port A Bus Control
Interrupt and Mode Control
Power and Clock
Host Interface or Port B I/O
Serial Communications Interface or Port C I/O
Synchronous Serial Interface or Port C I/O

PORT A ADDRESS AND DATA BUS

Address Bus (A0-A15)

These three-state output pins specify the address for external program and data memory accesses. To minimize power dissipation, A0-A15 do not change state when external memory spaces are not being accessed.

Data Bus (D0-D23)

These pins provide the bidirectional data bus for external program and data memory accesses. D0-D23 are in the high-impedance state when the bus grant signal is asserted.

PORT A BUS CONTROL

Program Memory Select ($\overline{PS}$)

This three-state output is asserted only when external program memory is referenced. This pin is three-stated during $\overline{RESET}$.

Data Memory Select ($\overline{DS}$)

This three-state output is asserted only when external data memory is referenced. This pin is three-stated during $\overline{RESET}$.

X/$\overline{Y}$ Select (X/$\overline{Y}$)

This three-state output selects which external data memory space (X or Y) is referenced by data memory select ($\overline{DS}$). This pin is three-stated during $\overline{RESET}$.

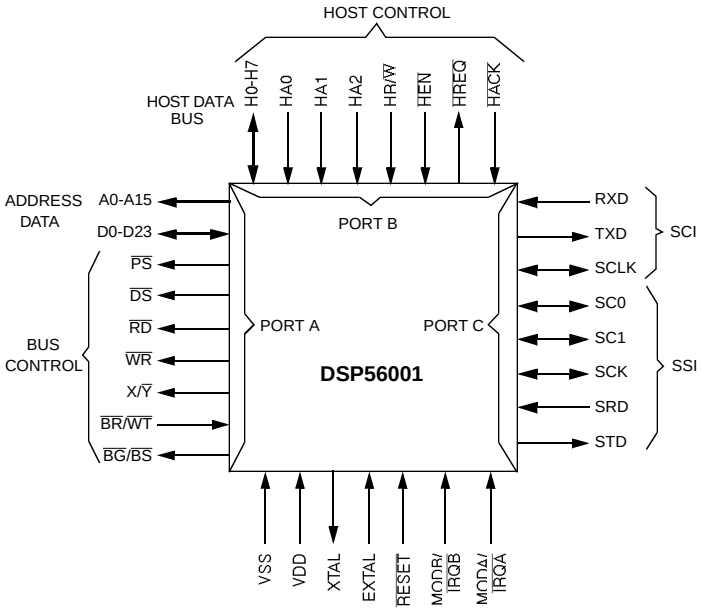


Figure 2. Functional Signal Groups

Read Enable ($\overline{RD}$)

This three-state output is asserted to read external memory on the data bus D0-D23. This pin is three-stated during $\overline{RESET}$.

Write Enable ($\overline{WR}$)

This three-state output is asserted to write external memory on the data bus D0-D23. This pin is three-stated during $\overline{RESET}$.

Bus Request ($\overline{BR}$/$\overline{WT}$)

The bus request input $\overline{BR}$ allows another device such as a processor or DMA controller to become the master of external data bus D0-D23 and external address bus A0-A15. When operating mode register (OMR) bit 7 is clear and $\overline{BR}$ is asserted, the DSP56001 will always release the external data bus D0-D23, address bus A0-A15, and bus control pins $\overline{PS}$, $\overline{DS}$, X/$\overline{Y}$, $\overline{RD}$, and $\overline{WR}$ (i. e., Port A), by placing these pins in the high-impedance state after execution of the current instruction has been completed. **The $\overline{BR}$ pin should be pulled up when not in use.**

If OMR bit 7 is set, this pin is an input that allows an external device to force wait states during an external Port A operation for as long as $\overline{WT}$ is asserted.

Bus Grant ($\overline{BG}$/$\overline{BS}$)

If OMR bit 7 is clear, this output is asserted to acknowledge an external bus request after Port A has been released. If OMR bit 7 is set, this pin is bus strobe and is asserted when the DSP accesses Port A. This pin is three-stated during $\overline{RESET}$.

INTERRUPT AND MODE CONTROL

Mode Select A/External Interrupt Request A (MODA/$\overline{IRQA}$),

Mode Select B/External Interrupt Request B (MODB/$\overline{IRQB}$)

These two inputs have dual functions: 1) to select the initial chip operating mode and 2) to receive an interrupt request from an external source. MODA and MODB are read and internally latched in the DSP when the processor exits the RESET state. Therefore these two pins should be forced into the proper state during reset. After leaving the RESET state, the MODA and MODB pins automatically change to external interrupt requests $\overline{IRQA}$ and $\overline{IRQB}$. After leaving the reset state the chip operating mode can be changed by software. $\overline{IRQA}$ and $\overline{IRQB}$ may be programmed to be level sensitive or negative edge triggered. When edge triggered, triggering occurs at a voltage level and is not directly related to the fall time of the interrupt signal, however, the probability of noise on $\overline{IRQA}$ or $\overline{IRQB}$ generating multiple interrupts increases with increasing fall time of the interrupt signal. These pins are inputs during $\overline{RESET}$.

Reset ($\overline{RESET}$)

This Schmitt trigger input pin is used to reset the DSP56001. When $\overline{RESET}$ is asserted, the DSP56001 is initialized and placed in the reset state. When the $\overline{RESET}$ signal is deasserted, the initial chip operating mode is latched from the MODA and MODB pins. When coming out of reset, deassertion occurs at a voltage level and is not directly related to the rise time of the reset signal; however, the probability of noise on $\overline{RESET}$ generating multiple resets increases with increasing rise time of the reset signal.

POWER AND CLOCK

Power (Vcc), Ground (GND)

There are five sets of power and ground pins used for the four groups of logic on the chip, two pairs for internal logic, one power and two ground for Port A address and control pins, one power and two ground for Port A data pins, and one pair for peripherals. Refer to the pin assignments in the **LAYOUT PRACTICES** section.

External Clock/Crystal Input (EXTAL)

EXTAL may be used to interface the crystal oscillator input to an external crystal or an external clock.

Crystal Output (XTAL)

This output connects the internal crystal oscillator output to an external crystal. If an external clock is used, XTAL should not be connected.

HOST INTERFACE

Host Data Bus (H0-H7)

This bidirectional data bus is used to transfer data between the host processor and the DSP56001. This bus is an input unless enabled by a host processor read. H0-H7 may be programmed as general purpose parallel I/O pins called PB0-PB7 when the Host Interface is not being used. These pins are configured as a GPIO input pins during hardware reset.

Host Address (HA0-HA2)

These inputs provide the address selection for each Host Interface register. HA0-HA2 may be programmed as general purpose parallel I/O pins called PB8-PB10 when the Host Interface is not being used. These pins are configured as a GPIO input pins during hardware reset.

Host Read/Write (HR/$\overline{W}$)

This input selects the direction of data transfer for each host processor access. HR/$\overline{W}$ may be programmed as a general purpose I/O pin called PB11 when the Host Interface is not being used. This pin is configured as a GPIO input pins during hardware reset.

Host Enable ($\overline{HEN}$)

This input enables a data transfer on the host data bus. When $\overline{HEN}$ is asserted and HR/$\overline{W}$ is high, H0-H7 become outputs, and DSP56001 data may be read by the host processor, When $\overline{HEN}$ is asserted and HR/$\overline{W}$ is low, H0-H7 become inputs and host data is latched inside the DSP when $\overline{HEN}$ is deasserted. Normally a chip select signal, derived from host address decoding and an enable clock, is used to generate $\overline{HEN}$. $\overline{HEN}$ may be programmed as a general purpose I/O pin called PB12 when the Host Interface is not being used. This pin is configured as a GPIO input pins during hardware reset.

Host Request ($\overline{HREQ}$)

This open-drain output signal is used by the DSP56001 Host Interface to request service from the host processor, DMA controller, or simple external controller. $\overline{HREQ}$ may be programmed as a general purpose I/O pin (not open-drain) called PB13 when the Host interface is not being used. $\overline{HREQ}$ should be pulled high when not in use. This pin is configured as a GPIO input pins during hardware reset.

Host Acknowledge ($\overline{HACK}$)

This input has two functions: 1) to receive a Host Acknowledge handshake signal for DMA transfers and, 2) to receive a Host Interrupt Acknowledge compatible with MC68000 Family processors. $\overline{HACK}$ may be programmed as a general purpose I/O pin called PB14 when the Host Interface is not being used. This pin is configured as a GPIO input pins during hardware reset. **$\overline{HACK}$ should be pulled high when not in use.**

SERIAL COMMUNICATIONS INTERFACE (SCI)

Receive Data (RXD)

This input receives byte-oriented data into the SCI Receive Shift Register. Input data is sampled on the positive edge of the Receive Clock. RXD may be programmed as a general purpose I/O pin called PC0 when the SCI is not being used. This pin is configured as a GPIO input pins during hardware reset.

Transmit Data (TXD)

This output transmits serial data from the SCI Transmit Shift Register. Data changes on the negative edge of the transmit clock. This output is stable on the positive edge of the transmit clock. TXD may be programmed as a general purpose I/O pin called PC1 when the SCI is not being used. This pin is configured as a GPIO input pins during hardware reset.

SCI Serial Clock (SCLK)

This bidirectional pin provides an input or output clock from which the transmit and/or receive baud rate is derived in the asynchronous mode and from which data is transferred in the synchronous mode. SCLK may be programmed as a general purpose I/O pin called PC2 when the SCI is not being used. This pin is configured as a GPIO input pins during hardware reset.

SYNCHRONOUS SERIAL INTERFACE (SSI)

Serial Control Zero (SC0)

This bidirectional pin is used for control by the SSI. SC0 may be programmed as a general purpose I/O pin called PC3 when the SSI is not being used. This pin is configured as a GPIO input pins during hardware reset.

Serial Control One (SC1)

This bidirectional pin is used for control by the SSI. SC1 may be programmed as a general purpose I/O pin called PC4 when the SSI is not being used. This pin is configured as a GPIO input pins during hardware reset.

Serial Control Two (SC2)

This bidirectional pin is used for control by the SSI. SC2 may be programmed as a general purpose I/O pin called PC5 when the SSI is not being used. This pin is configured as a GPIO input pins during hardware reset.

SSI Serial Clock (SCK)

This bidirectional pin provides the serial bit rate clock for the SSI when only one clock is used. SCK may be programmed as a general purpose I/O pin called PC6 when the SSI is not being used. This pin is configured as a GPIO input pins during hardware reset.

SSI Receive Data (SRD)

This input pin receives serial data into the SSI Receive Shift Register. SRD may be programmed as a general purpose I/O pin called PC7 when the SSI is not being used. This pin is configured as a GPIO input pins during hardware reset.

SSI Transmit Data (STD)

This output pin transmits serial data from the SSI Transmit Shift Register. STD may be programmed as a general purpose I/O pin called PC8 when the SSI is not being used. This pin is configured as a GPIO input pins during hardware reset.

DSP56001 Electrical Characteristics
Electrical Specifications

The DSP is fabricated in high density CMOS with TTL compatible inputs and outputs.

Maximum Ratings (V_{SS} = 0 Vdc)

Rating	Symbol	Value	Unit
Supply Voltage	Vcc	-0.3 to +7.0	V
All Input Voltages	Vin	V_{SS} - 0.5 to Vcc + 0.5	V
Current Drain per Pin excluding Vcc and V_{SS}	I	10	mA
Operating Temperature Range	T_J	-40 to +105	°C
Storage Temperature	Tstg	-55 to +150	°C

Maximum Electrical Ratings

Thermal Characteristics - PGA Package

Characteristics Thermal Resistance - Ceramic	Symbol	Value	Rating
Junction to Ambient Junction to Case (estimated)	θ_{JA} θ_{JC}	27 6.5	°C/W °C/W

Thermal Characteristics - CQFP Package

Characteristics Thermal Resistance - Ceramic	Symbol	Value	Rating
Junction to Ambient Junction to Case (estimated)	θ_{JA} θ_{JC}	40 7.0	°C/W °C/W

Thermal Characteristics - PQFP Package

Characteristics Thermal Resistance - Plastic	Symbol	Value	Rating
Junction to Ambient Junction to Case (estimated)	θ_{JA} θ_{JC}	38 13.0	°C/W °C/W

This device contains circuitry protecting against damage due to high static voltage or electrical fields; however, it is advised that normal precautions be taken 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 Vcc).

Power Considerations

The average chip-junction temperature, T_J, in °C can be obtained from:

$$T_J = T_A + (P_D \times \Theta_{JA}) \quad (1)$$

Where:

T_A = Ambient Temperature, °C

Θ_{JA} = Package Thermal Resistance, Junction-to-Ambient, °C/W

$P_D = P_{INT} + P_{I/O}$

$P_{INT} = I_{CC} \times Vcc$, Watts - Chip Internal Power

$P_{I/O}$ = Power Dissipation on Input and Output Pins - User Determined

For most applications $P_{I/O} << P_{INT}$ and can be neglected; however, $P_{I/O} + P_{INT}$ **must not** exceed P_D. An appropriate relationship between P_D and T_J (if $P_{I/O}$ is neglected) is:

$$P_D = K/(T_J + 273° C) \quad (2)$$

Solving equations (1) and (2) for K gives:

$$K = P_D \times (T_A + 273° C) + \Theta_{JA} \times P_D^2 \quad (3)$$

Where K is a constant pertaining to the particular part. K can be determined from equation (2) by measuring P_D (at equilibrium) for a known T_A. Using this value of K, the values of P_D and T_J can be obtained by solving equations (1) and (2) iteratively for any value of T_A. The total thermal resistance of a package (Θ_{JA}) can be separated into two components, Θ_{JC} and C_{JA}, representing the barrier to heat flow from the semiconductor junction to the package (case) surface (Θ_{JC}) and from the case to the outside ambient (C_{JA}). These terms are related by the equation:

$$\Theta_{JA} = \Theta_{JC} + C_{JA} \quad (4)$$

Θ_{JC} is device related and cannot be influenced by the user. However, C_{JA} is user dependent and can be minimized by such thermal management techniques as heat sinks, ambient air cooling, and thermal convection. Thus, good thermal management on the part of the user can significantly reduce C_{JA} so that Θ_{JA} approximately equals Θ_{JC}. Substitution of Θ_{JC} for Θ_{JA} in equation (1) will result in a lower semiconductor junction temperature. Values for thermal resistance presented in this document, unless estimated, were derived using the procedure described in Motorola Reliability Report 7843, "Thermal Resistance Measurement Method for MC68XX Microcomponent Devices", and are provided for design purposes only. Thermal measurements are complex and dependent on procedure and setup. User-derived values for thermal resistance may differ.

