



# Mixed-Signal Processor with Host Interface Port

## ADSP-21msp50/55/56

### FEATURES

77 ns Instruction Cycle Time from 13.00 MHz Crystal  
ADSP-2100 Family Code & Function Compatible  
2K Words of On-Chip Program Memory RAM  
1K Word of On-Chip Data Memory RAM  
2K Words of On-Chip Program Memory ROM  
(ADSP-21msp56 Only)

8- or 16-Bit Parallel Host Interface Port

Analog Interface Provides

16-Bit Sigma-Delta ADC and DAC

Programmable Gain Stages

On-Chip Antialiasing and Anti-Imaging Filters

8 kHz Sampling Frequency

65 dB SNR and THD

<1 mW Powerdown Mode with 100 Cycle Recovery

Dual Purpose Program Memory for Both Instruction  
and Data Storage

Independent ALU, Multiplier/Accumulator, and Barrel  
Shifter Computational Units

Two Independent Data Address Generators

Powerful Program Sequencer Provides:

Zero Overhead Looping

Conditional Instruction Execution

Two Double-Buffered Serial Ports with Companding  
Hardware, One Serial Port Has Automatic Data  
Buffering

Programmable 16-Bit Interval Timer with Prescaler

Programmable Wait State Generation

Automatic Booting of Internal Program Memory from  
Byte-Wide External Memory, e.g., EPROM, or  
Through Host Interface Port

Single-Cycle Instruction Execution

Single-Cycle Context Switch

Multifunction Instructions

Three Edge- or Level-Sensitive External Interrupts

Low Power Dissipation in Standby Mode

100-Lead PQFP and 144-Pin PGA

### GENERAL DESCRIPTION

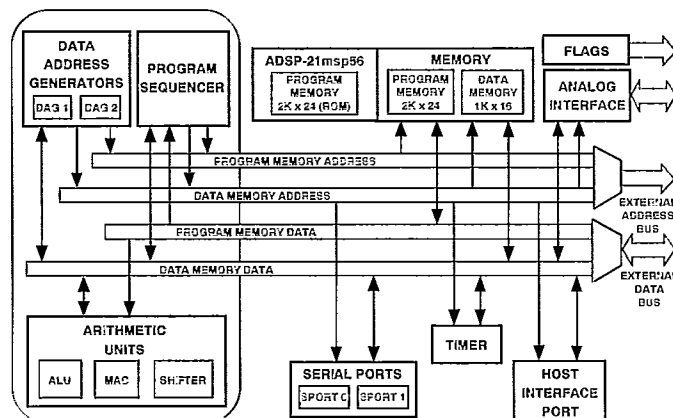
The ADSP-21msp5x Family of Mixed-Signal Processors (MSProcessors™) are fully integrated, single chip DSPs complete with a high performance analog front end. The ADSP-21msp5x Family is optimized for voice band applications such as Speech Compression, Speech Processing, Speech Recognition, Text-to-Speech, and Speech-to-Text conversion.

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### REV. 0

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### FUNCTIONAL BLOCK DIAGRAM



ADSP-2100 BASE ARCHITECTURE

The ADSP-21msp5x combines the ADSP-2100 base architecture (three computational units, data address generators, and a program sequencer) with two serial ports, a host interface port, an analog front end, a programmable timer, extensive interrupt capabilities, and on-chip program and data memory.

The ADSP-21msp50 and ADSP-21msp55 provide 2K words (24-bit) of program RAM and 1K word (16-bit) of data memory. The ADSP-21msp56 provides an additional 2K words (24-bit) of program ROM. All of the products in the ADSP-21msp5x family integrate a high performance analog front end based on a single chip, voice band front end, the AD28msp02. Powerdown circuitry is also provided to meet the low power needs of battery operated portable equipment. The ADSP-21msp50 is available in a 144-pin PGA package. The ADSP-21msp55 and ADSP-21msp56, reduced pin versions, are available in a 100-pin PQFP package.

Table I highlights the differences among ADSP-21msp5x processors.

Fabricated in a high-speed, double poly, double metal, low power, CMOS process, the ADSP-21msp5x family operates with a 77 ns instruction cycle time. Every instruction executes in a single cycle.

# ADSP-21msp50/55/56

Table I. ADSP-21msp5x Processor Differences

	Total Pins	V <sub>CC</sub>	V <sub>DD</sub>	GND <sub>A</sub>	GND	Program Memory	Flags	Powerdown Acknowledge Pin	HIP Width
ADSP-21msp50	144	1	5	2	7	2K RAM	3	Y	8 or 16 Bits
ADSP-21msp55	100	1	4	2	5	2K RAM	1	N	8 Bits
ADSP-21msp56	100	1	4	2	5	2K RAM 2K ROM	1	N	8 Bits

The ADSP-21msp5x's flexible architecture and comprehensive instruction set allow the processor to perform multiple tasks in parallel. In one cycle the ADSP-21msp5x can:

- generate the next program address
- fetch the next instruction
- perform one or two data moves
- update one or two data address pointers
- perform a computational operation

This takes place while the processor continues to:

- perform an analog conversion
- receive and transmit data through the two serial ports
- receive and/or transmit data through the host interface port

### In-Circuit Emulation

Analog Devices provides an ADSP-21msp5x In-Circuit Emulator (ICE) to debug your system. The emulator consists of hardware, host computer resident software, and the emulator probe (the part of the emulator that fits in the ADSP-21msp5x socket in your system). If you plan to use the emulator, you should consider the following:

- the physical dimensions of the emulator probe (you must leave enough clearance around the ADSP-21msp5x socket to connect the probe)
- the emulator probe has the same footprint as the 144-pin PGA package; adapter sockets are available to convert the probe to 100-lead PQFP packages
- the emulator's restrictions (differences between emulator and processor operation).

For detailed information about the restrictions, operation, and mechanical specifications of the emulator, see the ADDS-21XX-ICE data sheet, ADSP-21msp50 Emulator release note, and the *ADSP-21msp50 Emulator Manual Addendum* to the *ADSP-2111 Emulator Manual*.

### Development System

The ADSP-2100 Family Development Software, a complete set of tools for software and hardware system development, supports the ADSP-21msp5x. The System Builder provides a high-level method for defining the architecture of systems under development. The Assembler produces object code, and the Linker combines object modules and library calls into an executable file. The Simulator provides an interactive instruction-level simulation with a reconfigurable user interface. A PROM Splitter generates PROM programmer compatible files. The C Compiler generates ADSP-21msp5x assembly source code.

EZ-Tools, low cost, easy-to-use hardware tools, also support the ADSP-21msp5x. The ADSP-21msp50 EZ-ICE® emulator aids in the hardware debugging of ADSP-21msp5x systems. The emulator performs a full range of emulation functions including stand-alone operation, single-step or full-speed operation in the target, changing register values, and setting breakpoints. The EZ-LAB® demonstration board is a complete ADSP-21msp5x system that executes EPROM-based programs.

### Additional Information

This data sheet provides a general overview of ADSP-21msp5x functionality. For additional information on the architecture and instruction set of the processor, refer to the *ADSP-2100 Family User's Manual*. For more information about the Development System and ADSP-21msp5x programmer's reference information, refer to the *ADSP-2100 Family Development Software Manuals*, the *ADSP-2111 Emulator Manual*, and the *ADSP-21msp50 Emulator Manual Addendum*.

### DIGITAL ARCHITECTURE OVERVIEW

Figure 1 is an overall block diagram of the ADSP-21msp5x. The processor contains three independent computational units: the ALU, the multiplier/accumulator (MAC), and the shifter. The computational units process 16-bit data directly and have provisions to support multiprecision computations. The ALU performs a standard set of arithmetic and logic operations; division primitives are also supported. The MAC performs single-cycle multiply, multiply/add and multiply/subtract operations. The shifter performs logical and arithmetic shifts, normalization, denormalization, and derive exponent operations. The shifter can be used to efficiently implement numeric format control including multiword and block floating-point representations.

The internal result (R) bus directly connects the computational units so that the output of any unit may be the input of any unit on the next cycle.

A powerful program sequencer and two dedicated data address generators ensure efficient use of these computational units. The sequencer supports conditional jumps, subroutine calls, and returns in a single cycle. With internal loop counters and loop stacks, the ADSP-21msp5x executes looped code with zero overhead; no explicit jump instructions are required to maintain the loop.

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## ADSP-21msp50/55/56

outputs to signal an event to an external device. In addition, the data input and output pins on SPORT1 can be alternatively configured as an input flag and an output flag.

A programmable interval timer generates periodic interrupts. A 16-bit count register (TCOUNT) is decremented every  $n$  cycles, where  $n-1$  is a scaling value stored in an 8-bit register (TSCALE). When the value of the count register reaches zero, an interrupt is generated and the count register is reloaded from a 16-bit period register (TPERIOD).

The ADSP-21msp5x instruction set provides flexible data moves and multifunction (one or two data moves with a computation) instructions. Every instruction can be executed in a single processor cycle. The ADSP-21msp5x assembly language uses an algebraic syntax for ease of coding and readability. A comprehensive set of development tools supports program development.

### Serial Ports

The ADSP-21msp5x incorporates two complete synchronous serial ports (SPORT0 and SPORT1) for serial communications and multiprocessor communication.

Here is a brief list of the capabilities of the ADSP-21msp5x SPORTs. Refer to the *ADSP-2100 Family User's Manual* for further details.

- SPORTs are bidirectional and have a separate, double-buffered transmit and receive section.
- SPORTs can use an external serial clock or generate their own serial clock internally.
- SPORTs have independent framing for the receive and transmit sections. Sections run in a frameless mode or with frame synchronization signals internally or externally generated. Frame sync signals are active high or inverted, with either of two pulse widths and timings.
- SPORTs support serial data word lengths from 3 to 16 bits and provide optional A-law and  $\mu$ -law companding according to CCITT recommendation G.711.
- SPORTs receive and transmit sections can generate unique interrupts on completing a data word transfer.
- SPORT0 can receive and transmit an entire circular buffer of data with only one overhead cycle per data word (Autobuffering Mode). An interrupt is generated after a completed data buffer transfer.
- SPORT0 has a multichannel interface to selectively receive and transmit a 24 or 32 word, time-division multiplexed, serial bitstream.
- SPORT1 can be configured to have two external interrupts (IRQ0 and IRQ1) and the Flag In and Flag Out signals. The internally generated serial clock may still be used in this configuration.

### Pin Description

The ADSP-21msp5x is available in a 100-lead PQFP and a 144-pin PGA package. Table II contains the pin descriptions. Pins marked with an asterisk (\*) differ according to the package.

Table II. ADSP-21msp5x Pin List

Pin Group Name	# of Pins	Input/Output	Function
Digital Pins			
Address	14	O	Address output for program, data and boot memory spaces
Data	24	I/O	Data I/O pins for program and data memories. Input only for boot memory space, with two MSBs used as boot space addresses.
$\overline{\text{RESET}}$	1	I	Processor reset input
$\overline{\text{IRQ2}}$	1	I	External interrupt request #2
$\overline{\text{BR}}$	1	I	External bus request input
$\overline{\text{BG}}$	1	O	External bus grant output
$\overline{\text{PMS}}$	1	O	External program memory select
$\overline{\text{DMS}}$	1	O	External data memory select
$\overline{\text{BMS}}$	1	O	Boot memory select
$\overline{\text{RD}}$	1	O	External memory read enable
$\overline{\text{WR}}$	1	O	External memory write enable
MMAP	1	I	Memory map select
CLKIN, XTAL	2	I	External clock or quartz crystal input
CLKOUT	1	O	Processor clock output
$\overline{\text{HSEL}}$	1	I	HIP select input
$\overline{\text{HACK}}$	1	O	HIP acknowledge output
HSIZE	*	I	8/16 bit host select input 0 = 16-bit; 1 = 8-bit ADSP-21msp50 only
BMODE	1	I	Boot mode select input 0 = EPROM/data bus; 1 = HIP
HMD0	1	I	Bus strobe select input 0 = RD, WR; 1 = RW, DS
HMD1	1	I	HIP address/data mode select input 0 = separate; 1 = multiplexed
$\overline{\text{HRD}}/\overline{\text{HRW}}$	1	I	HIP read strobe/ read/write select input
$\overline{\text{HWR}}/\overline{\text{HDS}}$	1	I	HIP write strobe/ host data strobe select input
HD15-0/ HAD15-0	*	I/O	HIP data/data and address Only HD7-0 on ADSP-21msp55/56
HA2/ALE	1	I	Host address 2/ Address latch enable input
HA1-0/ unused	2	I	Host addresses 1 and 0 inputs
SPORT0	5	I/O	Serial port 0 I/O pins (TFS0, RFS0, DT0, DR0, SCLK0)
SPORT1 or $\overline{\text{IRQ1}}$ (TFS1) $\overline{\text{IRQ0}}$ (RFS1)	5 1 1	I/O I I	Serial port 1 I/O pins External interrupt request #1 External interrupt request #0

## ADSP-21msp50/55/56

Table II. 21msp5x Pin List (Continued)

Pin Group Name	# of Pins	Input/Output	Function
SCLK1	1	O	Programmable clock output
FO (DT1)	1	O	Flag Output pin
FI (DR1)	1	I	Flag Input pin
FL2-0	*	O	General purpose flag output pins, Only FL0 on ADSP-21msp55/56
V <sub>DD</sub>	*		Digital power supply, 4 on 100-lead PQFP, 5 on 144-pin PGA
GND	*		Digital ground, 5 on 100-lead PQFP, 7 on 144-pin PGA
PWD	1	I	Powerdown pin
PWDACK	*	O	Powerdown acknowledge pin, ADSP-21msp50 only
Analog Pins			
VIN <sub>NORM</sub>	1	I	Inverting input terminal of the NORM amplifier for the encoder section (ADC)
VFB <sub>NORM</sub>	1	O	Output terminal of the NORM amplifier for the encoder section
VIN <sub>AUX</sub>	1	I	Inverting input terminal of the AUX amplifier for the encoder section (ADC)
VFB <sub>AUX</sub>	1	O	Output terminal of the AUX amplifier for the encoder section
VOU <sub>T</sub> P	1	O	Noninverting output terminal of the differential amplifier from the decoder section (DAC)
VOU <sub>T</sub> N	1	O	Inverting output terminal of the differential amplifier from the decoder section (DAC)
V <sub>REF</sub>	1	O	Output voltage reference
V <sub>CC</sub>	1		Analog power supply, 1 on 100-lead PQFP and 144-pin PGA
GND <sub>A</sub>	2		Analog ground, 2 on 100-lead PQFP and 144-pin PGA

**Host Interface Port**

The ADSP-21msp5x host interface port is a parallel I/O port that allows for an easy connection to a host processor. Through the HIP, the ADSP-21msp5x can be used as a memory-mapped peripheral to a host computer. The HIP can be thought of as an area of dual-ported memory, or mailbox registers, that allow communication between the computational core of the ADSP-21msp5x and the host computer.