Layout Practices

Each Vcc pin on the DSP56001 should be provided with a low-impedance path to + 5 volts. Each GND pin should likewise be provided with a low-impedance path to ground. The power supply pins drive four distinct groups of logic on chip. They are:

Vcc	GND	Function
G12,C6	G11,B7	Internal Logic supply pins
L8	L6,L9	Address bus output buffer supply pins
G3	D3,J3	Data bus output buffer supply pins
C9	E11	Port B and C output buffer supply pins

Power and Ground Connections for PGA

Vcc	GND	Function
35, 36, 128, 129	33, 34, 130, 131	Internal Logic supply pins
63, 64	55, 56, 73, 74	Address bus output buffer supply pins
100, 101	90, 91, 111, 112	Data bus output buffer supply pins
12, 13	23, 24	Port B and C output buffer supply pins

Power and Ground Connections for CQFP and PQFP

Power and Ground Connections

The Vcc power supply should be bypassed to ground using at least four 0.1 uF by- pass capacitors located either underneath the chip or as close as possible to the four sides of the package. The capacitor leads and associated printed circuit traces connecting to chip Vcc and Gnd should be kept to less than 1/2" per capacitor lead. A four-layer board is recommended, employing two inner layers as Vcc and Gnd planes. All output pins on the DSP56001 have fast rise and fall times — typically less than 3 ns. with a 10 pf. load. Printed circuit (PC) trace interconnection length should be minimized in order to minimize undershoot and reflections caused by these fast output switching times. This recommendation particularly applies to the address and data buses as well as the $\overline{RD}$, $\overline{WR}$, $\overline{SHACK}$, $\overline{SHCS}$, and $\overline{PSTR}$ pins. Maximum PC trace lengths on the order of 6" are recommended. Capacitance calculations should consider all device loads as well as parasitic capacitances due to the PC traces. Attention to proper PCB layout and bypassing becomes especially critical in systems with higher capacitive loads because these loads create higher transient currents in the Vcc and GND circuits. Pull up/down all unused inputs or signals that will be inputs during reset.

Signal Stability

When designing hardware to interface with the Host Interface, it is important to ensure that all signals be clean and free from noise. Particular attention should be given to the quality of the Host Enable ($\overline{HEN}$). All inputs to the port should be stable when $\overline{HEN}$ is asserted and should remain stable until $\overline{HEN}$ has fully returned to the deasserted state. It is important to note that such phenomena as ground-bounce and cross-talk can inadvertently cause $\overline{HEN}$ to temporarily rise above $V_{IL\,max}$. Should this occur without completing the full logic transition to $V_{IL\,max}$, the DSP56001 Host Port may not correctly update the port status information which can result in storing two or more copies of a single down loaded data word. Of course, if a full logic transition occurs, the part will complete a normal data transfer operation.

DSP56001 Electrical Characteristics

DC Electrical Characteristics (V_{CC} = 5.0 Vdc ± 10%, T_J = -40 to +105° C at 20.5 MHz and 27 MHz)
(V_{CC} = 5.0 Vdc ± 5%, T_J = -40 to +105° C at 33 MHz)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Voltage 20, 27 MHz 33 MHz	V_{CC}	4.5 4.75	5.0	5.5 5.25	V
Input High Voltage Except EXTAL, RESET, MODA/IRQA, MODB/IRQB	V_{IH}	2.0	—	V_{CC}	V
Input Low Voltage Except EXTAL, MODA/IRQA, MODB/IRQB	V_{IL}	-0.5	—	0.8	V
Input High Voltage EXTAL	V_{IHC}	4.0	—	V_{CC}	V
Input Low Voltage EXTAL	V_{ILC}	-0.5	—	0.6	V
Input High Voltage RESET	V_{IHR}	2.5	—	V_{CC}	V
Input High Voltage MODA/IRQA and MODB/IRQB	V_{IHM}	3.5	—	V_{CC}	V
Input Low Voltage MODA/IRQA and MODB/IRQB	V_{ILM}	-0.5	—	2.0	V
Input Leakage Current EXTAL, RESET, MODA/IRQA, MODB/IRQB, SS	I_{IL}	-1	—	1	uA
Three-State (Off-State) Input Current (@2.4 V/0.4 V)	I_{TSI}	-10	—	10	uA
Output High Voltage (I_{OH} = -0.4 mA)	V_{OH}	2.4	—	—	V
Output Low Voltage SS, SDA, I_{OL} = 1.6 mA; Open Drain TXD, I_{OL} = 6.7 mA, TXD IOL = 6.7 mA)	V_{OL}	—	—	0.4	V
Total Supply Current 5.25 V, 33 MHz 5. 5 V, 27 MHz 5. 5 V, 20 MHz in WAIT Mode (see Note 1) in STOP Mode (see Note 1)	I_{CC33} I_{CC27} I_{CC20} I_{CCW} I_{CCS}	— — — — —	160 130 100 10 100	185 155 115 25 2000	mA mA mA mA µA
Input Capacitance (see Note 2)	Cin	—	10	—	pf

Notes:
1. In order to obtain these results all inputs must be terminated (i.e., not allowed to float).
2. Periodically sampled and not 100% tested.

AC Electrical Characteristics

The timing waveforms in the **AC Electrical Characteristics** are tested with a V_{IL} maximum of 0.5 V and a V_{IH} minimum of 2.4 V for all pins, except EXTAL, $\overline{RESET}$, MODA, and MODB. These four pins are tested using the input levels set forth in the **DC Electrical Characteristics**. 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. DSP56001 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.

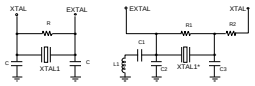
AC Electrical Characteristics - Clock Operation

The DSP56001 system clock may be derived from the on-chip crystal oscillator as shown in Clock Figure 1, or it may be externally supplied. An externally supplied square wave voltage source should be connected to EXTAL, leaving XTAL physically unconnected (see Clock Figure 2) to the board or socket. The rise and fall time of this external clock should be 5 ns maximum.

Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
	Frequency of Operation (EXTAL Pin)	4.0	20.5	4.0	27.0	4.0	33.0	MHz

Notes:

1. External Clock Input High and External Clock Input Low are measured at 50% of the input transition. tch and tcl are dependent on the duty cycle.
2. T = tcyc / 4 is used in the electrical characteristics. T represents an average which is independent of the duty cycle.



Fundamental Frequency Crystal Oscillator

Suggested Component Values
For f_{xtal} = 4 MHz:
R = 680 KΩ ± 10%
C = 20 pF ± 25%

For f_{xtal} = 30 MHz:
R = 680 KΩ ± 10%
C = 20 pF ± 25%

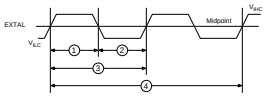
Notes:
(1) The suggested crystal source is ICM, # 431163 - 4.00 (4MHz fundamental, 20 pf load) or # 436163 - 30.00 (30 MHz fundamental, 20 pf load).

3rd Overtone Crystal Oscillator

Suggested Component Values
R1 = 470 KΩ ± 10%
R2 = 330 Ω ± 10%
C1 = 5.1 pF ± 20%
C2 = 24 pF ± 20%
C3 = 20 pF ± 10%
L1 = 2.37 µH ± 10%
XTAL =28 MHz, AT cut, 20 pf load, 50Ω max series resistance

Notes:
(1) *3rd overtone crystal.
(2) The suggested crystal source is ICM, # 471163 - 33.00 (33 MHz 3rd overtone, 20 pf load).
(3) R2 limits crystal current
(4) Reference Benjamin Parzen, The Design of Crystal and other Harmonic Oscillators, John Wiley& Sons, 1983

Clock Figure 1. Crystal Oscillator Circuits



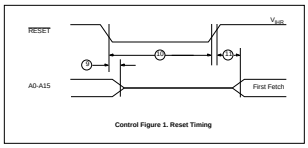
Note: The midpoint is V_{ILC} + 0.5 (V_{IHC} - V_{ILC}).

Clock Figure 2. External Clock Timing

AC Electrical Characteristics - Reset, Stop, Mode Select and Interrupt Timing

(Vcc = 5.0 Vdc ±10%, T_J = -40 to +105° C, CL = 50 pf + 1 TTL Load at 20.5 MHz and 27 MHz)
(Vcc = 5.0 Vdc ± 5%, T_J = -40 to +105° C, CL = 50 pf + 1 TTL Load at 33 MHz)
(See Control Figure 1 through 8)
cyc = Clock cycle = 1/2 instruction cycle = 2 T cycles
WS = Number of wait states (1 WS = 1 cyc = 2T) programmed into external bus access using BCR (WS = 0 - 15)
tch = Clock high period
tcl = Clock low period

Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
9	Delay from RESET Assertion to Address High Impedance (periodically sampled and not 100% tested)	—	50	—	38	—	31	ns
10	Minimum Stabilization Duration Internal Osc. (see Note 1) External Clock (see Note 2)	75000xcyc 25xcyc	— —	75000*cyc 25xcyc	— —	75000*cyc 25xcyc	— —	ms ns
11	Delay from Asynchronous RESET Deassertion to First External Address Output (Internal Reset Negation)	8xcyc	8xcyc+40	8*cyc	8*cyc+31	8*cyc	8*cyc+25	ns
12	Synchronous Reset Setup Time from RESET Deassertion to Falling Edge of External Clock	20	cyc-10	15	cyc-8	13	cyc-7	ns
13	Synchronous Reset Delay Time from the Synchronous Falling Edge of External Clock to the First External Address Output	8xcyc+5	8xcyc+30	8*cyc+5	8*cyc+23	8*cyc+5	8*cyc+19	ns
14	Mode Select Setup Time	100	—	77	—	62	—	ns
15	Mode Select Hold Time	0	—	0		0		ns
16 16a	Edge-Triggered Interrupt Request assertion deassertion	25 15	— —	17 10	— —	16 10	— —	ns ns



Control Figure 1. Reset Timing

AC Electrical Characteristics - Reset, Stop, Mode Select, and Interrupt Timing (Continued)

NOTE

When using fast interrupts and IRQA and IRQB are defined as level-sensitive, then timings 19 through 22 apply to prevent multiple interrupt service. To avoid these timing restrictions, the negative edge-triggered mode is recommended when using fast interrupt. Long interrupts are recommended when using level-sensitive mode.

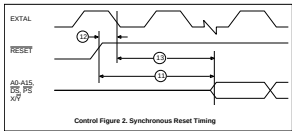
Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
17	Delay from IRQA, IRQB Assertion to External Memory Access Address Out Valid Caused by First Interrupt Instruction Fetch Interrupt Instruction Execution	5cyc+ich 5cyc+ich	— —	5cyc+ich 5cyc+ich	— —	5cyc+ich 5cyc+ich	— —	ns ns
18	Delay from IRQA, IRQB Assertion to General Purpose Transfer Output Valid Caused by First Interrupt Instruction Execution	11+cyc +ich	—	11cyc +ich	—	11cyc +ich	—	ns
19	Delay from Address Output Valid Caused by First Interrupt Instruction Execution to Interrupt Request Deassertion for Level Sensitive Fast Interrupts	—	2cyc+ich (cyc,IAS) -44	—	2cyc+ich (cyc,IAS) -34	—	2cyc+ich (cyc,IAS) -27	ns
20	Delay from RD Assertion to Interrupt Request Deassertion for Level Sensitive Fast Interrupts	—	2cyc+ (cyc,IAS) -60	—	2cyc+ (cyc,IAS) -31	—	2cyc+ (cyc,IAS) -25	ns
21	Delay from WR Assertion to WS=0 Interrupt Request Deassertion for WS=0 Level Sensitive Fast Interrupts	— —	2cyc-40 cyc+ich- (cyc,IAS) -40	— —	2cyc-31 cyc+ich- (cyc,IAS) -31	— —	2cyc-25 cyc+ich- (cyc,IAS) -25	ns ns
22	Delay from General Purpose Output Valid to Interrupt Request Deassertion for Level Sensitive Fast Interrupts + If Second Interrupt Instruction is: Single Cycle Two Cycle	— —	tol-60 (2-cyc)+ich -60	— —	tol-46 (2-cyc)+ich -46	— —	tol-37 (2-cyc)+ich -37	ns ns

AC Electrical Characteristics - Reset, Stop, Mode Select, and Interrupt Timing (Continued)

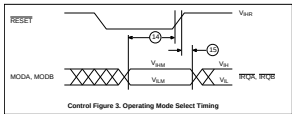
Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
23	Synchronous Interrupt Setup Time from $\overline{IRQA}$, $\overline{IRQB}$, $\overline{NMI}$, and the Synchronous Rising Edge of External Clock (see Notes 5, 6)	25	cyc-10	19	cyc-8	16	cyc-7	ns
24	Synchronous Interrupt Delay Time from the Synchronous Rising Edge of External Clock to the First External Address Output Valid Caused by the First Instruction Fetch after Coming out of Wait State (see Notes 3, 5)	13.cyc+ tch+8	13.cyc+ tch+30	13.cyc+ tch+6	13.cyc+ tch+23	13.cyc+ tch+5	13.cyc+ tch+19	ns
25	Duration for $\overline{IRQA}$ Assertion to Recover from Stop State (see Note 4)	25	—	19	—	16	—	ns
26	Delay from $\overline{IRQA}$ Assertion to Fetch of First Instruction (for Stop) for Internal Osc / OMR bit 6 = 0 External Clock / OMR bit 6 = 0 (see Notes 1, 2, and 7)	65545.cyc 17.cyc	— —	65545.cyc 17.cyc	— —	65545.cyc 17.cyc	— —	ns ns
27	Duration for Level Sensitive $\overline{IRQA}$ Assertion to Fetch of First Interrupt Instruction (for Stop) for Internal Osc / OMR bit 6 = 0 External Clock / OMR bit 6 = 1 (see Notes 1, 2, and 7)	65533.cyc + tid + 5.cyc+td	—	65533.cyc + tid + 5.cyc+td	—	65533.cyc + tid + 5.cyc+td	—	ns ns
28	Delay from Level Sensitive $\overline{IRQA}$ Assertion to Fetch of First Interrupt Instruction (for Stop) for Internal Osc / OMR bit 6 = 0 External Clock / OMR bit 6 = 1 (see Notes 1, 2, and 7)	65545.cyc 17.cyc	— —	65545.cyc 17.cyc	— —	65545.cyc 17.cyc	— —	ns ns

Notes:

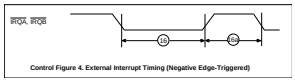
1. A clock stabilization delay is required when using the on-chip crystal oscillator in two cases:
   1) after power-on reset, and
   2) when recovering from Stop mode.
   During this stabilization period, T will not be constant. Since this stabilization period varies, a delay of 150,000T is typically allowed to assure that the oscillator is stabilized before executing programs. While it is possible to set OMR bit 6 = 1 when using the internal crystal oscillator, it is not recommended and these specifications do not guarantee timings for that case. See Section 8.5 in the*DSP56000/DSP56001 User's Manual*for additional information.
2. Circuit stabilization delay is required during reset when using an external clock in two cases:
   1) after power-on reset, and
   2) when recovering from Stop mode.
3. For Revision B silicon, the min and max numbers are 12cyc+Tch+8 and 12cyc+Tch+30, respectively.
4. The minimum is specified for the duration of an edge triggered $\overline{IRQA}$ interrupt required to recover from the STOP state without having the $\overline{IRQA}$ interrupt accepted.
5. Timing #23 is for all IRQs interrupts while timing #24 is only when exiting WAIT.
6. Timing #23 triggers off T1 in the normal state and off T1/T3 when exiting the WAIT state.
7. The timings in the table are for Rev. C parts. The timings for Rev. C parts are shorter by 1 cyc than the Rev. B parts when OMR6=0.