The HIP is completely asynchronous. The host processor can write data into the HIP while the ADSP-21msp5x is operating at full speed.

The HIP can be configured with the following pins:

- HSIZE (ADSP-21msp50 only) configures HIP for 8-bit or 16-bit communication with the host processor.
- BMODE determines whether the ADSP-21msp5x boots from the host processor (through the HIP) or external EPROM (through the data bus).

- HMD0 configures the bus strobes as separate read and write strobes, or a single read/write select and a host data strobe.
- HMD1 selects separate address (3-bit) and data (16-bit) buses, or a multiplexed, 16-bit address/data bus with address latch enable.

Tying these pins to appropriate values configures the ADSP-21msp5x for straight-wire interface to a variety of industry-standard microprocessors and microcomputers.

In 8-bit reads, the ADSP-21msp5x tristates the upper eight bits of the bus. When the host processor writes an 8-bit value to the HIP, the upper eight bits are all zeros. For additional information refer to the *ADSP-2100 Family User's Manual*, Chapter 7, Host Interface Port.

**HIP Operation**

The HIP contains six data registers (HDR5-0) and two status registers (HSR7-6) with an associated HMASK register for masking interrupts from individual HIP data registers. All HIP data registers are memory-mapped into the internal data memory of the ADSP-21msp5x. HIP transfers can be managed using either interrupts or a polling scheme. These registers are shown in the section "ADSP-21msp5x Registers."

The HIP allows a software reset to be performed by the host processor. The internal software reset signal is asserted for five ADSP-21msp5x cycles.

**Interrupts**

The interrupt controller allows the processor to respond to the eleven possible interrupts and reset with minimum overhead. The ADSP-21msp5x provides up to three external interrupt input pins,  $\overline{\text{IRQ0}}$ ,  $\overline{\text{IRQ1}}$  and  $\overline{\text{IRQ2}}$ .  $\overline{\text{IRQ2}}$  is always available as a dedicated pin; SPORT1 may be reconfigured for  $\overline{\text{IRQ0}}$ ,  $\overline{\text{IRQ1}}$ , and the flags. The ADSP-21msp5x also supports internal interrupts from the timer, the host interface port, the two serial ports, the analog interface, and the powerdown control circuit. The interrupt levels are internally prioritized and individually maskable (except powerdown and reset). The input pins can be programmed to be either level- or edge-sensitive. The priorities and vector addresses of all interrupts are shown in Table III, and the interrupt registers are shown in Figure 2.

Table III. Interrupt Priority &amp; Interrupt Vector Addresses

Source of Interrupt	Interrupt Vector Address (Hex)
Reset (or Power-Up with PUCR = 1)	0000 ( <i>highest priority</i> )
Powerdown (Nonmaskable)	002C
$\overline{\text{IRQ2}}$	0004
HIP Write	0008
HIP Read	000C
SPORT0 Transmit	0010
SPORT0 Receive	0014
Analog Interface Transmit	0018
Analog Interface Receive	001C
SPORT1 Transmit or $\overline{\text{IRQ1}}$	0020
SPORT1 Receive or $\overline{\text{IRQ0}}$	0024
Timer	0028 ( <i>lowest priority</i> )

# ADSP-21msp50/55/56

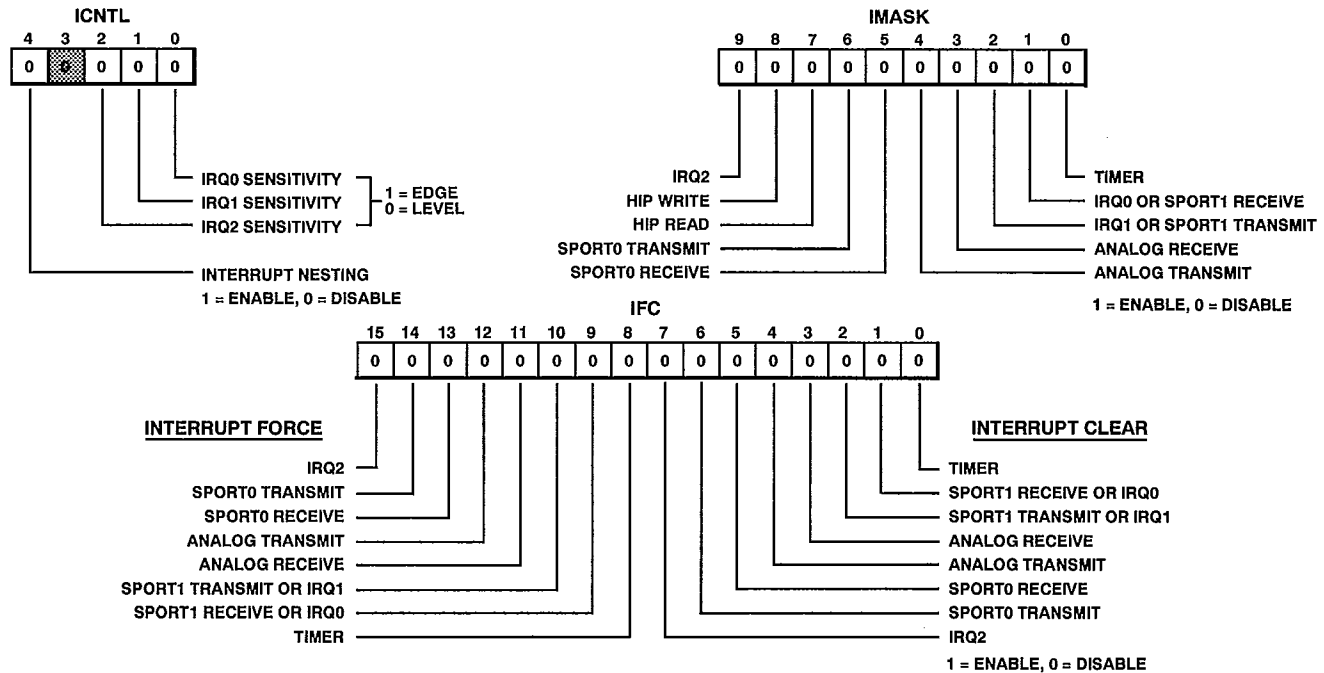


Figure 2. Interrupt Registers

Interrupts can be masked or unmasked with the IMASK register. Individual interrupt requests are logically ANDed with the bits in IMASK; the highest priority unmasked interrupt is then selected. The powerdown interrupt is nonmaskable.

The interrupt control register, ICNTL, allows the external interrupts to be either edge- or level-sensitive. Interrupt routines can either be nested with higher priority interrupts taking precedence or processed sequentially.

The IFC register is a write-only register used to force or clear interrupts generated from software.

On-chip stacks preserve the processor status and are automatically maintained during interrupt handling. The stacks are twelve levels deep to allow interrupt nesting.

### System Interface

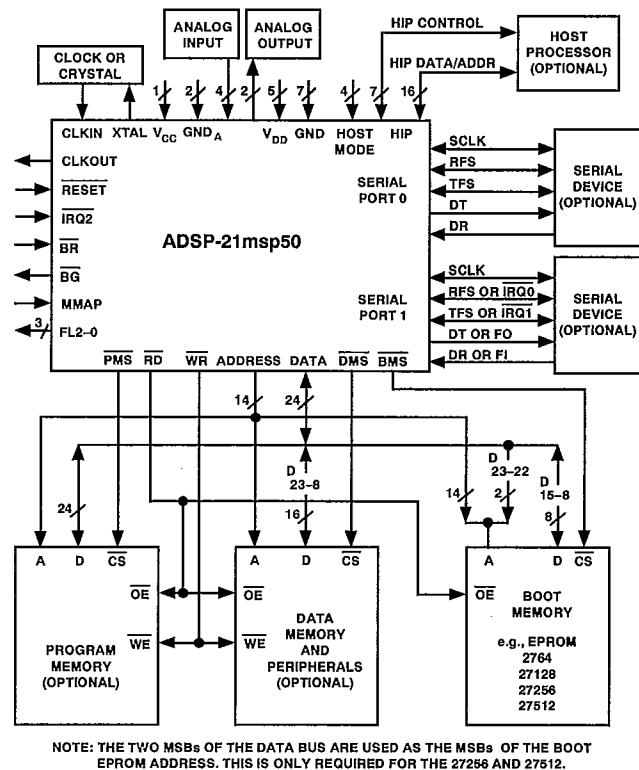
Figure 3 shows a basic system configuration with the ADSP-21msp5x, two serial devices, a host processor, a boot EPROM, optional external program and data memories, and an analog interface. Up to 15K words of data memory and 16K words of program memory can be supported. Programmable wait state generation allows the processor to interface easily to slow memories. The ADSP-21msp5x also provides one external interrupt and two serial ports.

### Clock Signals

The ADSP-21msp5x can be clocked by either a crystal or by a TTL-compatible clock signal.

The CLKIN input cannot be halted, changed during operation, or operated below the specified frequency.

If an external clock is used, it should be a TTL-compatible signal running at the instruction rate. The signal is connected to the processor's CLKIN input. When an external clock is used, the XTAL input *must* be left unconnected.



NOTE: THE TWO MSBs OF THE DATA BUS ARE USED AS THE MSBs OF THE BOOT EPROM ADDRESS. THIS IS ONLY REQUIRED FOR THE 27256 AND 27512.

Figure 3. ADSP-21msp5x Basic System Configuration

## ADSP-21msp50/55/56

Because the ADSP-21msp5x includes an on-chip oscillator circuit, an external crystal may be used. The crystal should be connected across the CLKIN and XTAL pins, with two capacitors connected as shown in Figure 4. A parallel-resonant, fundamental frequency, microprocessor-grade crystal should be used.

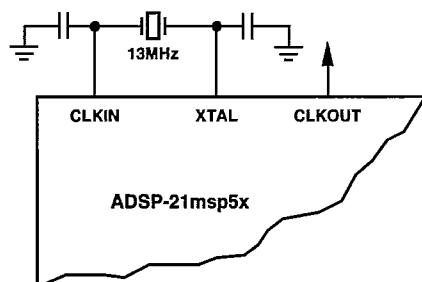


Figure 4. External Crystal Connections

A clock output (CLKOUT) signal is generated by the processor, synchronized to the processor's internal cycles.

### Reset

The  $\overline{\text{RESET}}$  signal initiates a master reset of the ADSP-21msp5x. The  $\overline{\text{RESET}}$  signal must be asserted when the chip is powered up to assure proper initialization.  $\overline{\text{RESET}}$  during initial power-up must be held long enough to allow the internal clock to stabilize. If  $\overline{\text{RESET}}$  is activated any time after power-up, the clock continues to run and does not require stabilization time.

The power-up sequence is defined as the total time required for the crystal oscillator circuit to stabilize after a valid  $V_{DD}$  is applied to the processor, and for the internal phase-locked loop (PLL) to lock onto the specific crystal frequency. A minimum of 1000  $t_{CK}$  cycles ensures that the PLL has locked but does not include the crystal oscillator start-up time. During this power-up sequence the  $\overline{\text{RESET}}$  signal should be held low. On any subsequent resets, the  $\overline{\text{RESET}}$  signal must meet the minimum pulse width specification,  $t_{RSP}$ .

The  $\overline{\text{RESET}}$  input contains some hysteresis; however, if you use an RC circuit to generate your  $\overline{\text{RESET}}$  signal, the use of an external Schmidt trigger is recommended.

The master reset sets all internal stack pointers to the empty stack condition, masks all interrupts and clears the MSTAT register. When  $\overline{\text{RESET}}$  is released, if there is no pending bus request and the chip is configured for booting ( $\text{MMAP} = 0$ ), the boot-loading sequence is performed. Then the first instruction is fetched from internal program memory location 0x0000.

### Program Memory Interface

The on-chip program memory address bus (PMA) and the on-chip program memory data bus (PMD) are multiplexed with on-chip DMA and DMD buses, creating a single external data bus and a single external address bus. The 14-bit address bus directly addresses up to 16K words, of which up to 4K are on-chip. The data bus is bidirectional and 24 bits wide to external program memory. Program memory may contain code and data.

The program memory data lines are bidirectional. The program memory select ( $\overline{\text{PMS}}$ ) signal indicates access to the program memory and can be used as a chip select signal. The write ( $\overline{\text{WR}}$ ) signal indicates a write operation and is used as a write strobe.

The read ( $\overline{\text{RD}}$ ) signal indicates a read operation and is used as a read strobe or output enable signal.

The ADSP-21msp5x writes data from its 16-bit registers to the 24-bit program memory using the PX register to provide the lower eight bits. When it reads data (not instructions) from 24-bit program memory to a 16-bit data register, the lower eight bits are placed in the PX register.

### Program Memory Maps

#### ADSP-21msp50/55

Program memory can be mapped in two ways, depending on the state of the MMAP pin. Figure 5 shows the two configurations. When  $\text{MMAP} = 0$ , internal RAM occupies 2K words beginning at address 0x0000; external program memory uses the remaining 14K words beginning at address 0x0800. In this configuration, the boot loading sequence (described in "Boot Memory Interface") is automatically initiated when  $\overline{\text{RESET}}$  is released.

When  $\text{MMAP} = 1$ , 14K words of external program memory begin at address 0x0000 and internal RAM is located in the upper 2K words, beginning at address 0x3800. In this configuration, program memory is not loaded although it can be written to and read from under program control.

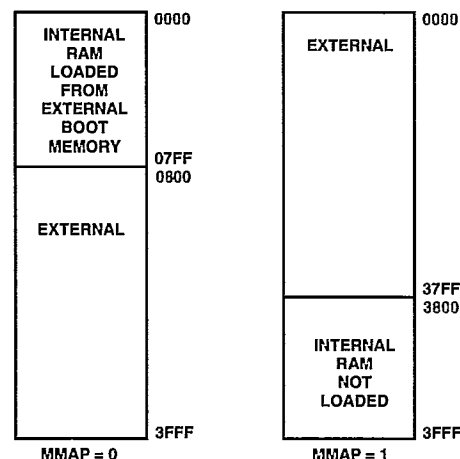


Figure 5. ADSP-21msp50/55 Program Memory Maps

#### ADSP-21msp56

The ADSP-21msp56 is functionally identical to the ADSP-21msp50/55. The ADSP-21msp56 includes an additional 2K by 24-bit mask programmable ROM (see Figure 6). The ROM can be used to hold program instructions or data and can be accessed twice in one instruction cycle if necessary. The ROM always resides at locations  $\text{PM}[0x0800]$  through  $\text{PM}[0x1000]$  regardless of the state of the MMAP pin. The ROM is enabled by the setting the ROMENABLE bit in the Data Memory Wait State control register,  $\text{DM}[0x3FFE]$ . When the ROMENABLE bit is set to 1, addressing program memory in this range will access the on-chip ROM. When set to zero, addressing program memory in this range will access external program memory. The ROMENABLE bit is set to 0 on chip reset.

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The program memory interface can generate 0 to 7 wait states for external memory devices; default is 7 wait states after **RESET**.

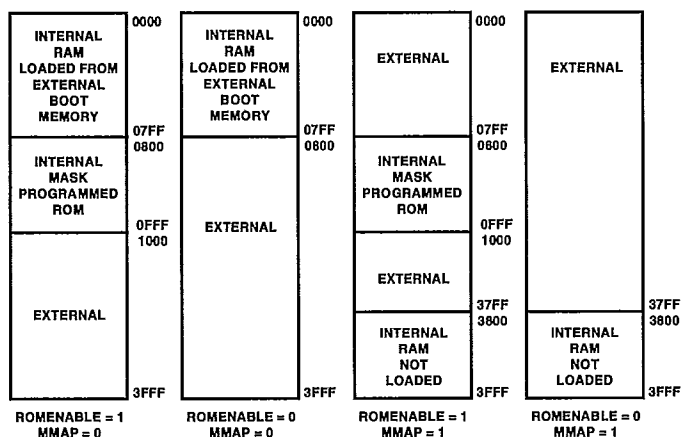


Figure 6. ADSP-21msp56 Program Memory Maps

## Data Memory Interface

The data memory address (DMA) bus is 14 bits wide. The bidirectional external data bus is 24 bits wide, with the upper 16 bits used for data memory data (DMD) transfers.

The data memory select ( $\overline{DMS}$ ) signal indicates access to the data memory and can be used as a chip select signal. The write ( $\overline{WR}$ ) signal indicates a write operation and can be used as a write strobe. The read ( $\overline{RD}$ ) signal indicates a read operation and can be used as a read strobe or output enable signal.

The ADSP-21msp5x supports memory-mapped I/O, with the peripherals memory mapped into the data or program memory address spaces and accessed by the processor in the same manner.

## Data Memory Map

The on-chip data memory RAM resides in the 1K words of data memory beginning at address 0x3800, as shown in Figure 7. In addition, data memory locations from 0x3C00 to the end of data memory at 0x3FFF are reserved. Control registers for the system, timer, wait state configuration, host interface port, codec, and serial port operations are located in this region of memory.

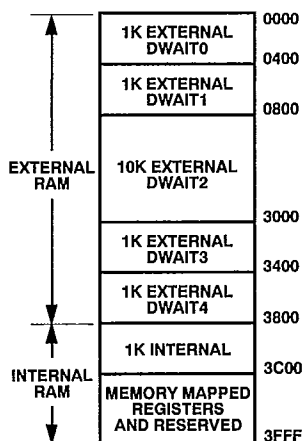


Figure 7. ADSP-21msp5x Data Memory Map

The remaining 14K of data memory is external. External data memory is divided into five zones, each associated with its own wait state generator. By mapping peripherals into different zones, you can accommodate peripherals with different wait state requirements. All zones default to 7 wait states after **RESET**.

## Boot Memory Interface

The ADSP-21msp5x can load on-chip memory from external boot memory space. The boot memory space consists of 64K by 8-bit space, divided into eight separate 8K by 8-bit pages. Three bits in the system control register select which page is loaded by the boot memory interface. Another bit in the system control register allows the user to force a boot loading sequence under software control. Boot loading from page 0 after **RESET** is initiated automatically if  $MMAP = 0$ .

The boot memory interface can generate 0 to 7 wait states; it defaults to 3 wait states after **RESET**. This allows the ADSP-21msp5x to boot from a single low cost EPROM such as a 27256. Program memory is booted one byte at a time and converted to 24-bit program memory words.

The  $\overline{BMS}$  and  $\overline{RD}$  signals are used to select and to strobe the boot memory interface. Only 8-bit data is read over the data bus, on pins D8–D15. To accommodate addressing up to eight pages of boot memory, the two MSBs of the data bus are used in the boot memory interface as the two MSBs of the boot space address.

The ADSP-2100 Family Assembler and Linker support the creation of programs and data structures requiring multiple boot pages during execution.

$\overline{RD}$  and  $\overline{WR}$  must always be qualified by  $\overline{PMS}$ ,  $\overline{DMS}$ , or  $\overline{BMS}$  to ensure the correct program, data, or boot memory accessing.

## HIP Booting

The ADSP-21msp5x can also boot programs through its Host Interface Port. If  $BMODE = 1$ , the ADSP-21msp5x boots from the HIP. If  $BMODE = 0$ , the ADSP-21msp5x boots through the data bus (in the same way as the ADSP-2101), as described above in "Boot Memory Interface." For additional information about HIP booting, refer to the *ADSP-2100 Family User's Manual*, Chapter 7, "Host Interface Port."

The ADSP-2100 Family Development Software includes a utility program called the HIP Splitter. This utility allows the creation of programs that can be booted via the ADSP-21msp5x's HIP, in a similar fashion as EPROM-bootable programs generated by the PROM Splitter utility.

## Bus Request and Bus Grant

The ADSP-21msp5x can relinquish control of the data and address buses to an external device. When the external device requires access to memory, it asserts the bus request ( $\overline{BR}$ ) signal. If the ADSP-21msp5x is not performing an external memory access, then it responds to the active  $\overline{BR}$  input in the same cycle by:

- tristating the data and address buses and the  $\overline{PMS}$ ,  $\overline{DMS}$ ,  $\overline{BMS}$ ,  $\overline{RD}$ ,  $\overline{WR}$  output drivers,
- asserting the bus grant ( $\overline{BG}$ ) signal, and
- halting program execution.

If the Go mode is enabled, the ADSP-21msp5x will not halt program execution until it encounters an instruction that requires an external memory access.



## ADSP-21msp50/55/56

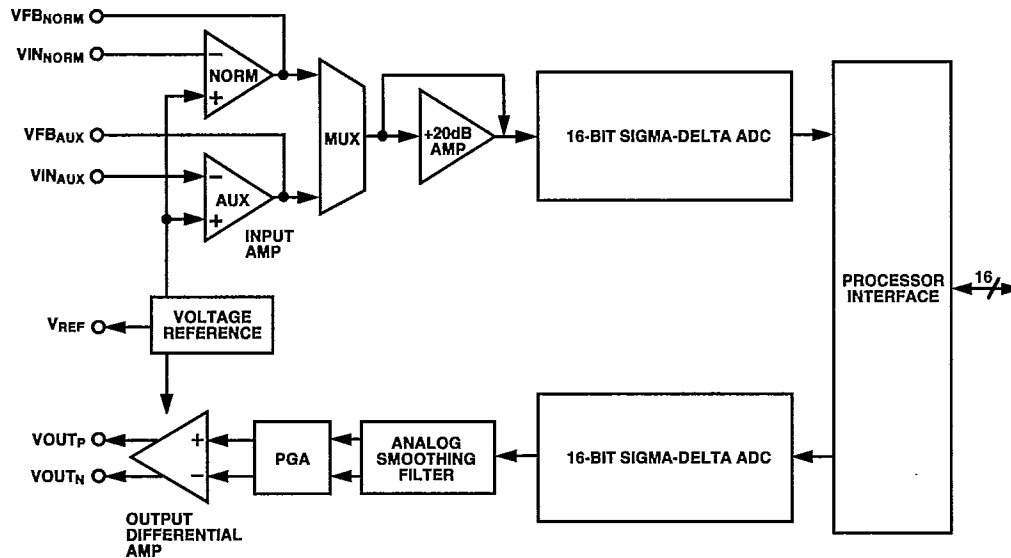


Figure 8. Analog Interface Block Diagram

If the ADSP-21msp5x is performing an external memory access when the external device asserts the  $\overline{BR}$  signal, then it will not tristate the memory interfaces or assert the  $\overline{BG}$  signal until the cycle after the access completes, which can be up to eight cycles later depending on the number of wait states. The instruction does not need to be completed when the bus is granted. If a single instruction requires two external memory accesses, the bus will be granted between the two accesses.

When the  $\overline{BR}$  signal is released, the processor releases the  $\overline{BG}$  signal, re-enables the output drivers and continues program execution from the point where it stopped.

The bus request feature operates at all times, including when the processor is booting and when  $\overline{RESET}$  is active.

## ANALOG INTERFACE

The analog interface contains encoding circuitry (ADC), decoding circuitry (DAC), and processor interface logic. A block diagram of the ADSP-21msp5x analog section is shown in Figure 8.

The analog interface is configured through the Analog Control Register and the Analog Autobuffer/Powerdown Register (refer to "ADSP-21msp5x Registers"). The Analog Control Register DM[0x3FEE] configures the programmable gain stages, the analog input multiplexer and the analog interface powerdown state. Note that unused bits in this register must be cleared to zero.

### A/D Conversion

The A/D conversion circuitry of the ADSP-21msp5x consists of two analog input amplifiers, an analog multiplexer, an optional 20 dB preamplifier, and a 16-bit sigma-delta ADC.

### Analog Input Amplifiers and Multiplexer

The analog multiplexer selects either the NORM or AUX amplifier as the input to the ADC's sigma-delta modulator. The two amplifiers are internally biased by the on-chip voltage reference,  $V_{REF}$ , allowing operation with a single +5 V power supply. The input amplifiers can be gain adjusted with external resistors and they must be ac coupled.

The optional 20 dB preamplifier may be used to additionally increase the signal level. Input signal level to the sigma-delta ADC should not exceed the  $V_{INMAX}$  specification.

### ADC

The analog interface's ADC consists of a 2nd-order analog sigma-delta modulator, an antialiasing decimation filter, and an optional digital high-pass filter. For a detailed description of the ADC components, refer to the *ADSP-2100 Family User's Manual*, Chapter 8, "Analog Interface."

### D/A Conversion

The D/A conversion circuitry of the ADSP-21msp5x's analog interface consists of a sigma-delta digital-to-analog converter (DAC), an analog smoothing filter, a programmable gain amplifier, and a differential output amplifier.

### DAC

The DAC consists of an optional digital high-pass filter, an anti-imaging interpolation filter, and a digital sigma-delta modulator. The digital filters and sigma-delta modulator have the same characteristics as the filters and modulator of the ADC. For a detailed description of the DAC components, refer to the *ADSP-2100 Family User's Manual*, Chapter 8, "Analog Interface."

### Analog Smoothing Filter & Programmable Gain Amplifier

The analog smoothing filter consists of a 2nd-order Sallen-Key continuous-time filter and a 3rd-order switched capacitor filter. The Sallen-Key filter has a 3 dB point at approximately 80 kHz.

The DAC's programmable gain amplifier (PGA) can be used to adjust the output signal level by -15 dB to +6 dB. This gain is selected by Bits 2-4 (OG0, OG1, OG2) of the of the ADSP-21msp5x's analog control register.