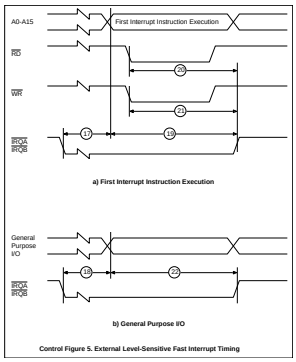
Control Figure 2. Synchronous Reset Timing



Control Figure 3. Operating Mode Select Timing



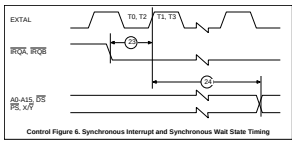
Control Figure 4. External Interrupt Timing (Negative Edge-Triggered)



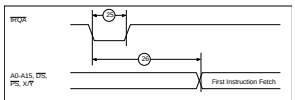
a) First Interrupt Instruction Execution

b) General Purpose I/O

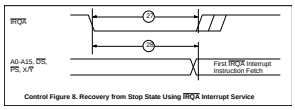
Control Figure 5. External Level-Sensitive Fast Interrupt Timing



Control Figure 6. Synchronous Interrupt and Synchronous Wait State Timing



Control Figure 7. Recovery from Stop State Using IRQA



Control Figure 8. Recovery from Stop State Using IRQA Interrupt Service

HOST PORT USAGE CONSIDERATIONS

Careful synchronization is required when reading multibit registers that are written by another asynchronous system. This is a common problem when two asynchronous systems are connected. The situation exists in the Host port. The considerations for proper operation are discussed below.

Host Programmer Considerations

1. Unsynchronized Reading of Receive Byte Registers
   When reading receive byte registers, RXH, RXM, or RXL, the Host programmer should use interrupts or poll the RXDF flag which indicates that data is available. This assures that the data in the receive byte registers will be stable.

2. Overwriting Transmit Byte Registers
   The Host programmer should not write to the transmit byte registers, TXH, TXM, or TXL, unless the 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 HRX register.

3. Synchronization of Status Bits from DSP to Host
   HC, HREQ, DMA, HF3, HF2, TRDY, TXDE, and RXDF (refer to *DSP56000/DSP56001 User's Manual*, I/O Interface section, Host/DMA Interface Programming Model for descriptions of these status bits) status bits are set or cleared from inside the DSP and read by the Host processor. The Host can read these status bits very quickly without regard to the clock rate used by the DSP, but the possibility exists that the state of the bit could be changing during the read operation. This is generally not a system problem, since the bit will be read correctly in the next pass of any Host polling routine.

   However, if the Host asserts the $\overline{\text{HEN}}$ for more than timing number 31a (T31a), with a minimum cycle time of timing number 32a (T32a), then the status is guaranteed to be stable.

   A potential problem exists when reading status bits HF3 and HF2 as an encoded pair. If the DSP changes HF3 and HF2 from 00 to 11, there is a small probability that the Host could read the bits during the transition and receive 01 or 10 instead of 11. If the combination of HF3 and HF2 has significance, the Host could read the wrong combination.

   Solution:
   a. Read the bits twice and check for consensus.
   b. Assert $\overline{\text{HEN}}$ access for T31a so that status bit transitions are stabilized.

4. Overwriting the Host Vector
   The Host programmer should change the Host Vector register only when the Host Command bit (HC) is clear. This change will guarantee that the DSP interrupt control logic will receive a stable vector.

5. Cancelling a Pending Host Command Exception
   The Host processor may elect to clear the HC bit to cancel the Host Command Exception request at any time before it is recognized by the DSP. Because the Host does not know exactly when the exception will be recognized (due to exception processing synchronization and pipeline delays), the DSP may execute the Host exception after the HC bit is cleared. For these reasons, the HV bits must not be changed at the same time the HC bit is cleared.

DSP Programmer Considerations

1. Reading HF3 and HF2 as an Encoded Pair
   DMA, HF1, HF0, and HCP, HTDE, and HRDF (refer to *DSP56000/DSP56001 User's Manual*, I/O Interface section, Host/DMA Interface Programming Model for descriptions of these status bits) status bits are set or cleared by the Host processor side of the interface. These bits are individually synchronized to the DSP clock.

   A potential problem exists when reading status bits HF1 and HF2 as an encoded pair, i.e., the four combinations 00, 01, 10, and 11 each have significance. A very small probability exists that the DSP will read the status bits synchronized during transition. The solution to this potential problem is to read the bits twice for consensus.

DSP56001 Electrical Characteristics

AC Electrical Characteristics - Host I/O Timing

(Vcc = 5.0 Vdc ± 10%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 20.5 MHz and 27 MHz)
(Vcc = 5.0 Vdc ± 5%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 33 MHz)
(see Host Figures 1 through 6)
cyc = Clock cycle = 1/2 instruction cycle = 2 T cycles
tHSDL = Host Synchronization Delay Time
Active low lines should be "pulled up" in a manner consistent with the AC and DC specifications

Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
30	Host Synchronous Delay (see Note 1)	tcl	cyc+tcl	tcl	cyc+tcl	tcl	cyc+tcl	ns
31	HEN/HRCK Assertion Width (see Note 2) a.CVR, ICR, ISR Read (see Note 4) b.Read c.Write	 cyc+60 50 25	 — — —	 cyc+46 39 19	 — — —	 cyc+37 31 16	 — — —	 ns ns ns
32	HEN/HRCK Deassertion Width (see Note 2 and 5)	25	—	19	—	16	—	ns
32a	Minimum Cycle Time Between Two Consecutive Accesses to CVR, ICR, and ISR Read (see Note 2)	2•cyc+60	—	2•cyc+46	—	2•cyc+37	—	ns
33	Host Data Input Setup Time Before HEN/HRCK Deassertion	5	—	4	—	4	—	ns
34	Host Data Input Hold Time After HEN/HRCK Deassertion	5	—	4	—	4	—	ns
35	HEN/HRCK Assertion to Output Data Active from High Impedance	0	—	0	—	0	—	ns
36	HEN/HRCK Assertion to Output Data Valid (periodically sampled, and not 100% tested)	—	60	—	39	—	31	ns
37	HEN/HRCK Deassertion to Output Data High Impedance	—	35	—	27	—	22	ns
38	Output Data Hold Time After HEN/HRCK Deassertion	5	—	4	—	4	—	ns
39	HA0/HR Low Setup Time Before HEN Assertion	0	—	0	—	0	—	ns
40	HA0/HR Low Hold Time After HEN Deassertion	5	—	4	—	4	—	ns
41	HA0/HR High Setup Time to HEN Assertion	0	—	0	—	0	—	ns
42	HA0/HR High Hold Time After HEN/HRCK Deassertion	5	—	4	—	4	—	ns
43	HA0-HA2 Setup Time Before HEN Assertion	0	—	0	—	0	—	ns
44	HA0-HA2 Hold Time After HEN Deassertion	5	—	4	—	4	—	ns
45	DMA HRCK Assertion to HREQ Deassertion (see Note 3)	5	60	4	46	4	49	ns

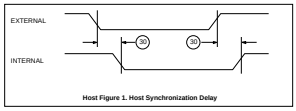
AC Electrical Characteristics - Host I/O Timing (Continued)

(Vcc = 5.0 Vdc ± 10%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 20.5 MHz and 27 MHz
(Vcc = 5.0 Vdc ± 5%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 33 MHz,
see Host Figures 1 through 6)
cyc = Clock cycle = 1/2 instruction cycle = 2 T cycles
tHSDL = Host Synchronization Delay Time
Active low lines should be "pulled up" in a manner consistent with the AC and DC specifications

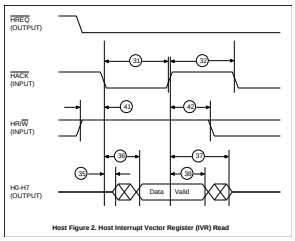
Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
46	DMA HACK Deassertion to HREQ Assertion (see Note 3) for DMA RXL Read for DMA TXL Write for All Other Cases	tHSDL+cyc+sch+5 tHSDL+cyc+5 5	— — —	tHSDL+cyc+sch+4 tHSDL+cyc+4 4	— — —	tHSDL+cyc+sch+4 tHSDL+cyc+4 4	— — —	ns ns ns
47	Delay from HEN Deassertion to HREQ Assertion for RXL Read (see Note 3)	tHSDL+cyc+sch+5	—	tHSDL+cyc+sch+4	—	tHSDL+cyc+sch+4	—	ns
48	Delay from HEN Deassertion to HREQ Assertion for TXL Write (see Note 3)	tHSDL+cyc+5	—	tHSDL+cyc+4	—	tHSDL+cyc+4	—	ns
49	Delay from HEN Assertion to HREQ Deassertion for RXL Read, TXL Write (see Note 3)	5	75	4	70	4	65	ns

Notes:

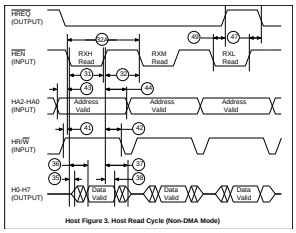
1. "Host synchronization delay (tHSDL)" is the time period required for the DSP56001 to sample any external asynchronous input signal, determine its state, and synchronize it to the DSP56001 internal clock.
2. See **HOST PORT USAGE CONSIDERATIONS**.
3. HREQ is pulled up by a 1kΩ resistor.
4. This timing must be adhered to only if two consecutive reads from one of these registers are executed.
5. It is recommended that timing #32 be 2cyc+sch+10 minimum for 20.5 MHz, 2cyc+sch+7 minimum for 27 MHz, and 2cyc+sch+6 minimum for 33 MHz if two consecutive writes to TXL are executed without polling TXDE or HREQ.



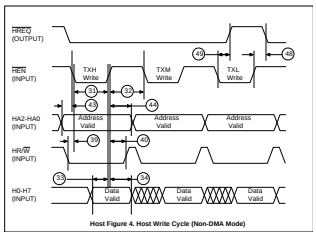
Host Figure 1. Host Synchronization Delay



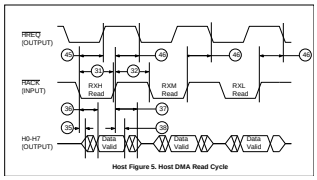
Host Figure 2. Host Interrupt Vector Register (IVR) Read



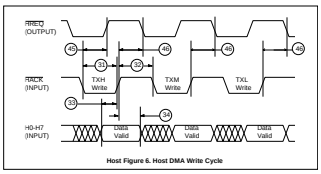
Host Figure 3. Host Read Cycle (Non-DMA Mode)



Host Figure 4. Host Write Cycle (Non-DMA Mode)



Host Figure 5. Host DMA Read Cycle



Host Figure 6. Host DMA Write Cycle

AC Electrical Characteristics - SCI Timing

(Vcc = 5.0 Vdc ± 10%, T_J = -40 to +100° C, CL = 50 pF + 1 TTL Load at 20.5 MHz and 27 MHz,
Vcc = 5.0 Vdc ± 5%, T_J = -40 to +100° C, CL = 50 pF + 1 TTL Load at 33 MHz,
see SCI Figures 1 and 2)
cyc = Clock cycle = 1/2 instruction cycle = 2 T cycles
(SCC = Synchronous Clock Cycle Time (for internal clock tSCC is determined by the SCI clock control register and tcyc.)