### Differential Output Amplifier

The ADSP-21msp5x's analog output signal ( $V_{OUTP} - V_{OUTN}$ ) is produced by a differential amplifier. The differential amplifier can drive loads of 2 k $\Omega$  or greater and has a maximum differential output voltage swing of  $\pm 3.156$  V peak-to-peak (3.17 dBm<sub>0</sub>). The output signal is dc-biased to the ADSP-21msp5x's on-chip voltage reference ( $V_{REF}$ ) and can be ac coupled directly to a load or dc-coupled to an external amplifier.

## ADSP-21msp50/55/56

The  $VOUT_P$ - $VOUT_N$  outputs must be used as a differential signal; do not use either pin as a single-ended output.

### OPERATING THE ANALOG INTERFACE

The analog interface of the ADSP-21msp5x is operated with several memory-mapped control and data registers. The ADC and DAC I/O data is received and transmitted through two memory-mapped data registers. The data can also be autobuffered directly into (or from) on-chip memory. In both cases, the I/O processing is interrupt-driven: two ADSP-21msp5x interrupts are dedicated to the analog interface, one for ADC receive data and one for DAC transmit data.

The ADSP-21msp5x must have an input clock frequency of 13 MHz. At this frequency, analog-to-digital and digital-to-analog converted data is transmitted at an 8 kHz rate with a single 16-bit word transmitted every 125  $\mu$ s.

For detailed information about the Analog Interface, refer to the *ADSP-2100 Family User's Manual*, Chapter 8, "Analog Interface."

#### Autobuffering

In some applications it is advantageous to perform block data transfers between the analog converters and processor memory. Analog interface autobuffering enables the automatic transfer of data blocks directly from the ADC to on-chip processor data memory or from on-chip processor data memory to the DAC.

#### ADC & DAC Interrupts

The analog interface generates two interrupts that signal either: 1) that a 16-bit, 8 kHz analog-to-digital or digital-to-analog conversion has been completed, or 2) that an autobuffer block transfer has been completed (i.e. the data buffer contents have been received or transmitted).

When an analog interrupt occurs, the processor vectors to the addresses listed in *Table III, Interrupt Priority and Interrupt Vector Address*.

The ADC receive and DAC transmit interrupts occur at an 8 kHz rate, indicating when the data registers should be accessed. On the receive side, the ADC interrupt is generated each time an A/D conversion cycle is completed and the 16-bit data word is available in the ADC receive register. On the transmit side, the DAC interrupt is generated each time a D/A conversion cycle is completed and the DAC transmit register is ready for the next 16-bit data word.

Both interrupts are generated simultaneously at an 8 kHz rate, occurring every 1625 instruction cycles with a 13.00 MHz processor clock. The interrupts are generated continuously, starting when the analog interface is powered up by setting the APWD bits (Bits 5, 6) to ones in the analog control register. Because both interrupts occur simultaneously, only one should be enabled (in IMASK) to vector to a single service routine which handles both transmit and receive data. However, when using autobuffer transfers, both interrupts should be enabled.

### POWERDOWN

The ADSP-21msp5x processors contain a low power feature that allows the processor to enter a very low power dormant state through hardware or software control. Here is a brief list of

powerdown features. Refer to the *ADSP-2100 Family User's Manual*, Chapter 9, "System Interface" for detailed information about the powerdown features.

- Powerdown mode holds the processor in CMOS standby with a maximum current of less than 100  $\mu$ A in some modes.
- Quick recovery from powerdown. In some modes, the processor can begin executing instructions in less than 100 cycles.
- Support for an externally generated TTL or CMOS processor clock. The external clock can continue running during powerdown without affecting the lowest power rating and 100 cycle recovery.
- Support for crystal operation includes disabling the oscillator to save power (the processor automatically waits 4096 cycles for the crystal oscillator to start and stabilize), and letting the oscillator run to allow 100 cycle startup.
- Powerdown is initiated by either the powerdown pin ( $\overline{PWD}$ ) or the software powerdown force bit.
- Interrupt support allows an unlimited number of instructions to be executed before optionally powering-down. The powerdown interrupt also can be used as a nonmaskable, edge sensitive interrupt.
- Context clear/save control allows the processor to continue where it left off or start with a clean context when leaving the powerdown state.
- The  $\overline{RESET}$  pin also can be used to terminate powerdown, and the host software reset feature can be used to terminate powerdown under certain conditions.
- Powerdown acknowledge pin (on ADSP-21msp50 only) indicates when the processor has entered powerdown.

### ADSP-21msp5x Registers

Figure 9 summarizes all the registers in the ADSP-21msp5x. Some registers store values. For example, AX0 stores an ALU operand; I4 stores a DAG2 pointer. Other registers consist of control bits and fields, or status flags. For example, ASTAT contains status flags from arithmetic operations, and fields in DWAIT control the numbers of wait states for different zones of data memory.

A secondary set of registers in all computational units allows a single-cycle context switch.

The bit and field definitions for control and status registers are given in the rest of this section, except for IMASK, ICNTL and IFC, which are defined earlier in this data sheet. The system control register, DWAIT register, timer registers, HIP control registers, HIP data registers, and SPORT control registers are all mapped into data memory; that is, you access these registers by reading and writing data memory locations rather than register names. The particular data memory address is shown with each memory-mapped register.

Register bit values shown on the following pages are the default bit values after reset. If no values are shown, the bits are indeterminate at reset. Reserved bits are shown in gray; these bits should always be written with zeros.

ADSP-21msp50/55/56

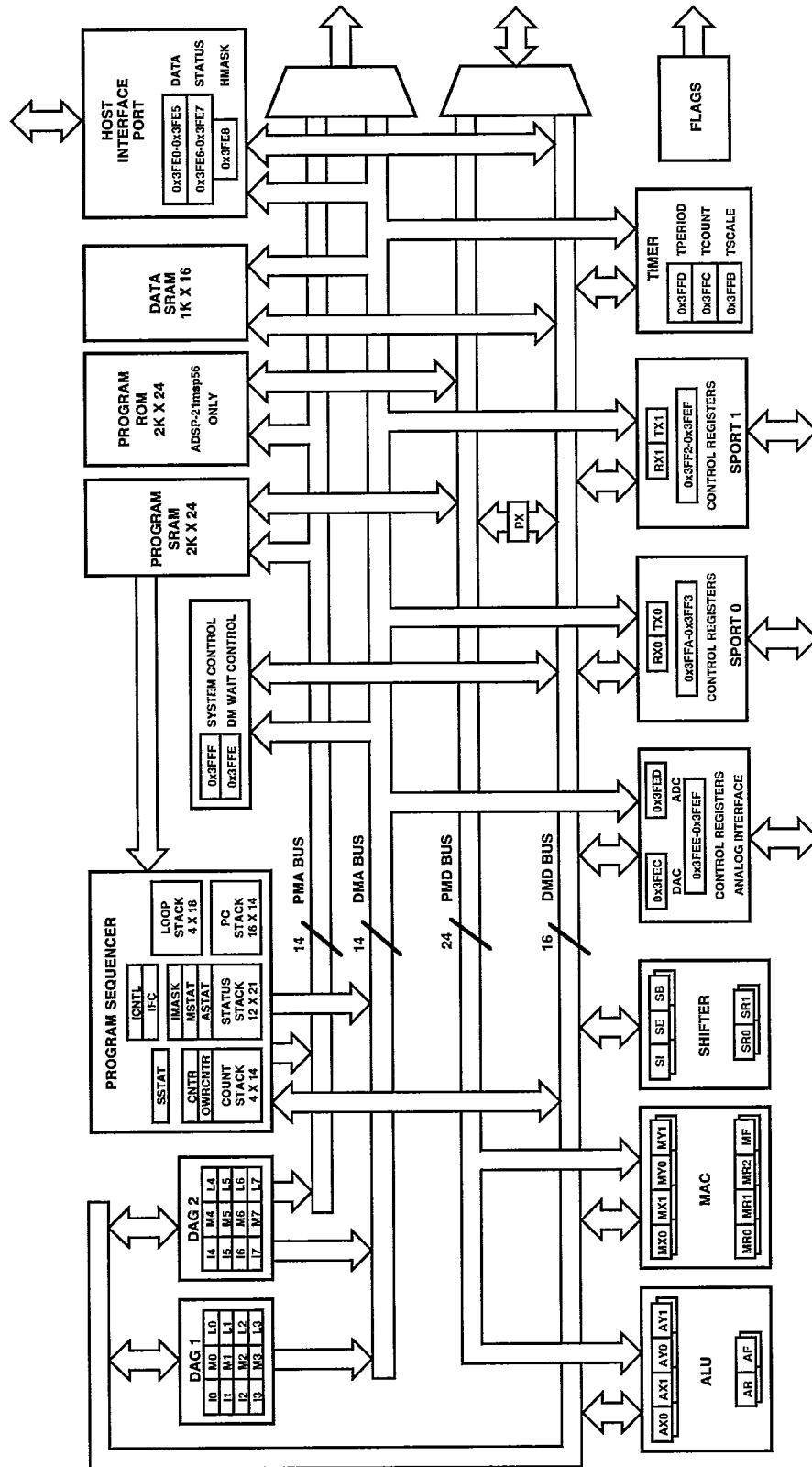
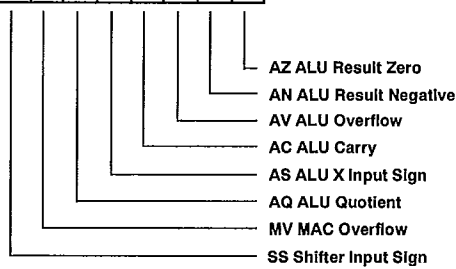
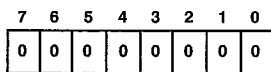


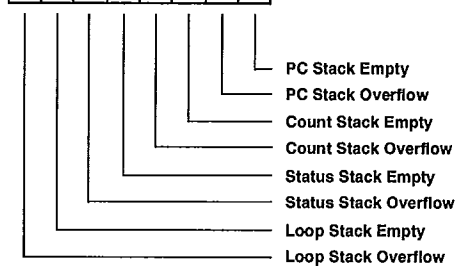
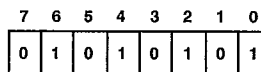
Figure 9. ADSP-21msp5x Registers

# ADSP-21msp50/55/56

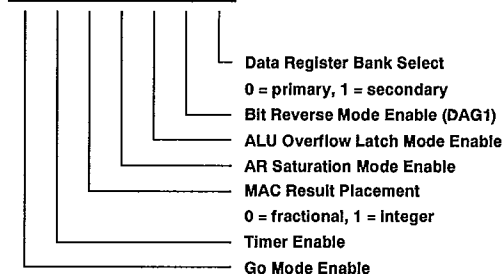
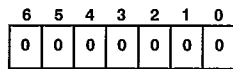
## ASTAT



## SSTAT (Read-Only)

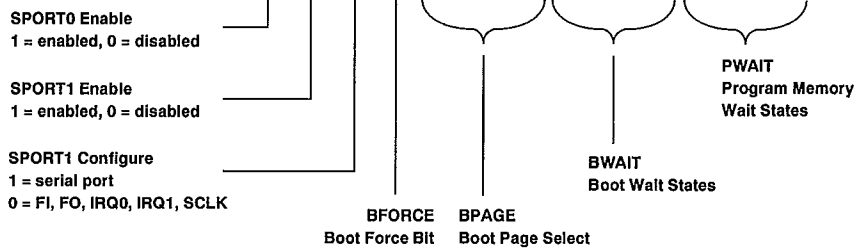
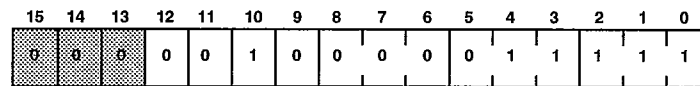


## MSTAT



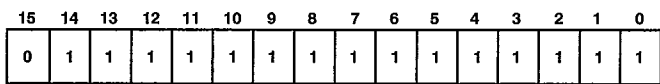
## System Control Register

0x3FFF



## ROM Enable/Data Memory Wait State Control Register

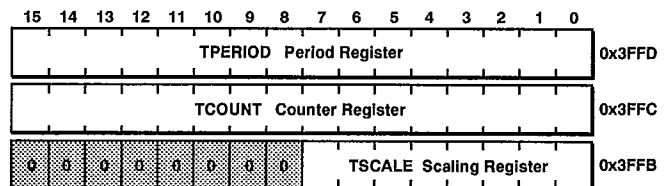
0x3FFE



DWAIT4      DWAIT3      DWAIT2      DWAIT1      DWAIT0

ROM enable (ADSP-21msp56)  
1 = enable  
0 = disable

## Timer Registers

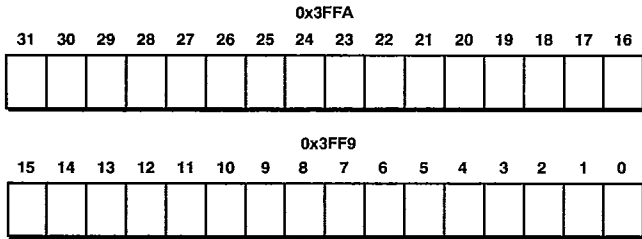


## Control Registers

# ADSP-21msp50/55/56

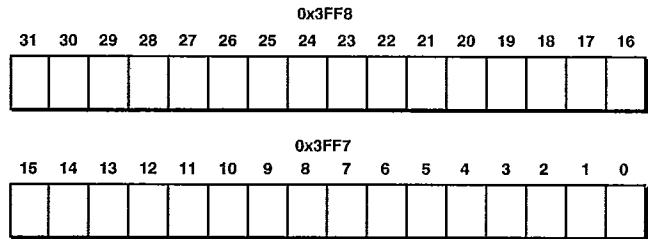
**SPORT0 Multichannel Receive Word Enable Registers**

1 = Channel Enabled  
0 = Channel Ignored



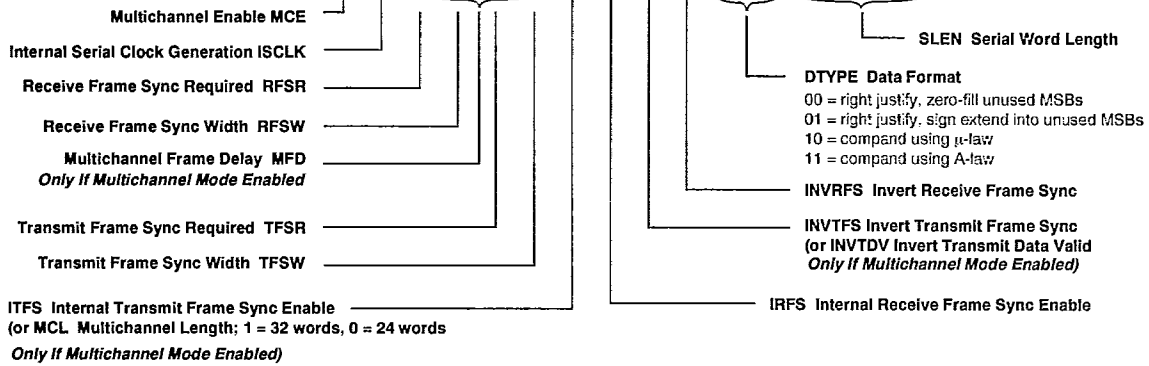
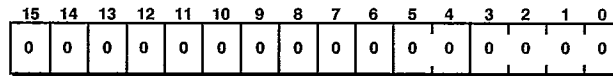
**SPORT0 Multichannel Transmit Word Enable Registers**

1 = Channel Enabled  
0 = Channel Ignored

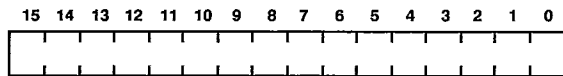


**SPORT0 Control Register**

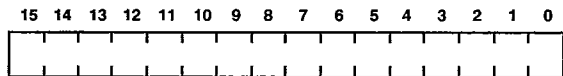
0x3FF6



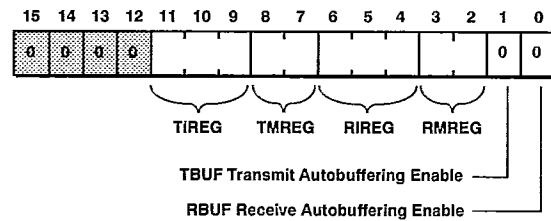
**SPORT0 SCLKDIV**  
Serial Clock Divide Modulus  
0x3FF5



**SPORT0 RFSDIV**  
Receive Frame Sync Divide Modulus  
0x3FF4

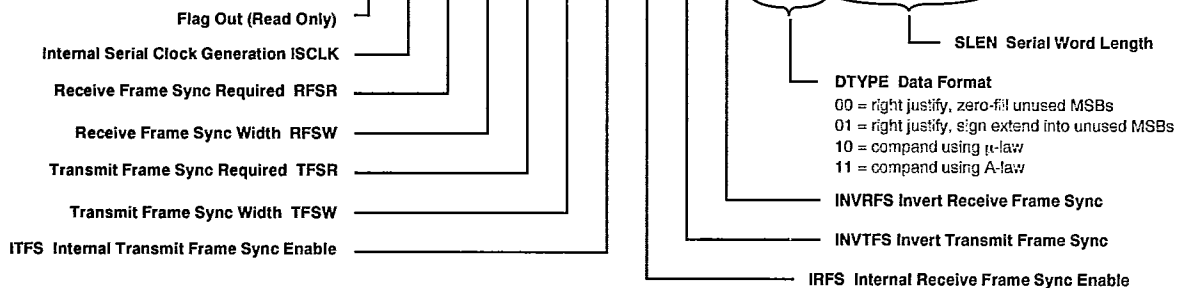
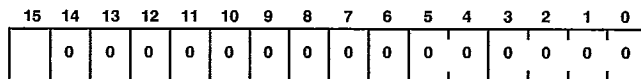


**SPORT0 Autobuffer Control Register**  
0x3FF3



**SPORT1 Control Register**

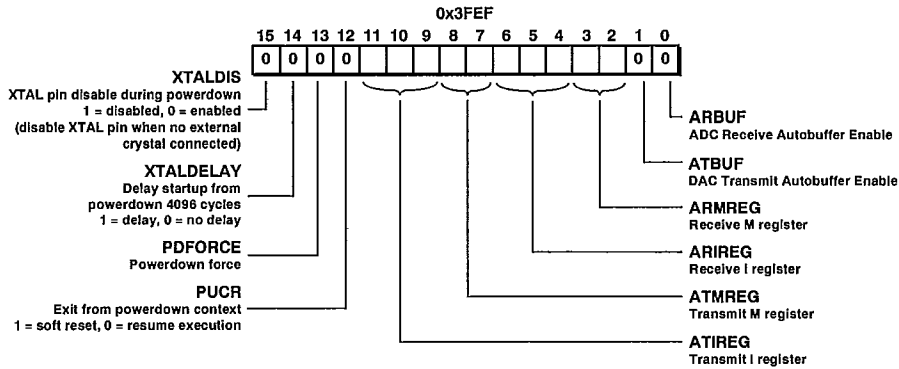
0x3FF2



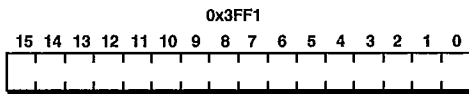
*Control Registers*

# ADSP-21msp50/55/56

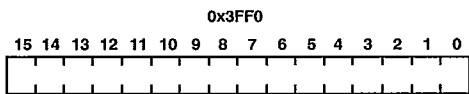
## Analog Autobuffer/Powerdown Control Register



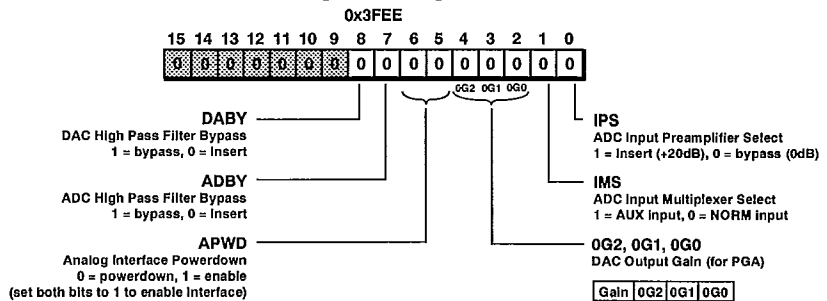
## SPORT1 SCLKDIV Serial Clock Divide Modulus



## SPORT1 RFSKDIV Receive Frame Sync Divide Modulus

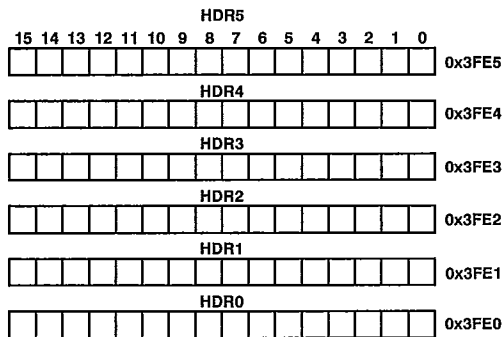


## Analog Control Register

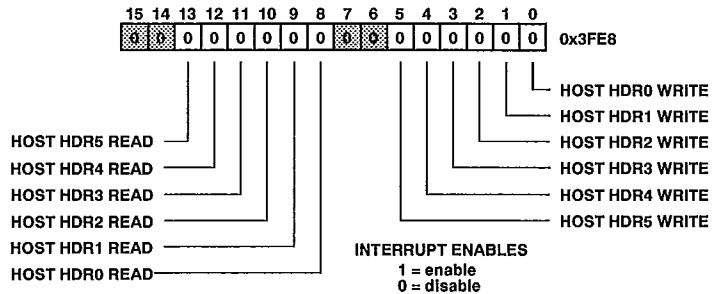


All bits are set to 0 at processor reset.  
(Reserved bits 9-15 must always be set to 0)

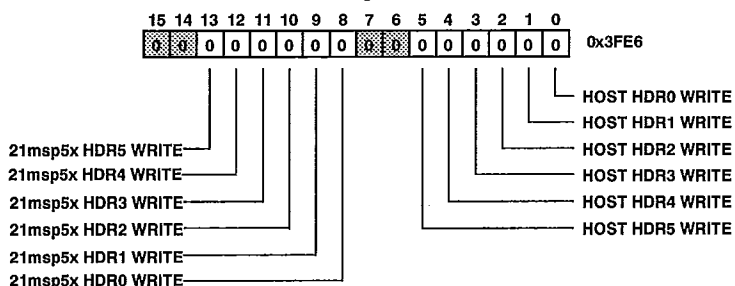
## HIP Data Registers



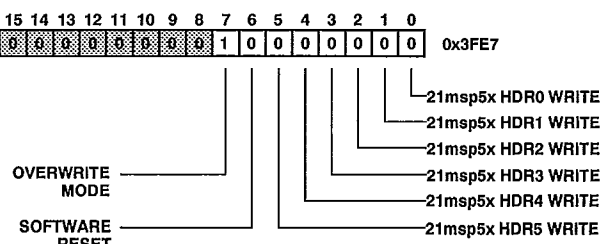
## HMASK Register



## HSR6 Register



## HSR7 Register



## Control Registers

# ADSP-21msp50/55/56

## INSTRUCTION SET DESCRIPTION

The ADSP-21msp5x assembly language instruction set has an algebraic syntax that was designed for ease of coding and readability. The assembly language, which takes full advantage of the processor's unique architecture, offers the following benefits:

- The algebraic syntax eliminates the need to remember cryptic assembler mnemonics. For example, a typical arithmetic add instruction, such as  $AR = AX0 + AY0$ , resembles a simple equation.
- Every instruction assembles into a single, 24-bit word that can execute in a single instruction cycle.
- The syntax is a superset ADSP-2100 Family assembly language and is completely source and object code compatible with other family members. Programs may need to be relocated to utilize internal memory and conform to the ADSP-21msp5x's interrupt vector and reset vector map.
- Sixteen condition codes are available. For conditional jump, call, return, or arithmetic instructions, the condition can be checked and the operation executed in the same instruction cycle.
- Multifunction instructions allow parallel execution of an arithmetic instruction with up to two fetches or one write to processor memory space during a single instruction cycle.

Consult the *ADSP-2100 Family User's Manual* for a complete description of the syntax and an instruction set reference.

### Example Code

The following example is a code fragment that performs the filter tap update for an adaptive (least-mean-squared algorithm) filter. Notice that the computations in the instructions are written like algebraic equations.

```
MF=MX0*MY1 (RND), MX0=DM (I2,M1); {MF=error*beta}
MR=MX0*MF (RND), AY0=PM (I6,MS);
DO adapt UNTIL CE;
  AR=MR1 + AY0, MX0=DM (I2,M1), AY0=PM (I6,M7);
adapt: PM(I6,M6)=AR, MR=MX0*MF (RND);
  MODIFY (I2, M3);           {Point to oldest data}
  MODIFY (I6, M7);          {Point to start of data}
```

## CIRCUIT DESIGN CONSIDERATIONS

The following sections discuss interfacing analog signals to the ADSP-21msp5x.

### Analog Signal Input

The analog input signal to the ADSP-21msp5x must be ac coupled. Figure 10 shows the recommended input circuit for the ADSP-21msp5x's analog input pin (either  $VIN_{NORM}$  or  $VIN_{AUX}$ ). The circuit of Figure 10 implements a first-order low-pass filter with a 3 dB point at 20 kHz; this is the only filter that must be implemented external to the processor to prevent aliasing of the sampled signal. Since the ADSP-21msp5x's sigma-delta ADC uses a highly oversampled approach that transfers the bulk of the antialiasing filtering into the digital domain, the off-chip antialiasing filter need only be of low order.

The feedback capacitor is only necessary if the input signal contains frequency components greater than 20 kHz.

In the circuit shown in Figure 10, scaling of the analog input is achieved by the resistors  $R_{IN}$  and  $R_{FB}$ . The input signal gain,  $-R_{FB}/R_{IN}$ , can be adjusted by varying the values of these resistors. The ADSP-21msp5x's on-chip 20 dB preamplifier can be enabled when there is not enough gain in the input circuit; the preamplifier is configured by Bit 0 (IPS) of the processor's analog control register. Total gain must be configured to ensure that a full-scale input signal (at  $C_{IN}$  in Figure 10) produces a signal level at the input to the sigma-delta modulator of the ADC that does not exceed  $V_{INMAX}$ , refer to the "Analog Interface Electrical Characteristics" specifications. If the total gain is increased above unity (i.e. gain > 1), signal-to-noise (SNR + THD) performance may not meet the listed specifications.