SCI Synchronous Mode Timing

Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
56	Synchronous Clock Cycle — tSCC	8xcyc	—	8xcyc	—	8xcyc	—	ns
56	Clock Low Period	4xcyc-20	—	4xcyc-15	—	4xcyc-13	—	ns
57	Clock High Period	4xcyc-20	—	4xcyc-15	—	4xcyc-13	—	ns
59	Output Data Setup to Clock Falling Edge (Internal Clock)	2xcyc +tct-50	—	2xcyc +tct-39	—	2xcyc +tct-31	—	ns
60	Output Data Hold After Clock Rising Edge (Internal Clock)	2xcyc -tct-15	—	2xcyc -tct-11	—	2xcyc -tct-9	—	ns
61	Input Data Setup Time Before Clock Rising Edge (Internal Clock)	2xcyc +tct+45	—	2xcyc +tct+35	—	2xcyc +tct+28	—	ns
62	Input Data Not Valid Before Clock Rising Edge (Internal Clock)	—	2xcyc +tct-10	—	2xcyc +tct-8	—	2xcyc +tct-6	ns
63	Clock Falling Edge to Output Data Valid (External Clock)	—	63	—	48	—	39	ns
64	Output Data Hold After Clock Rising Edge (External Clock)	cyc+12	—	cyc+9	—	cyc+8	—	ns
65	Input Data Setup Time Before Clock Rising Edge (External Clock)	30	—	23	—	19	—	ns
66	Input Data Hold Time After Clock Rising Edge (External Clock)	40	—	31	—	25	—	ns

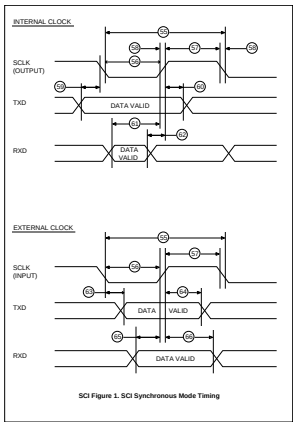
DSP56001 Electrical Characteristics

AC Electrical Characteristics - SCI Timing

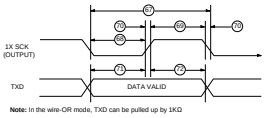
(Vcc = 5.0 Vdc ± 10%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 20.5 MHz and 27 MHz,
Vcc = 5.0 Vdc ± 5%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 33 MHz,
see SCI Figures 1 and 2)
cyc = Clock cycle = 1/2 instruction cycle = 2 T cycles
tACC = Asynchronous clock cycle time
tACC = Asynchronous Clock Cycle Time (for internal clock tACC is determined by the SCI clock control register and tcyc)

SCI Asynchronous Mode Timing - 1X Clock

Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
67	Asynchronous Clock Cycle	64cyc	—	64cyc	—	64cyc	—	ns
68	Clock Low Period	32cyc-20	—	32cyc-15	—	32cyc-13	—	ns
69	Clock High Period	32cyc-20	—	32cyc-15	—	32cyc-13	—	ns
71	Output Data Setup to Clock Rising Edge (Internal Clock)	32cyc -100	—	32cyc -77	—	32cyc -61	—	ns
72	Output Data Hold After Clock Rising Edge (Internal Clock)	32cyc -100	—	32cyc -77	—	32cyc -61	—	ns



SCI Figure 1. SCI Synchronous Mode Timing



Note: In the wire-OR mode, TXD can be pulled up by 1KΩ

SCI Figure 2. SCI Asynchronous Mode Timing

DSP56001 Electrical Characteristics

AC Electrical Characteristics - SSI Timing

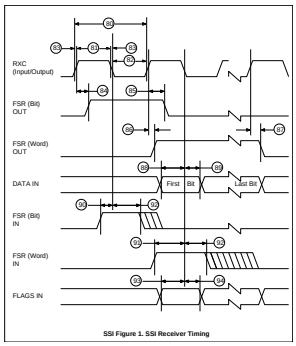
(Vcc = 5.0 Vdc ± 10%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 20.5 MHz and 27 MHz,
Vcc = 5.0 Vdc ± 5%, T_J = -40 to +105° C, CL = 50 pF + 1 TTL Load at 33 MHz,
see SSI Figures 1 and 2)
cyc = Clock cycle = 1/2 instruction cycle = 2 T cycles
tSSICC = SSI clock cycle time
TXC (SCK Pin) = Transmit Clock
RXC (SCI0 or SCK Pin) = Receive Clock
FST (SC2 Pin) = Transmit Frame Sync
FSR (SC1 or SC2 Pin) = Receive Frame Sync
i ck = Internal Clock
x ck = External Clock
g ck = Gated 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)
bl = bit length
wl = word length

Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
80	Clock Cycle (see Note 1)	4cyc	—	4cyc	—	4cyc	—	ns
81	Clock High Period	2cyc-30	—	2cyc-15	—	2cyc-13	—	ns
82	Clock High Period	2cyc-30	—	2cyc-15	—	2cyc-13	—	ns
84	RXC Rising Edge to FSR Out (bl) High x ck i ck a	— —	80 50	— —	61 38	— —	48 31	ns ns
85	RXC Rising Edge to FSR Out (bl) Low x ck i ck a	— —	70 40	— —	54 31	— —	43 25	ns ns
86	RXC Rising Edge to FSR Out (wl) High x ck i ck a	— —	70 40	— —	54 31	— —	43 25	ns ns
87	RXC Rising Edge to FSR Out (wl) Low x ck i ck a	— —	70 40	— —	54 31	— —	43 25	ns ns
88	Data In Setup Time Before RXC (SCK in Synchronous Mode) Falling Edge x ck i ck a i ck s	15 35 25	— — —	12 27 19	— — —	10 22 16	— — —	ns ns ns
89	Data In Hold Time After RXC Falling Edge x ck i ck a	35 5	— —	27 4	— —	22 4	— —	ns ns
90	FSR Input (bl) High Before RXC Falling Edge x ck i ck a	15 35	— —	12 27	— —	10 23	— —	ns ns

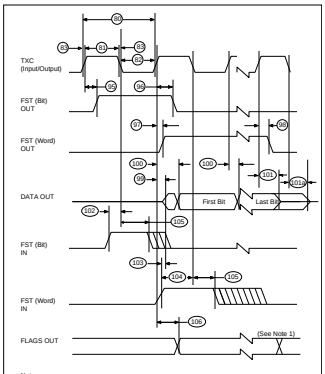
AC Electrical Characteristics - SSI Timing (Continued)

Num	Characteristics		20.5 MHz		27 MHz		33 MHz		Unit
			Min	Max	Min	Max	Min	Max	
93	Flags Input Setup Before RXC Falling Edge	x ck	30	—	23	—	19	—	ns
		i ck a	50	—	39	—	31	—	ns
94	Flags Input Hold Time After RXC Falling Edge	x ck	35	—	27	—	22	—	ns
		i ck a	5	—	4	—	4	—	ns
95	TXC Rising Edge to FST Out (bl) High	x ck	—	70	—	54	—	43	ns
		i ck a	—	30	—	23	—	19	ns
96	TXC Rising Edge to FST Out (bl) Low	x ck	—	65	—	50	—	40	ns
		i ck a	—	35	—	27	—	22	ns
97	TXC Rising Edge to FST Out (wl) High	x ck	—	65	—	50	—	40	ns
		i ck a	—	35	—	27	—	22	ns
98	TXC Rising Edge to FST Out (wl) Low	x ck	—	65	—	50	—	40	ns
		i ck a	—	35	—	27	—	22	ns
99	TXC Rising Edge to Data Out Enable from High Impedance	x ck	—	65	—	50	—	40	ns
		i ck a	—	40	—	31	—	25	ns
100	TXC Rising Edge to Data Out Valid	x ck	—	65	—	50	—	40	ns
		i ck a	—	40	—	31	—	25	ns
101	TXC Rising Edge to Data Out High Impedance (periodically sampled, and not 100% tested)	x ck	—	70	—	54	—	43	ns
		i ck a	—	40	—	31	—	25	ns
101a	TXC Falling Edge to Data Out High Impedance for Gated Clock Mode Only	g ck	cyc+ich	—	cyc+ich	—	cyc+ich	—	ns
102	FST Input (bl) Setup Time Before TXC Falling Edge	x ck	15	—	12	—	10	—	ns
		i ck a	35	—	27	—	23	—	ns
103	FST Input (wl) to Data Out Enable from High Impedance		—	60	—	46	—	37	ns
104	FST Input (wl) Setup Time Before TXC Falling Edge	x ck	20	—	15	—	13	—	ns
		i ck a	55	—	42	—	34	—	ns
105	FST Input Hold Time After TXC Falling Edge	x ck	35	—	27	—	22	—	ns
		i ck a	5	—	4	—	4	—	ns
106	Flag Output Valid After TXC Rising Edge	x ck	—	70	—	54	—	43	ns
		i ck a	—	40	—	31	—	25	ns

Note:
1. For internal clock, External Clock Cycle is defined by Icyc and SSI control register.



SSI Figure 1. SSI Receiver Timing



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

SSI Figure 2. SSI Transmitter Timing

AC Electrical Characteristics —
Capacitance Derating — External Bus Asynchronous Timing

Vcc = 5.0 Vdc ± 10%, T_J = -40 to +105° C, CL = 50 pf + 1 TTL Load at 20.5 MHz and 27 MHz,

Vcc = 5.0 Vdc ± 5%, T_J = -40 to +105° C, CL = 50 pf + 1 TTL Load at 33 MHz, see Bus Figures 1 and 2

cyc = Clock cycle = 1/2 instruction cycle = 2 T cycles
WS = Number of Wait States, Determined by BCR Register (WS = 0 to 15)

The DSP56001 External Bus Timing Specifications are designed and tested at the maximum capacitive load of 50 pf, including stray capacitance. Typically, the drive capability of the External Bus pins (A0-A15, D0-D23, $\overline{PS}$, $\overline{DS}$, $\overline{RD}$, $\overline{WR}$, X/$\overline{Y}$) derates linearly at 1 ns per 5 pf additional capacitance from 50 pf to 250 pf of loading. Port B and C pins derate linearly at 1 ns per 5 pf additional capacitance from 50 pf to 250 pf of loading.

Active low inputs should be "pulled up" in a manner consistent with the AC and DC specifications.

To conserve power, when an internal memory access follows an external memory access, the $\overline{RD}$ and $\overline{WR}$ strobes remain deasserted and A0-A15 and X/$\overline{Y}$ do not change from their previous state. Both $\overline{PS}$ and $\overline{DS}$ will be deasserted (they do not change between two external accesses to the same memory space) indicating that no external memory access is occurring. If $\overline{BR}$ has been asserted, then the bus signals will be three-stated according to the timing information in this data sheet.

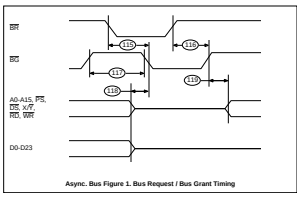
Num	Characteristics		20.5 MHz		27 MHz		33 MHz		Unit
			Min	Max	Min	Max	Min	Max	
115	Delay from $\overline{RD}$ Assertion to $\overline{RD}$ Assertion	(see Note 1)	2.cyc+tch	4*cyc+tch+ 15	2.cyc+tch	4*cyc+tch+ 15	2.cyc+tch	4*cyc+tch+ 13	ns
		(see Note 2)	cyc+tch	4*cyc+tch+ cyc*WS+20	cyc+tch	4*cyc+tch+ cyc*WS+15	cyc+tch	4*cyc+tch+ cyc*WS+13	ns
		(see Note 3)	cyc+tch	6*cyc+tch+ 2*cyc*WS+ 20	cyc+tch	6*cyc+tch+ 2*cyc*WS+ 15	cyc+tch	6*cyc+tch+ 2*cyc*WS+ 13	ns
		(see Note 4)	Infinity	Infinity	Infinity	Infinity	Infinity	Infinity	ns
		(see Note 5)	tch+3	cyc+tch+30	tch+3	cyc+tch+23	tch+3	cyc+tch+19	ns
116	Flags Input Hold Time After XRC Falling Edge Deassertion		2*cyc	4*cyc+20	2*cyc	4*cyc+15	2*cyc	4*cyc+13	ns
117	$\overline{RD}$ Deassertion Duration		2*cyc-10	—	2*cyc-8	—	2*cyc-6	—	ns
118	Delay from Address, Data, and Control Bus High Impedance to $\overline{RD}$ Assertion		0	—	0	—	0	—	ns
119	Delay from $\overline{RD}$ Deassertion to Address, Data, and Control Bus Enabled		—	tch-10	—	tch-8	—	tch-6	ns
120	Address Valid to $\overline{WR}$ Assertion	WS=0	tch-9	tch+5	tch-7	tch+5	tch-5.5	tch+5	ns
		WS>0	cyc-6	cyc+5	cyc-7	cyc+5	cyc-5.5	cyc+5	ns
121	$\overline{WR}$ Assertion Width	WS=0	cyc-9	—	cyc-7	—	cyc-5.0	—	ns
		WS>0	WS*cyc +tch-9	—	WS*cyc +tch-7	—	WS*cyc +tch-5.0	—	ns
122	$\overline{WR}$ Deassertion to Address Not Valid		tch-12	—	tch-9	—	tch-7.5	—	ns
123	$\overline{WR}$ Assertion to Data Out Valid	WS=0	tch-9	tch+10	tch-7	tch+8	tch-5.5	tch+6.5	ns
		WS>0	0	10	0	8	0	6.5	ns
124	Data Out Hold Time from $\overline{WR}$ Deassertion (The maximum specification is periodically sampled, and not 100% tested.)		tch-9	tch+7	tch-7	tch+6	tch-5.5	tch+4.5	ns
125	Data Out Setup Time to $\overline{WR}$ Deassertion (see Note 6)	WS=0	tcl-5	—	tcl-5	—	tcl-5	—	ns
		WS>0	WS*cyc +tcl-5	—	WS*cyc +tcl-5	—	WS*cyc +tcl-5	—	ns
126	$\overline{WR}$ Deassertion to Address Not Valid		tch-9	—	tch-7	—	tch-5.5	—	ns

AC Electrical Characteristics - External Bus Asynchronous Timing (Continued)

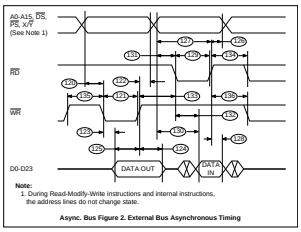
Num	Characteristics		20.5 MHz		27 MHz		33 MHz		Unit
			Min	Max	Min	Max	Min	Max	
127	Address Valid to $\overline{RD}$ deassertion	WS = 0 WS > 0	cyc+t2-9 ((WS+1)+ cyc)+t2-9	— —	cyc+t2-5 ((WS+1)+ cyc)+t2-5	— —	cyc+t2-4 ((WS+1)+ cyc)+t2-4	— —	ns ns
128	Input Data Hold Time to $\overline{RD}$ Deassertion		0	—	0	—	0	—	ns
129	$\overline{RD}$ Assertion Width	WS = 0 WS > 0	cyc-9 ((WS+1)* cyc)-9	— —	cyc-7 ((WS+1)* cyc)-7	— —	cyc-5.5 ((WS+1)* cyc)-5.5	— —	ns ns
130	Address Valid to Input Data Valid	WS = 0 WS > 0	— —	cyc+t2-18 ((WS+1)+ cyc)+t2-18	— —	cyc+t2-14 ((WS+1)+ cyc)+t2-14	— —	cyc+t2-11 ((WS+1)+ cyc)+t2-11	ns ns
131	Address Valid to $\overline{RD}$ Assertion		t2-9	t2+5	t2-7	t2+5	t2-5.5	t2+5	ns
132	$\overline{RD}$ Assertion to Input Data Valid	WS=0 WS>0	— —	cyc-14 ((WS+1)* cyc)-14	— —	cyc-11 ((WS+1)* cyc)-11	— —	cyc-9 ((WS+1)* cyc)-9	ns ns
133	$\overline{WR}$ Deassertion to $\overline{RD}$ Assertion		cyc-15	—	cyc-12	—	cyc-10	—	ns
134	$\overline{RD}$ Deassertion to $\overline{RD}$ Assertion		cyc-10	—	cyc-8	—	cyc-6.6	—	ns
135	$\overline{WR}$ Deassertion to $\overline{WR}$ Assertion	WS=0 WS>0	cyc-15 cyc+t2h-15	— —	cyc-12 cyc+t2h-12	— —	cyc-10 cyc+t2h-10	— —	ns ns
136	$\overline{RD}$ Deassertion to $\overline{WR}$ Assertion	WS=0 WS>0	cyc-10 cyc+t2h-10	— —	cyc-8 cyc+t2h-8	— —	cyc-6.6 cyc+t2h-6.6	— —	ns ns

Notes:

1. With no external access from the DSP.
2. During external read or write access.
3. During external read-modify-write access.
4. During the STOP mode the external bus will not be released and $\overline{BR}$ will not go low. However, if the bus is released ($\overline{BG}$ = 0) and the STOP instruction is executed while $\overline{BG}$ = 0 then the bus will remain released while the DSP is in the stop state and $\overline{BR}$ will remain low.
5. During the WAIT mode the $\overline{BR}$/$\overline{BG}$ circuits remain active.
6. Typical values at 5V are at 20.5MHz and WS=0, Min = t0-4
   at 20.5MHz and WS>0, Min = WS×cyc-t0-4
   at 27 MHz and WS=0, Min = t0-3
   at 27 MHz and WS>0, Min = WS×cyc-t0-3
   at 33 MHz and WS=0, Min = t0-2.5
   at 33 MHz and WS>0, Min = WS×cyc-t0-2.5



Async. Bus Figure 1. Bus Request / Bus Grant Timing



Note:
1. During Read-Modify-Write instructions and internal instructions, the address lines do not change state.