The dc offsetting of the analog input signal is accomplished with the processor's on-chip voltage reference which nominally equals 2.5 V. The input signal must be ac coupled with an external coupling capacitor ( $C_{IN}$ ).  $C_{IN}$  and  $R_{IN}$  should be chosen to ensure a coupling corner frequency of 30 Hz.  $C_{IN}$  should be 0.1  $\mu$ F or larger.

To select values for the components shown in Figure 10, use the following equations:

$$Gain = \frac{-R_{FB}}{R_{IN}}$$

$$C_{IN} = \frac{1}{60 \pi R_{IN}}$$

$$CFB = \frac{1}{(2 \pi) (20 \times 10^3) R_{FB}}$$

$$10 \text{ k}\Omega \leq R_{FB}$$

$$R_{IN} \leq 50 \text{ k}\Omega$$

$$150 \text{ pF} \leq C_{FB} \leq 600 \text{ pF}$$

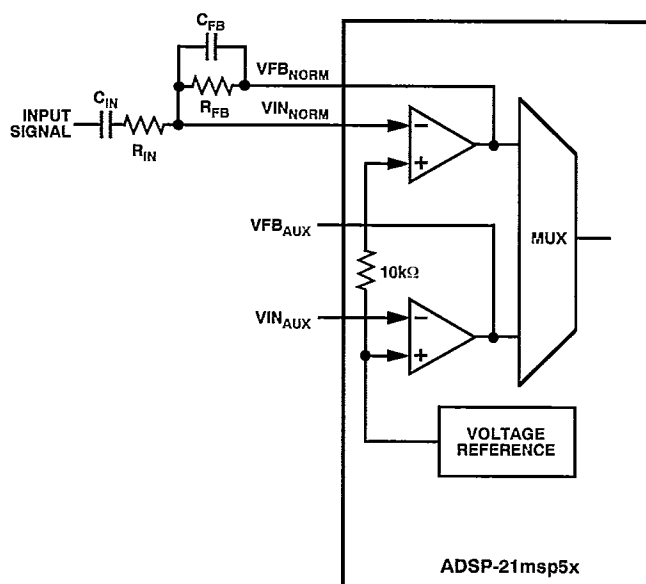


Figure 10. Recommended Analog Input Circuit

# ADSP-21msp50/55/56

Figure 11 shows an example of a typical input circuit configured for 0 dB gain. The circuit's diodes are used to prevent the input signal from exceeding maximum limits.

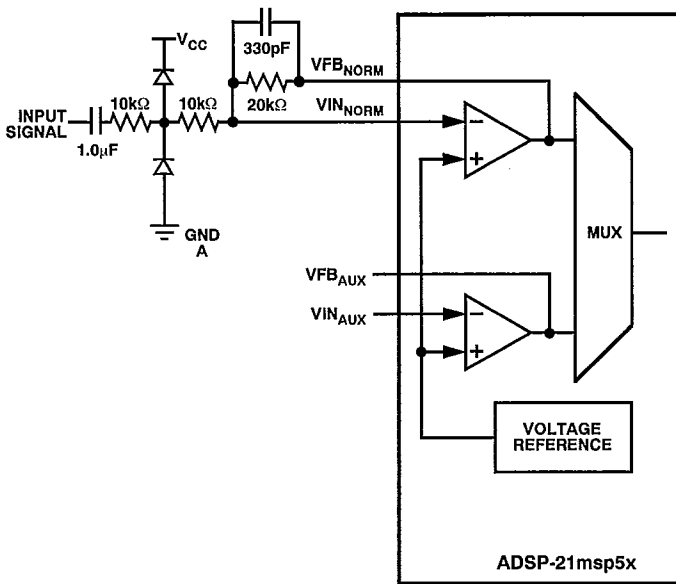


Figure 11. Typical Input Circuit (0 dB Gain)

### Analog Signal Output

The ADSP-21msp5x's differential analog output (VOUT<sub>P</sub>-VOUT<sub>N</sub>) is produced by an on-chip differential amplifier which is part of the processor's analog interface. The differential amplifier can drive a minimum load of 2 kΩ (R<sub>L</sub> ≥ 2 kΩ) and has a maximum differential output voltage swing of ±3.156 V peak-to-peak (3.17 dBm<sub>0</sub>). The differential output can be ac coupled directly to a load or dc-coupled to an external amplifier.

Figure 12 shows a simple circuit providing a differential output with ac coupling. The capacitor of this circuit (C<sub>OUT</sub>) is optional; if used, its value can be chosen as follows:

$$C_{OUT} = \frac{1}{(60 \pi) R_L}$$

The VOUT<sub>P</sub>-VOUT<sub>N</sub> outputs must be used as differential outputs; do not use either as a single-ended output. Figure 13 shows an example circuit which can be used to convert the differential output to a single-ended output. The circuit uses a differential-to-single-ended amplifier, the Analog Devices SSM-2141.

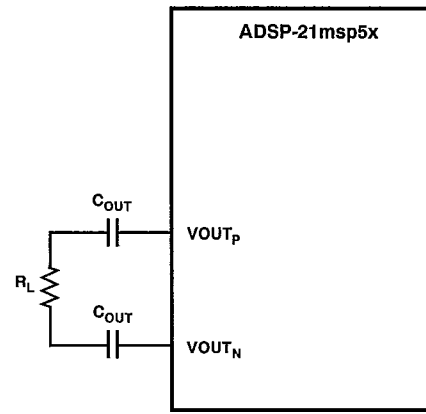


Figure 12. Example Circuit for Differential Output with AC Coupling

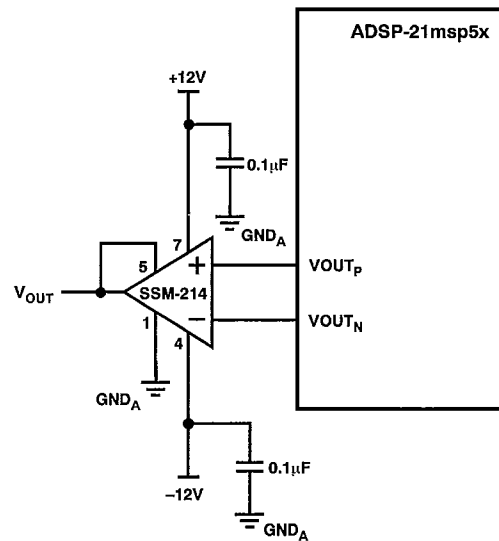


Figure 13. Example Circuit for Single-Ended Output

### APPLICATION EXAMPLES

The ADSP-21msp5x is ideal for speech processing applications where high performance for analog and digital circuitry is required, but board space is severely limited. The cellular radio handset is one application. Here, the ADSP-21msp5x can digitize the speech, then perform compression algorithms that sufficiently reduce the bit rate for transmission in a limited radio bandwidth.



**DEFINITION OF SPECIFICATIONS****Absolute Gain**

Absolute gain is a measure of converter gain for a known signal. Absolute gain is measured with a 1.0 kHz sine wave at 0 dBm0. The absolute gain specification is used as a reference for gain tracking error specification.

**Gain Tracking Error**

Gain tracking error measures changes in converter output for different signal levels relative to an absolute signal level. The absolute signal level is 1 kHz at 0 dBm0 (equal to absolute gain). Gain tracking error at 0 dBm0 is 0 dB by definition.

**SNR + THD**

Signal-to-noise ratio plus total harmonic distortion is defined to be the ratio of the rms value of the measured input signal to the rms sum of all other spectral components in the frequency range 300–3400 Hz, including harmonics but excluding dc.

**Intermodulation Distortion**

With inputs consisting of sine waves at two frequencies,  $f_a$  and  $f_b$ , any active device with nonlinearities will create distortion products at sum and difference frequencies of  $m f_a \pm n f_b$  where  $m, n = 0, 1, 2, 3$ , etc. Intermodulation terms are those for which neither  $m$  or  $n$  are equal to zero. For final testing, the second order terms include  $(f_a + f_b)$  and  $(f_a - f_b)$ , while the third order terms include  $(2f_a + f_b)$ ,  $(2f_a - f_b)$ ,  $(f_a + 2f_b)$ , and  $(f_a - 2f_b)$ .

**Idle Channel Noise**

Idle channel noise is defined as the total signal energy measured at the output of the device when the input is grounded (measured in the frequency range 300–3400 Hz).

**Crosstalk**

Crosstalk is defined as the ratio of the amplitude of a full-scale signal appearing on one channel to the amplitude of the same signal which couples onto the adjacent channel. Crosstalk is expressed in dB.

**Power Supply Rejection**

Power supply rejection measures the susceptibility of a device to noise on the power supply. Power supply rejection is measured by modulating the power supply with a sine wave and measuring the noise at the output (relative to 0 dB).

**Group Delay**

Group delay is defined as the derivative of radian phase with respect to radian frequency,  $\partial\phi(\omega)/\partial\omega$ . Group delay is a measure of average delay of a system as a function of frequency. A linear system with a constant group delay has a linear phase response. The deviation of group delay away from a constant indicates the degree of nonlinear phase response of the system.

# ADSP-21msp50/55/56 — SPECIFICATIONS

## RECOMMENDED OPERATING CONDITIONS

Parameter		K Grade		B Grade		Unit
		Min	Max	Min	Max	
V <sub>DD</sub>	Supply Voltage	4.50	5.50	4.50	5.50	V
T <sub>AMB</sub>	Ambient Operating Temperature	0	+70	-40	+85	°C

Refer to Environmental Conditions for information on thermal specifications.

## ELECTRICAL CHARACTERISTICS

Parameter	Test Conditions	K/B Grades		Unit
		Min	Max	
V <sub>IH</sub>	Hi-Level Input Voltage <sup>3, 5</sup>	@ V <sub>DD</sub> = max	2.0	V
V <sub>IH</sub>	Hi-Level CLKIN Voltage	@ V <sub>DD</sub> = max	2.2	V
V <sub>IL</sub>	Lo-Level Input Voltage <sup>1, 3</sup>	@ V <sub>DD</sub> = min		0.8
V <sub>OH</sub>	Hi-Level Output Voltage <sup>2, 3, 7</sup>	@ V <sub>DD</sub> = min, I <sub>OH</sub> = -0.5 mA	2.4	V
		@ V <sub>DD</sub> = min, I <sub>OH</sub> = -100 μA <sup>10</sup>	V <sub>DD</sub> - 0.3	V
V <sub>OL</sub>	Lo-Level Output Voltage <sup>2, 3, 7</sup>	@ V <sub>DD</sub> = min, I <sub>OL</sub> = 2 mA		0.4
I <sub>IH</sub>	Hi-Level Input Current <sup>1</sup>	@ V <sub>DD</sub> = max, V <sub>IN</sub> = V <sub>DD</sub> max		10
I <sub>IL</sub>	Lo-Level Input Current <sup>1</sup>	@ V <sub>DD</sub> = max, V <sub>IN</sub> = 0 V		10
I <sub>OZH</sub>	Tristate Leakage Current <sup>4</sup>	@ V <sub>DD</sub> = max, V <sub>IN</sub> = V <sub>DD</sub> max <sup>6</sup>		10
I <sub>OZL</sub>	Tristate Leakage Current <sup>4</sup>	@ V <sub>DD</sub> = max, V <sub>IN</sub> = 0 V <sup>6</sup>		10
I <sub>DD</sub>	Digital Supply Current (Idle) <sup>8, 9</sup>	Codec Inactive		22
I <sub>DD</sub>	Digital Supply Current (Dynamic) <sup>9</sup>	Processor Fully Loaded, Codec Active <sup>11</sup>		90
I <sub>DD</sub>	Digital Supply Current (Powerdown) <sup>9</sup>	See ADSP-2100 Family User's Manual, Chapter 9		100
I <sub>CC</sub>	Analog Supply Current (Dynamic) <sup>9</sup>	Codec Active		19
C <sub>I</sub>	Input Pin Capacitance <sup>1, 10, 12</sup>	@ V <sub>IN</sub> = 2.5 V, f <sub>IN</sub> = 1.0 MHz, T <sub>AMB</sub> = 25°C		8
C <sub>O</sub>	Output Pin Capacitance <sup>4, 10, 12, 13</sup>	@ V <sub>IN</sub> = 2.5 V, f <sub>IN</sub> = 1.0 MHz, T <sub>AMB</sub> = 25°C		8

### NOTES

- <sup>1</sup>Input only pins: CLKIN, RESET, IRQ2, BR, MMAP, DR0, DR1, HSEL, HSIZE, BMODE, HMD0, HMD1, HRD/HWR, HWR/HDS, HA2/ALE, HA1-0.
  - <sup>2</sup>Output pins: BG, PMS, DMS, BMS, RD, WR, A0-A13, DT0, DT1, CLKOUT, HACK, FL2-0.
  - <sup>3</sup>Bidirectional pins: D0-D23, RFS0, RFS1, SCLK0, SCLK1, TFS0, TFS1 HD0-HD15/HAD0-HAD15.
  - <sup>4</sup>Tristatable pins: A0-A13, D0-D23, PMS, DMS, BMS, RD, WR, DT0, DT1, SCLK0, SCLK1, TFS0, TFS1, RFS0, RFS1, HD0-HD15/HAD0-HAD15.
  - <sup>5</sup>RESET, IRQ2, BR, MMAP, DR1, DR0 input pins.
  - <sup>6</sup>0 V on BR, CLKIN Active (to force tristate condition).
  - <sup>7</sup>Although specified for TTL outputs, all ADSP-21msp5x outputs are CMOS-compatible and will drive to V<sub>DD</sub> and GND assuming no dc loads.
  - <sup>8</sup>Idle refers to ADSP-21msp5x state of operation during execution of IDLE instruction. Deasserted pins are driven to either V<sub>DD</sub> or GND.
  - <sup>9</sup>Current reflects device operating with no output loads.
  - <sup>10</sup>Guaranteed but not tested.
  - <sup>11</sup>V<sub>CC</sub> = V<sub>DD</sub> = max, t<sub>CK</sub> = 77 ns, ambient temperature = +85°C, executing type 1 instructions, with worst case data. Refer to section titled "Power Dissipation" for typical figures for digital and analog supply currents.
  - <sup>12</sup>Applies to PGA and PQFP package types.
  - <sup>13</sup>Output pin capacitance is the capacitive load for any tristated output pin.
- Specifications subject to change without notice.

### ABSOLUTE MAXIMUM RATINGS\*

Supply Voltage	-0.3 V to +7 V
Input Voltage	-0.3 V to V <sub>DD</sub> +0.3 V
Output Voltage Swing	-0.3 V to V <sub>DD</sub> +0.3 V
Operating Temperature Range (Ambient)	-40°C to +85°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (10 sec) PGA	+300°C
Lead Temperature (5 sec) PQFP	+280°C

\*Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**ADSP-21msp50/55/56****ESD SENSITIVITY**

The ADSP-21msp5x is an ESD (electrostatic discharge) sensitive device. Electrostatic charges readily accumulate on the human body and equipment and can discharge without detection. Permanent damage may occur to devices subjected to high energy electrostatic discharges.

The ADSP-21msp5x features proprietary ESD protection circuitry to dissipate high energy discharges (Human Body Model). Per method 3015 of MIL-STD-883, the ADSP-21msp5x has been classified as a Class 1 device.

Proper ESD precautions are recommended to avoid performance degradation or loss of functionality. Unused devices must be stored in conductive foam or shunts, and the foam should be discharged to the destination socket before devices are removed.

**TIMING PARAMETERS****GENERAL NOTES**

Use the exact timing information given. Do not attempt to derive parameters from the addition or subtraction of others. While addition or subtraction would yield meaningful results for an individual device, the values given in this data sheet reflect statistical variations and worst cases. Consequently, you cannot meaningfully add up parameters to derive longer times.

**TIMING NOTES**

Switching characteristics specify how the processor changes its signals. You have no control over this timing; it is dependent on the internal design. Timing requirements apply to signals that are controlled outside the processor, such as the data input for a read operation.

Timing requirements guarantee that the processor operates correctly with another device. Switching characteristics tell you what the device will do under a given circumstance. Also use switching characteristics to ensure that any timing requirement of a device connected to the processor (such as memory) is satisfied.

**MEMORY REQUIREMENTS**

This chart links common memory device specification names and ADSP-21msp5x timing parameters for your convenience.

Parameter Name	Function	Common Memory Device Specification Name
$t_{ASW}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ Setup before $\overline{WR}$ Low	Address Setup to Write Start
$t_{AW}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ Setup before $\overline{WR}$ Deasserted	Address Setup to Write End
$t_{WRA}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ Hold after $\overline{WR}$ Deasserted	Address Hold Time
$t_{DW}$	Data Setup before $\overline{WR}$ High	Data Setup Time
$t_{DH}$	Data Hold after $\overline{WR}$ High	Data Hold Time
$t_{RDD}$	$\overline{RD}$ Low to Data Valid	$\overline{OE}$ to Data Valid
$t_{AA}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ , $\overline{BMS}$ to Data Valid	Address Access Time

## ADSP-21msp50/55/56

## FREQUENCY RESPONSE

Input Freq (Hz)	Min Output (dB)	Max Output (dB)
0	-∞	-25
100	-∞	-25
150	-0.3	+0.3
200	-0.3	+0.3
300	-0.2	+0.2
1000	-0.2	+0.2
2000	-0.2	+0.2
3000	-0.2	+0.2
3400	-0.2	+0.2
3700	-0.3	+0.3
4000	-∞	-60
>4000	-∞	-60

Frequency responses of ADC and DAC measured with input at audio reference level (the input level that produces an output level of -10 dBm0), with 20 dB preamplifier bypassed and input gain of 0 dB. The in-band ripple shall not exceed 0.2 dB.

## NOISE AND DISTORTION

Parameter	Min	Max	Unit	Test Conditions
ADC Intermodulation Distortion		-70	dB	ADC input signal level: 1.0 kHz, 0 dBm0 DAC input at idle.
DAC Intermodulation Distortion		-70	dB	
ADC Idle Channel Noise		72	dBm0	
DAC Idle Channel Noise		72	dBm0	
ADC Crosstalk		-65	dB	ADC input signal level: analog ground DAC output signal level: 1.0 kHz, 0 dBm0
DAC Crosstalk		-65	dB	
ADC Power Supply Rejection		-55	dB	Input signal level at $V_{CC}$ and $V_{DD}$ pins: 1.0 kHz, 100 mV p-p sine wave
DAC Power Supply Rejection		-55	dB	
ADC Group Delay <sup>1</sup>		1	ms	Input signal level at $V_{CC}$ and $V_{DD}$ pins: 1.0 kHz, 100 mV p-p sine wave
DAC Group Delay <sup>1</sup>		1	ms	

<sup>1</sup>Guaranteed but not tested.

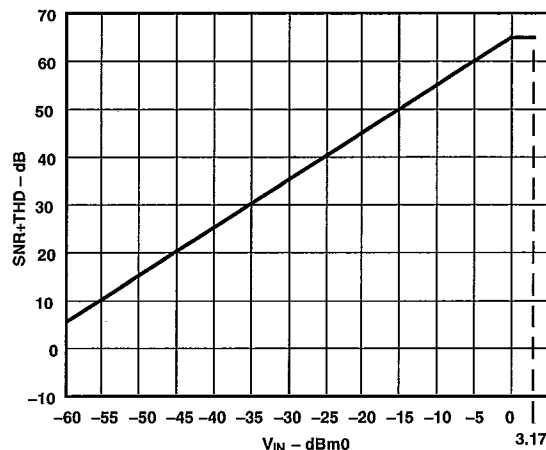


Figure 14. SNR + THD vs.  $V_{IN}$

## ADSP-21msp50/55/56

## ANALOG INTERFACE ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Min	Typ	Max	Unit
<b>ADC:</b>					
$I_L$	Input Leakage Current <sup>4</sup> at $V_{IN_{NORM}}$ , $V_{IN_{AUX}}$		10		nA
$R_I$	Input Resistance <sup>4</sup> at $V_{IN_{NORM}}$ , $V_{IN_{AUX}}$		100		M $\Omega$
$C_{IL}$	Input Load Capacitance <sup>4</sup> at $V_{FB_{NORM}}$ , $V_{FB_{AUX}}$		10		pF
$V_{IN_{MAX}}$	Maximum Input Range <sup>1, 4</sup>			3.156	V p-p
<b>DAC:</b>					
$R_O$	Output Resistance <sup>2, 4</sup>		1		$\Omega$
$V_{O_{OFF}}$	Output DC Offset <sup>3</sup>	-400		400	mV
$C_{OL}$	Output Load Capacitance <sup>2</sup>			100	pF
$V_{VREF}$	Voltage Reference ( $V_{REF}$ )	2.25		2.75	V
$V_O$	Maximum Voltage Output Swing (p-p) Across $R_L$				
	Single-Ended <sup>4</sup>			3.156	V
	Differential <sup>4</sup>			6.312	V
$R_L$	Load Resistance <sup>2, 4</sup>	2			k $\Omega$

Test Conditions for all analog interface tests: Unity input gain, A/D 20 dB preamplifier bypassed, D/A PGA set for 0 dB gain, no load on analog output ( $V_{OUT_P}$ - $V_{OUT_N}$ ).

<sup>1</sup>At input to sigma-delta modulator of ADC.

<sup>2</sup>At  $V_{OUT_P}$ - $V_{OUT_N}$ .

<sup>3</sup>Between  $V_{OUT_P}$  and  $V_{OUT_N}$ .

<sup>4</sup>Guaranteed but not tested.

## GAIN

Parameter	Min	Typ	Max	Unit	Test Conditions
ADC Absolute Gain	-0.2	0	0.2	dBm0	1.0 kHz, 0 dBm0
ADC Gain Tracking Error	-0.1	0	0.1	dBm0	1.0 kHz, +3 to -50 dBm0
DAC Absolute Gain	-0.2	0	0.2	dBm0	1.0 kHz, 0 dBm0
DAC Gain Tracking Error	-0.1	0	0.1	dBm0	1.0 kHz, +3 to -50 dBm0

# ADSP-21msp50/55/56

Parameter	Min	Max	Unit
<b>Clock Signals</b>			
Timing Requirement:			
$t_{CK}^1$ CLKIN Period	76.9	150	ns
$t_{CKL}$ CLKIN Width Low	20		ns
$t_{CKH}$ CLKIN Width High	20		ns
Switching Characteristic:			
$t_{CPL}$ CLKOUT Width Low	$0.5t_{CK} - 10$		ns
$t_{CPH}$ CLKOUT Width High	$0.5t_{CK} - 10$		ns
$t_{CKOH}$ CLKIN High to CLKOUT High	0	20	ns
<b>Control Signals</b>			
Timing Requirement:			
$t_{RSP}$ $\overline{\text{RESET}}$ Width Low	$5t_{CK}^2$		ns

**NOTES**

<sup>1</sup> $t_{CK}$  values within the range of CLKIN period should be substituted for all relevant timing parameters to obtain specification value. Example:

$t_{CPH} = 0.5 t_{CK} - 10 \text{ ns} = 0.5 (76.9) - 10 \text{ ns} = 28.5 \text{ ns}$ .

<sup>2</sup>Applies after power-up sequence is complete. Internal phase lock loop requires no more than 1000 processor cycles assuming stable CLKIN (not including crystal oscillator start-up time).

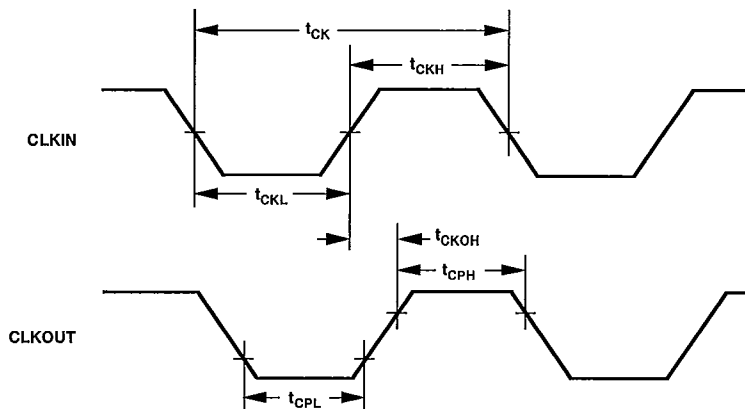


Figure 15. Clock Signals

## ADSP-21msp50/55/56

Parameter	Min	Max	Unit
<b>Interrupts and Flags</b>			
Timing Requirement:			
$t_{IFS}$	IRQx or FI Setup before CLKOUT Low <sup>1, 2</sup>		ns
$t_{IFH}$	IRQx or FI Hold after CLKOUT High <sup>1, 2</sup>		ns
	IRQx = $\overline{IRQ0}$ , $\overline{IRQ1}$ and $\overline{IRQ2}$		
Switching Characteristic:			
$t_{FOH}$	Flag Output Hold after CLKOUT High		ns
$t_{FOD}$	Flag Output Delay from CLKOUT High		15
	Flag Output = FL0, FL1, FL2, and FO		

## NOTES

<sup>1</sup>If  $\overline{IRQx}$  and FI inputs meet  $t_{IFS}$  and  $t_{IFH}$  setup/hold requirements, they will be recognized during the current clock cycle; otherwise the signals will be recognized on the following cycle. (Refer to "Interrupt Controller Operation" in the Program Control chapter of the User's Manual for further information on interrupt servicing.)

<sup>2</sup>Edge-sensitive interrupts require pulse widths greater than 10 ns; level-sensitive interrupts must be held low until serviced.

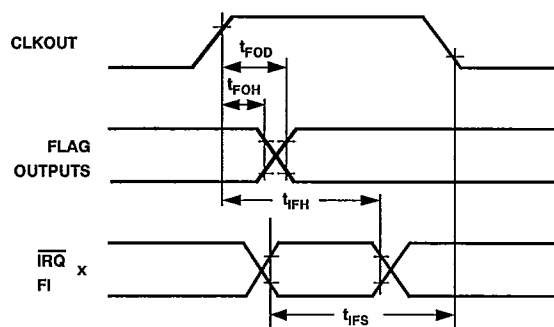


Figure 16. Interrupts and Flags

# ADSP-21msp50/55/56

Parameter	Min	Max	Unit
<b>Bus Request/Grant</b>			
Timing Requirement:			
$t_{BH}$	$\overline{BR}$ Hold after CLKOUT High <sup>1</sup>	$0.25t_{CK} + 5$	ns
$t_{BS}$	$\overline{BR}$ Setup before CLKOUT Low <sup>1</sup>	$0.25t_{CK} + 20$	ns
Switching Characteristic:			
$t_{SD}$	CLKOUT High to $\overline{DMS}$ , $\overline{PMS}$ , $\overline{BMS}$ , $\overline{RD}$ , $\overline{WR}$ Disable	$0.25t_{CK} + 20$	ns
$t_{SDB}$	$\overline{DMS}$ , $\overline{PMS}$ , $\overline{BMS}$ , $\overline{RD}$ , $\overline{WR}$ Disable to $\overline{BG}$ Low	0	ns
$t_{SE}$	$\overline{BG}$ High to $\overline{DMS}$ , $\overline{PMS}$ , $\overline{BMS}$ , $\overline{RD}$ , $\overline{WR}$ Enable	0	ns
$t_{SEC}$	$\overline{DMS}$ , $\overline{PMS}$ , $\overline{BMS}$ , $\overline{RD}$ , $\overline{WR}$ Enable to CLKOUT High	$0.25t_{CK} - 10$	ns

**NOTE**

<sup>1</sup> $\overline{BR}$  is a synchronous signal which must meet setup/hold time requirements. Refer to the User's Manual for  $\overline{BR}/\overline{BG}$  cycle relationships.