Async. Bus Figure 2. External Bus Asynchronous Timing

DSP56001 Electrical Characteristics

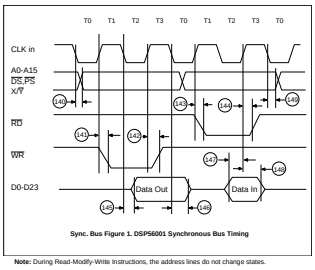
AC Electrical Characteristics - External Bus Synchronous Timing

V_{CC} = 5.0 Vdc ± 10%, T_J = -40 to 105° C at 20.5 MHz 27 MHz
V_{CC} = 5.0 Vdc ± 5%, T_J = -40 to 105° C at 33 MHz

Num	Characteristics		20.5 MHz		27 MHz		33 MHz		Unit
			Min	Max	Min	Max	Min	Max	
140	Clk Low Transition To Address Valid		—	24	—	19	—	19	ns
141	Clk High Transition To $\overline{WR}$ Assertion (see Note 2)	WS = 0 WS > 0	0 0	19 tch+19	0 0	15 tch+15	0 0	17 tch+17	ns ns
142	Clk High Transition To $\overline{WR}$ Deassertion		5	21	5	16	5	13	ns
143	Clk High Transition To $\overline{RD}$ Assertion		0	19	0	15	0	16	ns
144	Clk High Transition To $\overline{RD}$ Deassertion		5	17	5	13	4.5	10.5	ns
145	Clk Low Transition To Data-Out Valid		—	25	—	19	—	19	ns
146	Clk Low Transition To Data-Out Invalid (see Note 3)		5	—	4	—	3.5	—	ns
147	Data-In Valid To Clk High Transition (Setup)		0	—	0	—	0	—	ns
148	Clk High Transition To Data-In Invalid (Hold)		12	—	12	—	13	—	ns ns
149	Clk Low To Address Invalid (see Note 3)		3	—	3	—	3	—	ns

Notes:

1. 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.
2. WS equals the wait states values specified in the BCR.
3. Clk low to data-out invalid (spec. 146) and Clk low to address invalid (spec. 149) indicate the time after which data/address are no longer guaranteed to be valid.



Sync. Bus Figure 1. DSP56001 Synchronous Bus Timing

Note: During Read-Modify-Write Instructions, the address lines do not change states.

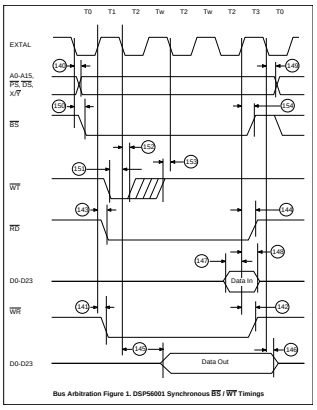
DSP56001 Electrical Characteristics

AC Electrical Characteristics - Bus Strobe / Wait Timing

Num	Characteristics	20.5 MHz		27 MHz		33 MHz		Unit
		Min	Max	Min	Max	Min	Max	
150	Clk Low Transition To $\overline{BS}$ Assertion	4	24	3	19	2.5	19	ns
151	$\overline{WT}$ Assertion To Clk Low Transition (setup time)	4	—	3	—	2.5	—	ns ns
152	Clk Low Transition To $\overline{WT}$ Deassertion For Minimum Timing	14	cyc-9	11	cyc-6	12	cyc-5	ns
153	$\overline{WT}$ Deassertion To Clk Low Transition For Maximum Timing (2 wait states	8	—	6	—	5	—	ns
154	Clk High Transition To $\overline{BS}$ Deassertion	5	26	4	20	3.5	19	ns
155	$\overline{BS}$ Assertion To Address Valid	-2	10	-2	8	-2	6.5	ns
156	$\overline{BS}$ Assertion To $\overline{WT}$ Assertion (see Note 2)	0	cyc-15	0	cyc-11	0	cyc-10	ns
157	$\overline{BS}$ Assertion To $\overline{WT}$ Deassertion (See Note 2 and Note 4) WS = 2 WS ≥ 3	cyc (WS-1) -cyc	2*cyc-15 WS*cyc -15	cyc (WS-1) -cyc	2*cyc-11 WS*cyc -11	cyc+4 (WS-1) -cyc+4	2*cyc-10 WS*cyc -10	ns ns
158	$\overline{WT}$ Deassertion To $\overline{BS}$ Deassertion	cyc+td	2-cyc+td +23	cyc+td	2-cyc+td +17	cyc+td	2-cyc+td +15	ns
159	Minimum $\overline{BS}$ Deassertion Width For Consecutive External Accesses	tch-7	—	tch-6	—	tch-4.5	—	ns
160	$\overline{BS}$ Deassertion To Address Invalid (see Note 3)	tch-10		tch-8		tch-6.5		
161	Data-In Valid to $\overline{BS}$ Deassertion (Set Up)	16	—	12	—	10	—	ns

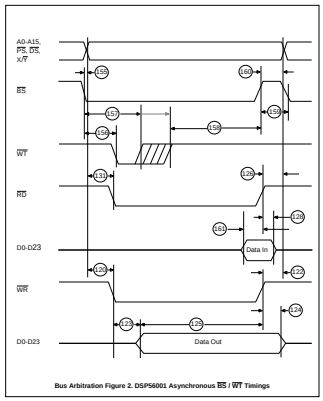
Note:

1. 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.
2. If wait states are also inserted using the BCR and if the number of wait states is greater than 2, then specification numbers 156 and 157 can be increased accordingly.
3. $\overline{BS}$ deassertion to address invalid indicates the time after which the address are no longer guaranteed to be valid.
4. The minimum number of wait states when using $\overline{BS}$/$\overline{WT}$ is two (2).
5. For read-modify-write instructions, the address lines will not change states between the read and the write cycle. However, $\overline{BS}$ will deassert before asserting again for the write cycle. If wait states are desired for each of the read and write cycle, the $\overline{WT}$ pin must be asserted once for each cycle.



Bus Arbitration Figure 1. DSP56001 Synchronous $\overline{BS}$ / $\overline{WT}$ Timings

Note: During Read-Modify-Write instructions, the address lines do not change state. However, $\overline{BS}$ will deassert before asserting again for the write cycle.

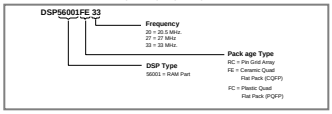


Bus Arbitration Figure 2. DSP56001 Asynchronous $\overline{RS}$ / $\overline{WT}$ Timings

Note: During Read-Modify-Write Instructions, the address lines will not change states. However, $\overline{RS}$ will deassert before asserting again for the write cycle.

APPENDIX A

ORDERING INFORMATION



DSP56001 SOCKET INFORMATION

PGA

Supplier	Telephone	Socket Type	Part Number	Comment
Advanced Interconnections	(401) 823-5200	Standard 88 Pin	4CS08B-01TG[2]	Includes Cutout in Center
AMP	(717) 564-0100	Standard 88 Pin	1-91623-3	Low Insertion Force
			1-55283-9	ZIF Production
		Standard 128 Pin	1-55283-4	ZIF Burn-In and Test
Robinson Nugent	(812) 945-0211	Custom Pinout	PGA-08BCM3P-S-TG[2]	
			PGA-08BCHP3-SL-TG[2]	High Temp, Longer Leads
Samtec	(812) 944-6733	Standard 120 Pin	MHAS-120-ZSTT-13[2]	Includes Cutout in Center
		Custom 88 Pin	CPAS-88-ZSTT-13BF[3]	No Cutout

NOTES:
1. Please specify wirewrap and plating options. The part numbers shown specify low profile solder tail pins having a tin contact and tin shell.
2. Please specify wirewrap and plating options. The part number shown specifies gold contact and tin shell.
3. Cutout in the center, unused holes are plugged, solder tail.

CQFP

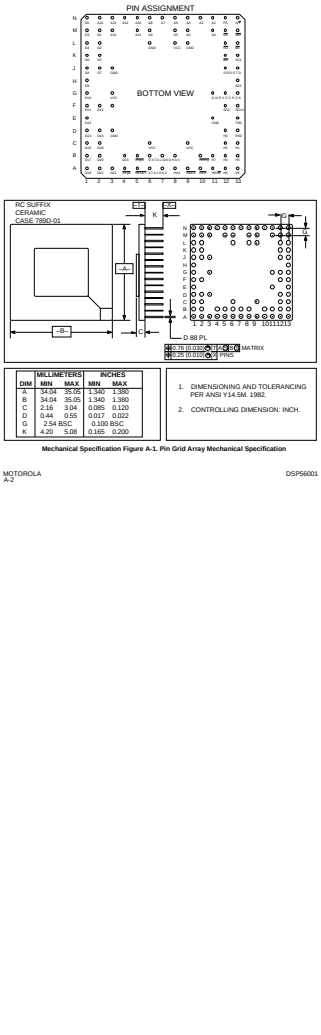
Supplier	Telephone	Socket Type	Part Number	Comment
AMP	(717)564-0100	—	822054-2[1]	Converts CQFP to fit AMP's 132 position PQFP "Micro-Pitch Socket".

NOTES:
1. This part is not a socket. It is a converter that allows a CQFP part to be used in the PQFP socket described below.

PQFP

Supplier	Telephone	Socket Type	Part Number	Comment
AMP	(717)564-0100	132 Pin	821949-5[1]	Housing Sub-Assembly and
			821942-1[1]	Cover for 132 position PQFP "Micro-Pitch Socket".

NOTES:
1. One housing sub-assembly and one cover are required for each socket.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	34.04	35.05	1.340	1.380
B	34.04	35.05	1.340	1.380
C	2.16	3.04	0.085	0.120
D	0.44	0.55	0.017	0.022
G	2.54 BSC		0.100 BSC	
K	4.20	5.08	0.165	0.200

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M. 1982.
2. CONTROLLING DIMENSION: INCH.

Mechanical Specification Figure A-1. Pin Grid Array Mechanical Specification

Mechanical Specification Table A-1. CQFP and PQFP Pin Out

PIN	#FUNCTION	PIN	#FUNCTION	PIN	#FUNCTION	PIN	#FUNCTION
17	NO CONNECT	116	NO CONNECT	83	NO CONNECT	50	NO CONNECT
16	H4	115	D20	82	D1	49	$\overline{PS}$
15	H5	114	D19	81	D0	48	A$\overline{0}$
14	H6	113	D18	80	A15	47	$\overline{RD}$
13	PERIPHERAL VCC	112	DATA BUS GND	79	A14	46	$\overline{WR}$
12	PERIPHERAL VCC	111	DATA BUS GND	78	NO CONNECT	45	$\overline{DS}$
11	H7	110	NO CONNECT	77	A13	44	NO CONNECT
10	$\overline{HREQ}$	109	D17	76	A12	43	$\overline{BR}$
9	HA$\overline{8}$	108	D16	75	A11	42	SRD
8	$\overline{HDS}$	107	NO CONNECT	74	ADDRESS BUS GND	41	NO CONNECT
7	NO CONNECT	106	D15	73	ADDRESS BUS GND	40	SCI
6	$\overline{HACK}$	105	D14	72	NO CONNECT	39	STD
5	HA9	104	D13	71	A10	38	NO CONNECT
4	NO CONNECT	103	NO CONNECT	70	A9	37	SCI
3	NO CONNECT	102	D12	69	NO CONNECT	36	INTERNAL LOGIC VCC
2	HA1	101	DATA BUS VCC	68	A8	35	INTERNAL LOGIC VCC
1	HA2	100	DATA BUS VCC	67	A7	34	INTERNAL LOGIC GND
132	NO CONNECT	99	D11	66	NO CONNECT	33	INTERNAL LOGIC GND
131	INTERNAL LOGIC GND	98	NO CONNECT	65	A6	32	SCK
130	INTERNAL LOGIC GND	97	D10	64	ADDRESS BUS VCC	31	SCO
129	INTERNAL LOGIC VCC	96	D9	63	ADDRESS BUS VCC	30	NO CONNECT
128	INTERNAL LOGIC VCC	95	D8	62	NO CONNECT	29	TCLK
127	EXTAL	94	D8	61	A5	28	TXD
126	XTAL	93	D7	60	A4	27	RXD
125	NO CONNECT	92	D6	59	NO CONNECT	26	NO CONNECT
124	$\overline{HREQ1}$	91	DATA BUS GND	58	A3	25	H0
123	MODA/$\overline{IRQA}$	90	DATA BUS GND	57	A2	24	PERIPHERAL GND
122	NO CONNECT	89	NO CONNECT	56	ADDRESS BUS GND	23	PERIPHERAL GND
121	MMAP/MODB/$\overline{IRQB}$	88	D5	55	ADDRESS BUS GND	22	H1
120	D23	87	D4	54	A1	21	NO CONNECT
119	D22	86	D3	53	A0	20	H2
118	D21	85	D2	52	$\overline{PS}$	19	H3
117	NO CONNECT	84	NO CONNECT	51	NO CONNECT	18	NO CONNECT

Note: Do not connect to "NO CONNECT" pins.
"NO CONNECT" pins are reserved for future enhancements.

Mechanical Specification Figure A-2. Ceramic Quad Flat Pack

Mechanical Specification Figure A-2. Ceramic Quad Flat Pack (Continued)

Mechanical Specification Figure A-3. Plastic Quad Flat Pack

Mechanical Specification Figure A-3. Plastic Quad Flat Pack (Continued)

APPENDIX B
APPLICATION EXAMPLES

The lowest cost DSP56001 based system is shown in Figure B-1. It uses no run time external memory and requires only two chips, the DSP56001 and a low cost EPROM. The EPROM read access time should be less than 780 nanoseconds when the DSP56001 is operating at a clock rate of 20.5 MHz.

A system with external data RAM memory requires no glue logic to select the external EPROM from bootstrap mode. $\overline{PS}$ is used to enable the EPROM and $\overline{DS}$ is used to enable the high speed data memories as shown in Figure B-2.

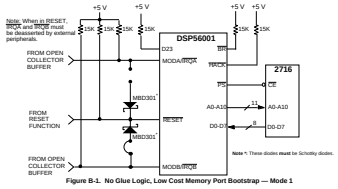


Figure B-1. No Glue Logic, Low Cost Memory Port Bootstrap — Mode 1

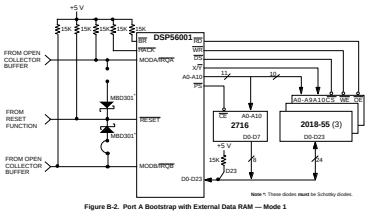
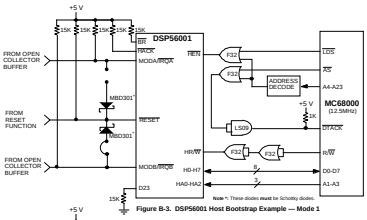


Figure B-2. Port A Bootstrap with External Data RAM — Mode 1

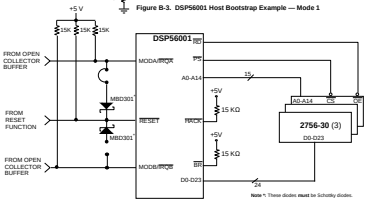
Figure B-3 shows the DSP56001 bootstrapping via the Host Port from an MC68000.

Systems with external program memory can load the on-chip PRAM without using the bootstrap mode. In Figure B-4, the DSP56001 is operated in mode 2 with external program memory at location $E000. The programmer can overlay the high speed on-chip PRAM with DSP algorithms by using the MOVEM instruction.



Note *: These diodes **must** be Schottky diodes.

Figure B-3. DSP56001 Host Bootstrap Example — Mode 1



Note *: These diodes **must** be Schottky diodes.

Figure B-4. 32K Words of External Program ROM — Mode 2

Figure B-5 shows an alternative clock oscillator circuit used in the Graphic Equalizer application note (APR2). The 330Ω resistor provides additional current limiting in the crystal. Figure B-6 shows a circuit which waits until Vcc on the DSP is at least 4.5 V before initiating a 3.75 ms minimum (150,000T) oscillator stabilization delay required for the on-chip oscillator (only 50T is required for an external oscillator). This insures that the DSP is operational and stable before releasing the reset signal.

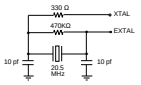
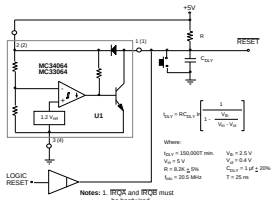


Figure B-5. Alternative Clock Circuit from the Graphic Equalizer (APR2)



Notes: 1. IRQA and IRQB must be hardwired.

2. MODA and MODB must be hard wired.

Figure B-6. Reset Circuit Using MC34064/MC33064

Figure 7 illustrates how to connect a 20 ns static RAM with a 33 MHz DSP56001. The important parameters are $T_{DW} \leq 10$ ns, $T_{DOE} \leq 10$ ns, and $T_{AA} = 20$ ns maximum. A 7.5 ns PLD is used to minimize decoding delays. This example maps the static RAM into the ranges X:$1000-1FFF and Y:$1000-1FFF. The PLD equation is:

$\overline{RAM\_ENABLE} = \overline{PS} \,\&\, \overline{DS} \,\&\, !A15 \,\&\, !A14 \,\&\, !A13 \,\&\, !A12$

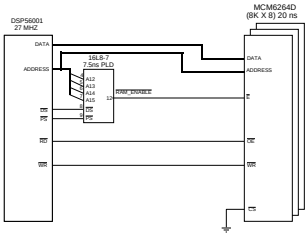


Figure B-7. 27 MHz DSP56001 with 20 ns SRAM

Figure B-8 shows the DSP56001 connected to the bus of an IBM-PC computer. The PAL equations and other details of this circuit are available in "An ISA BUS INTERFACE FOR THE DSP56001" which is provided on request by the Motorola DSP Marketing Department (512-891-2030).

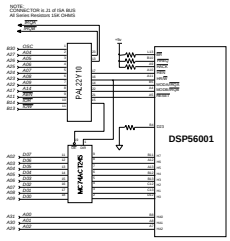


Figure B-8. DSP56001-to-ISA Bus Interface Schematic

APPENDIX C
MU-LAW / A-LAW EXPANSION TABLES

```
        ORG  X:$100
;
M_00    DC   $707C00  ; 8931
M_01    DC   $797C00  ; 7775
M_02    DC   $757C00  ; 7519
M_03    DC   $717C00  ; 7263
M_04    DC   $7D7C00  ; 7007
M_05    DC   $697C00  ; 6751
M_06    DC   $657C00  ; 6495
M_07    DC   $617C00  ; 6239
M_08    DC   $7D7C00  ; 5983
M_09    DC   $797C00  ; 5727
M_0A    DC   $757C00  ; 5471
M_0B    DC   $717C00  ; 5215
M_0C    DC   $4D7C00  ; 4959
M_0D    DC   $497C00  ; 4703
M_0E    DC   $457C00  ; 4447
M_0F    DC   $417C00  ; 4191
M_10    DC   $3E7C00  ; 3999
M_11    DC   $3C7C00  ; 3871
M_12    DC   $3A7C00  ; 3743
M_13    DC   $387C00  ; 3615
M_14    DC   $367C00  ; 3487
M_15    DC   $347C00  ; 3359
M_16    DC   $327C00  ; 3231
M_17    DC   $307C00  ; 3103
M_18    DC   $2E7C00  ; 2975
M_19    DC   $2C7C00  ; 2847
M_1A    DC   $2A7C00  ; 2719
M_1B    DC   $287C00  ; 2591
M_1C    DC   $267C00  ; 2463
M_1D    DC   $247C00  ; 2335
M_1E    DC   $227C00  ; 2207
M_1F    DC   $207C00  ; 2079
M_20    DC   $1EFC00  ; 1983
M_21    DC   $1DFC00  ; 1919
M_22    DC   $1CFC00  ; 1855
M_23    DC   $1BFC00  ; 1791
M_24    DC   $1AFC00  ; 1727
M_25    DC   $19FC00  ; 1663
M_26    DC   $18FC00  ; 1599
M_27    DC   $17FC00  ; 1535
M_28    DC   $16FC00  ; 1471
M_29    DC   $15FC00  ; 1407
M_2A    DC   $14FC00  ; 1343
M_2B    DC   $13FC00  ; 1279
M_2C    DC   $12FC00  ; 1215
M_2D    DC   $11FC00  ; 1151
M_2E    DC   $10FC00  ; 1087
M_2F    DC   $0FFC00  ; 1023
M_30    DC   $0F3C00  ; 975
M_31    DC   $0E3C00  ; 943
M_32    DC   $0E3C00  ; 911
M_33    DC   $0D8C00  ; 879
M_34    DC   $0D3C00  ; 847
M_35    DC   $0CBC00  ; 815
M_36    DC   $0C3C00  ; 783
M_37    DC   $0BBC00  ; 751
M_38    DC   $0B3C00  ; 719
M_39    DC   $0ABC00  ; 687
M_3A    DC   $0A3C00  ; 655
M_3B    DC   $098C00  ; 623
M_3C    DC   $093C00  ; 591
M_3D    DC   $08DC00  ; 559
M_3E    DC   $083C00  ; 527
M_3F    DC   $078C00  ; 495
M_40    DC   $075C00  ; 471
M_41    DC   $071C00  ; 455
M_42    DC   $06DC00  ; 439
M_43    DC   $069C00  ; 423
M_44    DC   $065C00  ; 407
M_45    DC   $061C00  ; 391
M_46    DC   $05DC00  ; 375
M_47    DC   $059C00  ; 359
M_48    DC   $055C00  ; 343
M_49    DC   $051C00  ; 327
M_4A    DC   $04DC00  ; 311
M_4B    DC   $049C00  ; 295
M_4C    DC   $045C00  ; 279
M_4D    DC   $041C00  ; 263
M_4E    DC   $03DC00  ; 247
M_4F    DC   $039C00  ; 231
M_50    DC   $036C00  ; 219
M_51    DC   $034C00  ; 211
M_52    DC   $032C00  ; 203
M_53    DC   $030C00  ; 195
M_54    DC   $02EC00  ; 187
M_55    DC   $02CC00  ; 179
M_56    DC   $02AC00  ; 171
M_57    DC   $028C00  ; 163
M_58    DC   $026C00  ; 155
M_59    DC   $024C00  ; 147
M_5A    DC   $022C00  ; 139
M_5B    DC   $020C00  ; 131
M_5C    DC   $01EC00  ; 123
M_5D    DC   $01CC00  ; 115
M_5E    DC   $01AC00  ; 107
M_5F    DC   $018C00  ; 99
M_60    DC   $017400  ; 93
M_61    DC   $016400  ; 89
M_62    DC   $015400  ; 85
M_63    DC   $014400  ; 81
M_64    DC   $013400  ; 77
M_65    DC   $012400  ; 73
M_66    DC   $011400  ; 69
M_67    DC   $010400  ; 65
M_68    DC   $00F400  ; 61
M_69    DC   $00E400  ; 57
M_6A    DC   $00D400  ; 53
M_6B    DC   $00C400  ; 49
M_6C    DC   $00B400  ; 45
M_6D    DC   $00A400  ; 41
M_6E    DC   $009400  ; 37
M_6F    DC   $008400  ; 33
M_70    DC   $007800  ; 30
M_71    DC   $007000  ; 28
M_72    DC   $006800  ; 26
M_73    DC   $006000  ; 24
M_74    DC   $005800  ; 22
M_75    DC   $005000  ; 20
M_76    DC   $004800  ; 18
M_77    DC   $004400  ; 16
M_78    DC   $003800  ; 14
M_79    DC   $003000  ; 12
M_7A    DC   $002800  ; 10
M_7B    DC   $002000  ;  8
M_7C    DC   $001800  ;  6
M_7D    DC   $001000  ;  4
M_7E    DC   $000800  ;  2
M_7F    DC   $000000  ;  0
```

Figure C-1. Mu-Law/A-Law Expansion Table Contents (Sheet 1 of 2)

```
A_80    DC    $158000  ;  688                A_C0    DC    $015800  ;   43
A_81    DC    $148000  ;  656                A_C1    DC    $014000  ;   41
A_82    DC    $178000  ;  752                A_C2    DC    $017600  ;   47
A_83    DC    $168000  ;  720                A_C3    DC    $016800  ;   45
A_84    DC    $118000  ;  560                A_C4    DC    $011600  ;   35
A_85    DC    $108000  ;  528                A_C5    DC    $010800  ;   33
A_86    DC    $138000  ;  624                A_C6    DC    $013800  ;   39
A_87    DC    $128000  ;  592                A_C7    DC    $012000  ;   37
A_88    DC    $1D8000  ;  944                A_C8    DC    $01D800  ;   59
A_89    DC    $1C8000  ;  912                A_C9    DC    $01C800  ;   57
A_8A    DC    $1F8000  ; 1008                A_CA    DC    $01F800  ;   63
A_8B    DC    $1E8000  ;  976                A_CB    DC    $01E800  ;   61
A_8C    DC    $198000  ;  816                A_CC    DC    $019800  ;   51
A_8D    DC    $188000  ;  784                A_CD    DC    $018800  ;   49
A_8E    DC    $1B8000  ;  880                A_CE    DC    $01B800  ;   55
A_8F    DC    $1A8000  ;  848                A_CF    DC    $01A800  ;   53
A_90    DC    $0A2000  ;  344                A_D0    DC    $00A800  ;   11
A_91    DC    $0AA000  ;  328                A_D1    DC    $00A000  ;    9
A_92    DC    $0BC000  ;  376                A_D2    DC    $00B600  ;   15
A_93    DC    $0B4000  ;  360                A_D3    DC    $00B000  ;   13
A_94    DC    $0942000 ;  292                A_D4    DC    $009800  ;    1
A_95    DC    $0945E00 ;  294                A_D5    DC    $009E00  ;    3
A_96    DC    $09C000  ;  312                A_D6    DC    $009800  ;    7
A_97    DC    $094E00  ;  296                A_D7    DC    $00E200  ;    5
A_98    DC    $0EC000  ;  472                A_D8    DC    $00D800  ;   27
A_99    DC    $0E4E00  ;  456                A_D9    DC    $00CE00  ;   25
A_9A    DC    $0FC000  ;  504                A_DA    DC    $00F800  ;   31
A_9B    DC    $0F4E00  ;  488                A_DB    DC    $00E200  ;   29
A_9C    DC    $0CC000  ;  408                A_DC    DC    $009800  ;   19
A_9D    DC    $0C4E00  ;  392                A_DD    DC    $008E00  ;   17
A_9E    DC    $0DC000  ;  440                A_DE    DC    $008800  ;   23
A_9F    DC    $0D4E00  ;  424                A_DF    DC    $00AE00  ;   21
A_A0    DC    $160000  ; 2752                A_E0    DC    $05E000  ;  172
A_A1    DC    $120000  ; 2624                A_E1    DC    $052000  ;  164
A_A2    DC    $1E3000  ; 3008                A_E2    DC    $05E000  ;  188
A_A3    DC    $1A5000  ; 2980                A_E3    DC    $054A00  ;  180
A_A4    DC    $140000  ; 2240                A_E4    DC    $040000  ;  140
A_A5    DC    $420000  ; 2112                A_E5    DC    $042000  ;  132
A_A6    DC    $4E3000  ; 2496                A_E6    DC    $04E200  ;  156
A_A7    DC    $4A5000  ; 2368                A_E7    DC    $04A000  ;  148
A_A8    DC    $760000  ; 3776                A_E8    DC    $070000  ;  236
A_A9    DC    $720000  ; 3648                A_E9    DC    $072000  ;  228
A_AA    DC    $7E3000  ; 4032                A_EA    DC    $07E200  ;  252
A_AB    DC    $7A5000  ; 3904                A_EB    DC    $07A000  ;  244
A_AC    DC    $660000  ; 3264                A_EC    DC    $066000  ;  204
A_AD    DC    $620000  ; 3136                A_ED    DC    $062000  ;  196
A_AE    DC    $6E3000  ; 3520                A_EE    DC    $06E200  ;  220
A_AF    DC    $6A5000  ; 3392                A_EF    DC    $06A000  ;  212
A_B0    DC    $290000  ; 1376                A_F0    DC    $038000  ;   86
A_B1    DC    $290000  ; 1312                A_F1    DC    $029000  ;   82
A_B2    DC    $2F0000  ; 1504                A_F2    DC    $02F000  ;   94
A_B3    DC    $2D0000  ; 1440                A_F3    DC    $02D000  ;   90
A_B4    DC    $230000  ; 1120                A_F4    DC    $023000  ;   70
A_B5    DC    $210000  ; 1056                A_F5    DC    $021000  ;   66
A_B6    DC    $270000  ; 1248                A_F6    DC    $027000  ;   78
A_B7    DC    $250000  ; 1184                A_F7    DC    $025000  ;   74
A_B8    DC    $3B0000  ; 1888                A_F8    DC    $03B000  ;  118
A_B9    DC    $390000  ; 1824                A_F9    DC    $039000  ;  114
A_BA    DC    $3F0000  ; 2016                A_FA    DC    $03F000  ;  126
A_BB    DC    $3D0000  ; 1952                A_FB    DC    $03D000  ;  122
A_BC    DC    $330000  ; 1632                A_FC    DC    $033000  ;  102
A_BD    DC    $310000  ; 1568                A_FD    DC    $031000  ;   98
A_BE    DC    $370000  ; 1760                A_FE    DC    $037000  ;  110
A_BF    DC    $350000  ; 1696                A_FF    DC    $035000  ;  106
```

Figure C-1. Mu-Law/A-Law Expansion Table Contents (Sheet 2 of 2)

APPENDIX D
SINE WAVE TABLE

This sine wave table is normally used by FFT routines which use bit reversed address pointers. This table can be used as it is for up to 512 point FFTs; however, for larger FFTs, the table must be copied to a different memory location to allow the reverse-carry addressing mode to be used (see **Section 5.3.2.3 REVERSE-CARRY MODIFIER (Mn=$0000)** in the **DSP56000/DSP56001 Digital Signal Processor User's Manual** for additional information).

```
        ORG   Y:$100
;
S_00    DC    $000000  ; +0.0000000000
S_01    DC    $03242B  ; +0.0245412998
S_02    DC    $0647D9  ; +0.0490676016
S_03    DC    $096A90  ; +0.0735644996
S_04    DC    $0C8BD3  ; +0.0980170965
S_05    DC    $0FAB27  ; +0.1224106997
S_06    DC    $12C810  ; +0.1467303932
S_07    DC    $15E214  ; +0.1709619015
S_08    DC    $18F8B8  ; +0.1950902939
S_09    DC    $1C0B82  ; +0.2191012055
S_0A    DC    $1F19F9  ; +0.2429800928
S_0B    DC    $2223A5  ; +0.2667128146
S_0C    DC    $25280C  ; +0.2902846038
S_0D    DC    $2826B9  ; +0.3136816919
S_0E    DC    $2B1F35  ; +0.3368898928
S_0F    DC    $2E110A  ; +0.3598949909
S_10    DC    $30FBC5  ; +0.3826833963
S_11    DC    $33DEF3  ; +0.4052414000
S_12    DC    $36BA20  ; +0.4275551140
S_13    DC    $398CDD  ; +0.4496113062
S_14    DC    $3C56BA  ; +0.4713967144
S_15    DC    $3F174A  ; +0.4928981960
S_16    DC    $41CE1E  ; +0.5141026974
S_17    DC    $447ACD  ; +0.5349975824
S_18    DC    $471CED  ; +0.5555701852
S_19    DC    $49B415  ; +0.5758082271
S_1A    DC    $4C3FE0  ; +0.5956993103
S_1B    DC    $4EBFE9  ; +0.6152315736
S_1C    DC    $5133CD  ; +0.6343932748
S_1D    DC    $539B2B  ; +0.6531729102
S_1E    DC    $55F5A5  ; +0.6715589762
S_1F    DC    $5842DD  ; +0.6895405054
S_20    DC    $5A827A  ; +0.7071068287
S_21    DC    $5CB421  ; +0.7242470980
S_22    DC    $5ED77D  ; +0.7409511805
S_23    DC    $60EC38  ; +0.7572088242
S_24    DC    $62F202  ; +0.7730104923
S_25    DC    $64E889  ; +0.7883464098
S_26    DC    $66CF81  ; +0.8032075167
S_27    DC    $68A69F  ; +0.8175848722
S_28    DC    $6A6D99  ; +0.8314697146
S_29    DC    $6C2429  ; +0.8448535204
S_2A    DC    $6DCA0D  ; +0.8577286005
S_2B    DC    $6F5F03  ; +0.8700870275
S_2C    DC    $70E2CC  ; +0.8819212914
S_2D    DC    $72552D  ; +0.8932244182
S_2E    DC    $73B5EC  ; +0.9039893150
S_2F    DC    $7504D3  ; +0.9142097235
S_30    DC    $7641AF  ; +0.9238795042
S_31    DC    $776C4F  ; +0.9329928160
S_32    DC    $788484  ; +0.9415441155
S_33    DC    $798A24  ; +0.9495282173
S_34    DC    $7A7D05  ; +0.9569402933
S_35    DC    $7B5D04  ; +0.9637761116
S_36    DC    $7C29FC  ; +0.9700313210
S_37    DC    $7CE3CF  ; +0.9757022262
S_38    DC    $7D8A5F  ; +0.9807853103
S_39    DC    $7E1D94  ; +0.9852777123
S_3A    DC    $7E9D56  ; +0.9891765118
S_3B    DC    $7F0992  ; +0.9924796224
S_3C    DC    $7F6237  ; +0.9951847792
S_3D    DC    $7FA737  ; +0.9972904921
S_3E    DC    $7FD888  ; +0.9987955093
S_3F    DC    $7FF622  ; +0.9996988773
S_40    DC    $7FFFFF  ; +0.9999998808
S_41    DC    $7FF622  ; +0.9996988773
S_42    DC    $7FD888  ; +0.9987955093
S_43    DC    $7FA737  ; +0.9972904921
S_44    DC    $7F6237  ; +0.9951847792
S_45    DC    $7F0992  ; +0.9924796224
S_46    DC    $7E9D56  ; +0.9891765118
S_47    DC    $7E1D94  ; +0.9852777123
S_48    DC    $7D8A5F  ; +0.9807853103
S_49    DC    $7CE3CF  ; +0.9757022262
S_4A    DC    $7C29FC  ; +0.9700313210
S_4B    DC    $7B5D04  ; +0.9637761116
S_4C    DC    $7A7D05  ; +0.9569402933
S_4D    DC    $798A24  ; +0.9495282173
S_4E    DC    $788484  ; +0.9415441155
S_4F    DC    $776C4F  ; +0.9329928160
S_50    DC    $7641AF  ; +0.9238795042
S_51    DC    $7504D3  ; +0.9142097235
S_52    DC    $73B5EC  ; +0.9039893150
S_53    DC    $72552D  ; +0.8932244182
S_54    DC    $70E2CC  ; +0.8819212914
S_55    DC    $6F5F03  ; +0.8700870275
S_56    DC    $6DCA0D  ; +0.8577286005
S_57    DC    $6C2429  ; +0.8448535204
S_58    DC    $6A6D99  ; +0.8314697146
S_59    DC    $68A69F  ; +0.8175848722
S_5A    DC    $66CF81  ; +0.8032075167
S_5B    DC    $64E889  ; +0.7883464098
S_5C    DC    $62F202  ; +0.7730104923
S_5D    DC    $60EC38  ; +0.7572088242
S_5E    DC    $5ED77D  ; +0.7409511805
S_5F    DC    $5CB421  ; +0.7242470980
S_60    DC    $5A827A  ; +0.7071068287
S_61    DC    $5842DD  ; +0.6895405054
S_62    DC    $55F5A5  ; +0.6715589762
S_63    DC    $539B2B  ; +0.6531729102
S_64    DC    $5133CD  ; +0.6343932748
S_65    DC    $4EBFE9  ; +0.6152315736
S_66    DC    $4C3FE0  ; +0.5956993103
S_67    DC    $49B415  ; +0.5758082271
S_68    DC    $471CED  ; +0.5555701852
S_69    DC    $447ACD  ; +0.5349975824
S_6A    DC    $41CE1E  ; +0.5141026974
S_6B    DC    $3F174A  ; +0.4928981960
S_6C    DC    $3C56BA  ; +0.4713967144
S_6D    DC    $398CDD  ; +0.4496113062
S_6E    DC    $36BA20  ; +0.4275551140
S_6F    DC    $33DEF3  ; +0.4052414000
S_70    DC    $30FBC5  ; +0.3826833963
S_71    DC    $2E110A  ; +0.3598949909
S_72    DC    $2B1F35  ; +0.3368898928
```

Figure D-1. Sine Wave Table Contents (Sheet 1 of 3)

```
S_73    DC    $2826B9  ; +0.3136816919
S_74    DC    $25280C  ; +0.2902846038
S_75    DC    $2223A5  ; +0.2667128146
S_76    DC    $1F19F9  ; +0.2429800928
S_77    DC    $1C0B82  ; +0.2191012055
S_78    DC    $18F8B8  ; +0.1950902939
S_79    DC    $15E214  ; +0.1709619015
S_7A    DC    $12C810  ; +0.1467303932
S_7B    DC    $0FAB27  ; +0.1224106997
S_7C    DC    $0C8BD3  ; +0.0980170965
S_7D    DC    $096A90  ; +0.0735644996
S_7E    DC    $0647D9  ; +0.0490676016
S_7F    DC    $03242B  ; +0.0245412998
S_80    DC    $000000  ; +0.0000000000
S_81    DC    $FCDBD5  ; -0.0245412998
S_82    DC    $F9B827  ; -0.0490676016
S_83    DC    $F69570  ; -0.0735644996
S_84    DC    $F3742D  ; -0.0980170965
S_85    DC    $F054D9  ; -0.1224106997
S_86    DC    $ED37F0  ; -0.1467303932
S_87    DC    $EA1DEC  ; -0.1709619015
S_88    DC    $E70748  ; -0.1950902939
S_89    DC    $E3F47E  ; -0.2191012055
S_8A    DC    $E0E607  ; -0.2429800928
S_8B    DC    $DDDC5B  ; -0.2667128146
S_8C    DC    $DAD7F4  ; -0.2902846038
S_8D    DC    $D7D947  ; -0.3136816919
S_8E    DC    $D4E0CB  ; -0.3368898928
S_8F    DC    $D1EEF6  ; -0.3598949909
S_90    DC    $CF043B  ; -0.3826833963
S_91    DC    $CC210D  ; -0.4052414000
S_92    DC    $C945E0  ; -0.4275551140
S_93    DC    $C67323  ; -0.4496113062
S_94    DC    $C3A946  ; -0.4713967144
S_95    DC    $C0E8B6  ; -0.4928981960
S_96    DC    $BE31E2  ; -0.5141026974
S_97    DC    $BB8533  ; -0.5349975824
S_98    DC    $B8E313  ; -0.5555701852
S_99    DC    $B64BEB  ; -0.5758082271
S_9A    DC    $B3C020  ; -0.5956993103
S_9B    DC    $B14017  ; -0.6152315736
S_9C    DC    $AECC33  ; -0.6343932748
S_9D    DC    $AC64D5  ; -0.6531729102
S_9E    DC    $AA0A5B  ; -0.6715589762
S_9F    DC    $A7BD23  ; -0.6895405054
S_A0    DC    $A57D86  ; -0.7071068287
S_A1    DC    $A34BDF  ; -0.7242470980
S_A2    DC    $A12883  ; -0.7409511805
S_A3    DC    $9F13C8  ; -0.7572088242
S_A4    DC    $9D0DFE  ; -0.7730104923
S_A5    DC    $9B1777  ; -0.7883464098
S_A6    DC    $99307F  ; -0.8032075167
S_A7    DC    $975961  ; -0.8175848722
S_A8    DC    $959267  ; -0.8314697146
S_A9    DC    $93DBD7  ; -0.8448535204
S_AA    DC    $9235F3  ; -0.8577286005
S_AB    DC    $90A0FD  ; -0.8700870275
S_AC    DC    $8F1D34  ; -0.8819212914
S_AD    DC    $8DAAD3  ; -0.8932244182
S_AE    DC    $8C4A14  ; -0.9039893150
S_AF    DC    $8AFB2D  ; -0.9142097235
S_B0    DC    $89BE51  ; -0.9238795042
S_B1    DC    $8893B1  ; -0.9329928160
S_B2    DC    $877B7C  ; -0.9415441155
S_B3    DC    $8675DC  ; -0.9495282173
S_B4    DC    $8582FB  ; -0.9569402933
S_B5    DC    $84A2FC  ; -0.9637761116
S_B6    DC    $83D604  ; -0.9700313210
S_B7    DC    $831C31  ; -0.9757022262
S_B8    DC    $8275A1  ; -0.9807853103
S_B9    DC    $81E26C  ; -0.9852777123
S_BA    DC    $8162AA  ; -0.9891765118
S_BB    DC    $80F66E  ; -0.9924796224
S_BC    DC    $809DC9  ; -0.9951847792
S_BD    DC    $8058C9  ; -0.9972904921
S_BE    DC    $802778  ; -0.9987955093
S_BF    DC    $8009DE  ; -0.9996988773
S_C0    DC    $800000  ; -1.0000000000
S_C1    DC    $8009DE  ; -0.9996988773
S_C2    DC    $802778  ; -0.9987955093
S_C3    DC    $8058C9  ; -0.9972904921
S_C4    DC    $809DC9  ; -0.9951847792
S_C5    DC    $80F66E  ; -0.9924796224
S_C6    DC    $8162AA  ; -0.9891765118
S_C7    DC    $81E26C  ; -0.9852777123
S_C8    DC    $8275A1  ; -0.9807853103
S_C9    DC    $831C31  ; -0.9757022262
S_CA    DC    $83D604  ; -0.9700313210
S_CB    DC    $84A2FC  ; -0.9637761116
S_CC    DC    $8582FB  ; -0.9569402933
S_CD    DC    $8675DC  ; -0.9495282173
S_CE    DC    $877B7C  ; -0.9415441155
S_CF    DC    $8893B1  ; -0.9329928160
S_D0    DC    $89BE51  ; -0.9238795042
S_D1    DC    $8AFB2D  ; -0.9142097235
S_D2    DC    $8C4A14  ; -0.9039893150
S_D3    DC    $8DAAD3  ; -0.8932244182
S_D4    DC    $8F1D34  ; -0.8819212914
S_D5    DC    $90A0FD  ; -0.8700870275
S_D6    DC    $9235F3  ; -0.8577286005
S_D7    DC    $93DBD7  ; -0.8448535204
S_D8    DC    $959267  ; -0.8314697146
S_D9    DC    $975961  ; -0.8175848722
S_DA    DC    $99307F  ; -0.8032075167
S_DB    DC    $9B1777  ; -0.7883464098
S_DC    DC    $9D0DFE  ; -0.7730104923
S_DD    DC    $9F13C8  ; -0.7572088242
S_DE    DC    $A12883  ; -0.7409511805
S_DF    DC    $A34BDF  ; -0.7242470980
S_E0    DC    $A57D86  ; -0.7071068287
S_E1    DC    $A7BD23  ; -0.6895405054
S_E2    DC    $AA0A5B  ; -0.6715589762
S_E3    DC    $AC64D5  ; -0.6531729102
S_E4    DC    $AECC33  ; -0.6343932748
S_E5    DC    $B14017  ; -0.6152315736
S_E6    DC    $B3C020  ; -0.5956993103
S_E7    DC    $B64BEB  ; -0.5758082271
S_E8    DC    $B8E313  ; -0.5555701852
S_E9    DC    $BB8533  ; -0.5349975824
S_EA    DC    $BE31E2  ; -0.5141026974
S_EB    DC    $C0E8B6  ; -0.4928981960
S_EC    DC    $C3A946  ; -0.4713967144
S_ED    DC    $C67323  ; -0.4496113062
S_EE    DC    $C945E0  ; -0.4275551140
S_EF    DC    $CC210D  ; -0.4052414000
S_F0    DC    $CF043B  ; -0.3826833963
S_F1    DC    $D1EEF6  ; -0.3598949909
S_F2    DC    $D4E0CB  ; -0.3368898928
S_F3    DC    $D7D947  ; -0.3136816919
S_F4    DC    $DAD7F4  ; -0.2902846038
```

Figure D-1. Sine Wave Table Contents (Sheet 2 of 3)

```
S_F5   DC   $DDDC5B  ; -0.2667128146
S_F6   DC   $E0E607  ; -0.2429800928
S_F7   DC   $E3F47E  ; -0.2191012055
S_F8   DC   $E70748  ; -0.1950902939
S_F9   DC   $EA1DEC  ; -0.1709619015
S_FA   DC   $ED37F0  ; -0.1467303932
S_FB   DC   $F054D9  ; -0.1224106997
S_FC   DC   $F3742D  ; -0.0980170965
S_FD   DC   $F69570  ; -0.0735644996
S_FE   DC   $F9B827  ; -0.0490676016
S_FF   DC   $FCDBD5  ; -0.0245412998
```

Figure D-1. Sine Wave Table Contents (Sheet 3 of 3)

APPENDIX E
BOOTSTRAP MODE — OPERATING MODE 1

The bootstrap feature of the DSP56001 consists of four special on-chip modules: the 512 words of PRAM, a 32-word bootstrap ROM, the bootstrap control logic, and the bootstrap firmware program.

BOOTSTRAP ROM

This 32-word on-chip ROM has been factory programmed to perform the actual bootstrap operation from the memory expansion port (Port A) or from the Host Interface. You have no access to the bootstrap ROM other than through the bootstrap process. Control logic will disable the bootstrap ROM during normal operations.

BOOTSTRAP CONTROL LOGIC

The bootstrap mode control logic is activated when the DSP56001 is placed in Operating Mode 1. The control logic maps the bootstrap ROM into program memory space as long as the DSP56001 remains in Operating Mode 1. The bootstrap firmware changes operating modes when the bootstrap load is completed. When the DSP56001 exits the reset state in Mode 1, the following actions occur.

1. The control logic maps the bootstrap ROM into the internal DSP program memory space starting at location $0000. This P: space is read-only.
2. The control logic forces the entire P: space to be write-only memory during the bootstrap loading process. Attempts to read from this space will result in fetches from the read-only bootstrap ROM.
3. Program execution begins at location $0000 in the bootstrap ROM. The bootstrap ROM program is able to perform a program load through either the memory expansion port from a byte-wide external memory, or through the Host Interface.
4. The bootstrap ROM program executes the following sequence to end the bootstrap operation and begin your program execution.
   - A. Enter Operating Mode 2 by writing to the OMR. This action will be timed to remove the bootstrap ROM from the program memory map and re-enable read/write access to the PRAM.
   - B. The change to Mode 2 is timed exactly to allow the boot program to execute a single cycle instruction then a JMP #00 and begin execution of the program at location $0000.

You may also select the bootstrap mode by setting Operating Mode 1 into the OMR. This initiates a timed operation to map the bootstrap ROM into the program address space after a delay to allow execution of a single cycle instruction and then a JMP #>00 (e.g., see Bootstrap code for DSP56001) to begin the bootstrap process as described above in steps 1-4. This technique allows the DSP56001 user to reboot the system (with a different program if desired).

BOOTSTRAP FIRMWARE PROGRAM

Bootstrap ROM contains the bootstrap firmware program that performs initial loading of the DSP56001 PRAM. The program is written in DSP56000/DSP56001 assembly language. It contains two separate methods of initializing the PRAM: loading from a byte-wide memory starting at location P:$C000 or loading through the Host Interface. The particular method used is selected by the level of program memory location $C000, bit 23. If location P:$C000, bit 23 is read as a one, the external bus version of the bootstrap program will be selected. Typically, a byte wide EPROM will be connected to the DSP56001 Address and Data Bus as shown in Figure B-1 of the applications examples given in **APPENDIX B APPLICATIONS EXAMPLES**. The data contents of the EPROM must be organized as shown below.

Address of External Byte Wide P Memory	Contents Loaded to Internal PRAM at:
P:$C000	P:$0000 low byte
P:$C001	P:$0000 mid byte
P:$C002	P:$0000 high byte
.	.
.	.
.	.
P:$C5FD	P:$01FF low byte
P:$C5FE	P:$01FF mid byte
P:$C5FF	P:$01FF high byte

If location P:$C000, bit 23 is read as a zero, the Host Interface version of the bootstrap program will be selected. Typically a host microprocessor will be connected to the DSP56001 Host Interface. The host microprocessor must write the Host Interface registers THA, TXM, and then TSL with the desired contents of PRAM from location P:$0000 up to P:$01FF. If less than 512 words are transferred, the host microprocessor must write a NOP instruction and force the DSP56001 to begin executing at location P:$0000 by setting HF0=1 in the Host Interface during the bootstrap load. In most systems, the DSP56001 responds so fast that handshaking between the DSP56001 and the host is not necessary.

The bootstrap program is shown in flowchart form in Figure E-1 and in assembler listing format in Figure E-2.

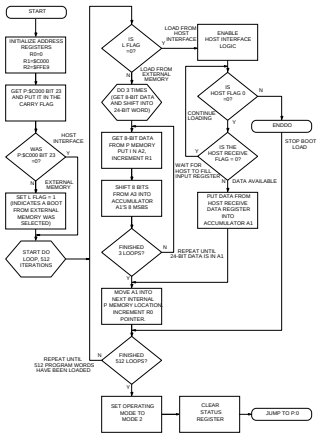


Figure E-1. Bootstrap Program Flowchart

```
1                                       PAGE 132,50,0,10
2                               ; BOOTSTRAP SOURCE CODE FOR DSP56001 - (C) Copyright 1986 Motorola Inc.
4                               ; Host algorithm / AND / external bus method
6                               ; This is the Bootstrap source code contained in the DSP56001 32 word boot ROM.
7                               ; This program can load the internal program memory from one of two external sources.
8                               ; The program reads P:$C000 bit 23 to decide which external source to access. If
9                               ; P:$C000 bit 23 = 0 then it loads internal PRAM from HDI-H7, using the Host Interface
10                              ; logic. If P:$C000 bit 23 = 1 then it loads from 1,536 consecutive byte-wide P:
11                              ; memory locations (starting at P:$C000).
13  0000C000                    BOOT        EQU     $C000               ; The location in P: memory
14                                                                      ; where the external byte-wide
15                                                                      ; EPROM is expected to be mapped.
16
17  p:0000                              ORG     PL:$0                   ; Bootstrap code starts at P:$0
18
19  P:0000      62F400          START   MOVE                #$FFE9,R2   ; R2 = address of the Host
            00FFE9
20                                                                      ; Interface status register.
21  P:0002      61F400                  MOVE                #BOOT,R1    ; R1 = starting P: address of
            00C000
22                                                                      ; external bootstrap byte-wide ROM.
23  P:0004      300000                  MOVE                #0,R0       ; R0 = starting P: address of
24                                                                      ; internal memory where program
25                                                                      ; will begin loading.
26
27  P:0005      07E18C                  MOVE                P:(R1),A    ; Get the data at P:$C000
28  P:0006      200037                  ROL     A                       ; Shift bit 23 into the Carry flag
29  P:0007      0E0009                  JCC     <INLOOP                 ; Perform load from Host Interface
30                                                                      ; if carry is zero.
31
32                              ; IMPORTANT NOTE: This routine assumes that the L bit has been cleared before entering
33                              ; this program and that M0 and M1 have been preloaded with $FFFF (linear addressing).
34                              ; This would be the case after a reset. If this program is entered by changing the OMR
```

Figure E-2. Assembler Listing for Bootstrap Program (Sheet 1 of 3)

```
35                              ; to bootstrap operating mode, make certain that the L bit is cleared and registers M0
36                              ; and M1have been set to $FFFF. Also, make sure the BCR is set to $xxF-x since
37                              ; EPROMS are slow and BCR is set to $FFFF after a reset. If the L bit was set before
38                              ; changing modes, the program will load from external program memory.
39
40  P:0008      0040F9                  ORI     #$40,CCR                ; Set the L bit to indicate
41                                                                      ; that the bootstrap program
42                                                                      ; is being loaded from the
43                                                                      ; external P- space.
44
45                              ; The first routine will load 1,536 bytes from the external P: memory space beginning
46                              ; at P:$C000 (bits 7-0). These will be packed into 512 24-bit words and stored in
47                              ; contiguous internal PRAM memory locations starting at P:$0.
48
49                              ; The shifter moves the 8-bit input data from register A2 into register A1 eight bits
50                              ; at a time. After assembling one 24-bit word (this takes three loops) it stores the
51                              ; result in internal PRAM and continues until internal PRAM is filled. Note that the
52                              ; first routine loads data starting with the least significant byte of P:$C first.
53
54                              ; The second routine loads the internal PRAM using the Host Interface logic.
55                              ; If the host only wants to load a portion of the PRAM, the Host Interface bootstrap
56                              ; load program can be aborted and execution of the loaded program started, by setting
57                              ; the Host Flag (HF0) = 1 at any time during the load from the Host Processor.
58
59  P:0009      060082  INLOOP  DO      #512,_LOOP1             ; Load 512 instruction words.
                000018
60
61                              ; This is the context switch
62
63  P:000B      0E6012                  JLC     <_HOSTLD                ; Load from the Host Interface
64                                                                      ; if the Limit flag is clear.
65
66                              ; This is the first routine. It loads from external P: memory.
67
68  P:000C      060380                  DO      #3,_LOOP2               ; Each instruction has 3 bytes.
                000010
```

Figure E-2. Assembler Listing for Bootstrap Program (Sheet 2 of 3)

```
69   P:000E    07D98A                  MOVE                    P:(R1)+,A2      ; Get the 8 LSB from external
70                                                                             ; P: memory.
71   P:000F    0608A0                  REP     #8                              ; Shift 8 bit data into A1
72   P:0010    200022                  ASR     A
73                             _LOOP2                                          ; Get another byte
74   P:0011    0C001B                  JMP     <_STORE                         ; then put the word in PRAM.
75
76                             ; This is the second routine. It loads from the Host Interface pins.
77
78   P:0012    0AA020    _HOSTLD       BSET    #0,X:$FFE0                      ; Configure Port B as Host Interface
79   P:0013    0AA983    _LBLA         JCLR    #3,X:$FFE9,_LBLB                ; If HF0=1, stop loading data.
                000017
80   P:0015    00008C                  ENDDO                                   ; Must terminate the DO loop
81   P:0016    0C001C                  JMP     <_BOOTEND
82
83   P:0017    0AE280    _LBLB         JCLR    #0,X:(R2) _LBLA                 ; Wait for HRDF to go high
                000013
84                                                                             ; (meaning 24-bit data is present)
85   P:0019    54F000                  MOVE                    X:$FFEB,A1      ; Put 24-bit host data in A1
                00FFEB
86
87   P:001B    0758BC    _STORE        MOVE                    A1,P:(R0)+      ; Store 24-bit result in PRAM.
88
89                             _LOOP1                                          ; and return for another 24-bit word
90
91                             ; This is the exit handler that returns execution to normal expanded mode
92                             ; and jumps to the RESET location.
93
94   P:001C    05028A    _BOOTEND      MOVEC                   #2,OMR          ; Set the operating mode to 2
95                                                                             ; (and trigger an exit from
96                                                                             bootstrap mode).

97   P:001D    000089                  ANDI    #$0,CCR                         ; Clear SR as if RESET and
98                                                                             ; introduce delay needed for
99                                                                             ; Op. Mode change.
100P:001E    0C0000                  JMP     <$0                             ; Start fetching from PRAM P:$0000
101
```


0 Errors
0 Warnings

Figure E-2. Assembler Listing for Bootstrap Program (Sheet 3 of 3)

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