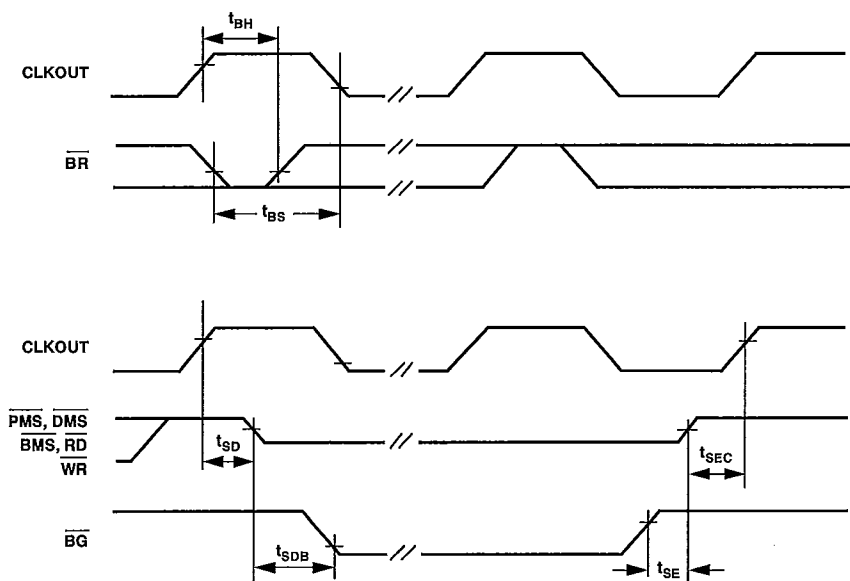


Figure 17. Bus Request – Bus Grant



**ADSP-21msp50/55/56**

Parameter	Min	Max	Unit
<b>Memory Read</b>			
Timing Requirement:			
$t_{RDD}$	$\overline{RD}$ Low to Data Valid	$0.5t_{CK} - 15 + w$	ns
$t_{AA}$	A0-A13, $\overline{PMS}$ , $\overline{DMS}$ , $\overline{BMS}$ to Data Valid	$0.75t_{CK} - 20 + w$	ns
$t_{RDH}$	Data Hold from $\overline{RD}$ High	0	ns
Switching Characteristic:			
$t_{RP}$	$\overline{RD}$ Pulse Width	$0.5t_{CK} - 5 + w$	ns
$t_{CRD}$	CLKOUT High to $\overline{RD}$ Low	$0.25t_{CK} - 5$	ns
$t_{ASR}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ , $\overline{BMS}$ Setup before $\overline{RD}$ Low	$0.25t_{CK} - 12$	ns
$t_{RDA}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ , $\overline{BMS}$ Hold after $\overline{RD}$ Deasserted	$0.25t_{CK} - 10$	ns
$t_{RWR}$	$\overline{RD}$ High to $\overline{RD}$ or $\overline{WR}$ Low	$0.5t_{CK} - 5$	ns
$w = \text{wait states} \times (t_{CK})$			

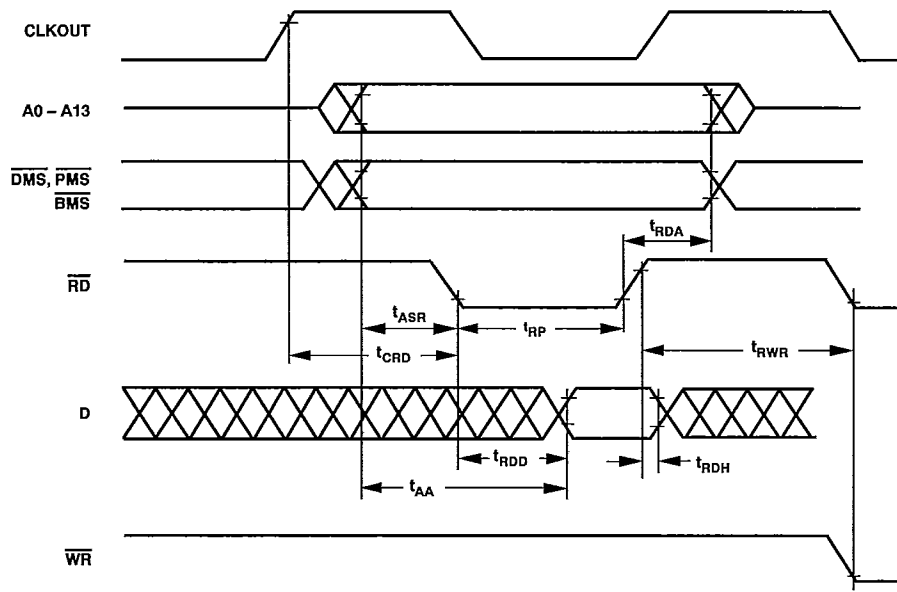


Figure 18. Memory Read

# ADSP-21msp50/55/56

Parameter	Min	Max	Unit
<b>Memory Write</b>			
Switching Characteristic:			
$t_{DW}$	Data Setup before $\overline{WR}$ High	$0.5t_{CK} - 10 + w$	ns
$t_{DH}$	Data Hold after $\overline{WR}$ High	$0.25t_{CK} - 10$	ns
$t_{WP}$	$\overline{WR}$ Pulse Width	$0.5t_{CK} - 5 + w$	ns
$t_{WDE}$	$\overline{WR}$ Low to Data Enabled	0	ns
$t_{ASW}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ Setup before $\overline{WR}$ Low	$0.25t_{CK} - 12$	ns
$t_{DDR}$	Data Disable before $\overline{WR}$ or $\overline{RD}$ Low	$0.25t_{CK} - 10$	ns
$t_{CWR}$	CLKOUT High to $\overline{WR}$ Low	$0.25t_{CK} - 5$	ns
$t_{AW}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ Setup before $\overline{WR}$ Deasserted	$0.75t_{CK} - 15 + w$	ns
$t_{WRA}$	A0-A13, $\overline{DMS}$ , $\overline{PMS}$ Hold after $\overline{WR}$ Deasserted	$0.25t_{CK} - 10$	ns
$t_{WWR}$	$\overline{WR}$ High to $\overline{RD}$ or $\overline{WR}$ Low	$0.5t_{CK} - 5$	ns
$w = \text{wait states} \times (t_{CK})$			

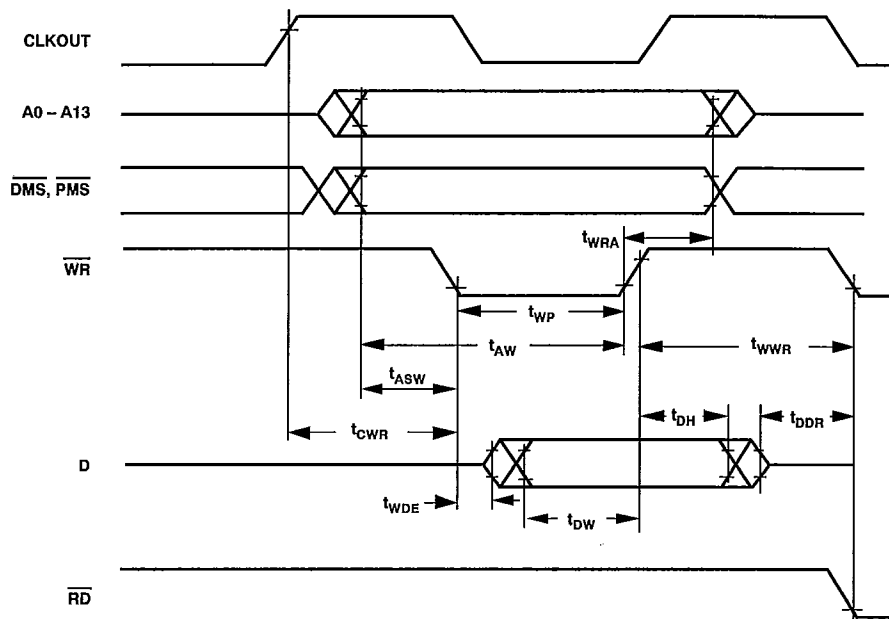


Figure 19. Memory Write

**ADSP-21msp50/55/56**

Parameter	Min	Max	Unit
<b>Serial Ports</b>			
Timing Requirement:			
$t_{SCK}$ SCLK Period	76.9		ns
$t_{SCS}$ DR/TFS/RFS Setup before SCLK Low	8		ns
$t_{SCH}$ DR/TFS/RFS Hold after SCLK Low	10		ns
$t_{SCP}$ SCLK <sub>in</sub> Width	28		ns
Switching Characteristic:			
$t_{CC}$ CLKOUT High to SCLK <sub>out</sub>	$0.25t_{CK}$	$0.25t_{CK} + 15$	ns
$t_{SCDE}$ SCLK High to DT Enable	0		ns
$t_{SCDV}$ SCLK High to DT Valid		20	ns
$t_{RH}$ TFS/RFS <sub>out</sub> Hold after SCLK High	0		ns
$t_{RD}$ TFS/RFS <sub>out</sub> Delay from SCLK High		20	ns
$t_{SCDH}$ DT Hold after SCLK High	0		ns
$t_{TDE}$ TFS <sub>in</sub> (alt) to DT Enable	0		ns
$t_{TDV}$ TFS <sub>in</sub> (alt) to DT Valid		18	ns
$t_{SCDD}$ SCLK High to DT Disable		25	ns
$t_{RDV}$ RFS <sub>in</sub> (multichannel, frame delay zero) to DT Valid		20	ns

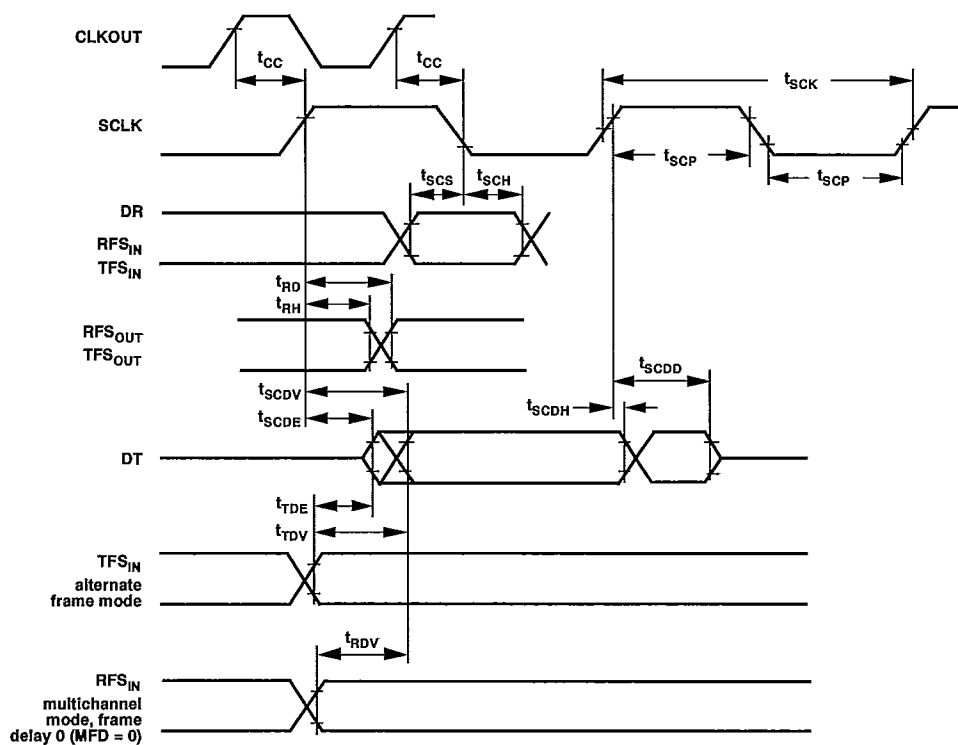


Figure 20. Serial Ports

# ADSP-21msp50/55/56

Parameter	Min	Max	Unit
<b>Host Interface Port</b>			
Separate Data and Address (HMD1 = 0)			
Read Strobe and Write Strobe (HMD0 = 0)			
Timing Requirement:			
$t_{HSU}$	HA2-0 Setup before Start of Write or Read <sup>1, 2</sup>		ns
$t_{HDSU}$	Data Setup before End of Write <sup>3</sup>		ns
$t_{HWDH}$	Data Hold after End of Write <sup>3</sup>		ns
$t_{HH}$	HA2-0 Hold after End of Write or Read <sup>3, 4</sup>		ns
$t_{HRWP}$	Read or Write Pulse Width <sup>5</sup>		ns
Switching Characteristic:			
$t_{HSHK}$	$\overline{HACK}$ Low after Start of Write or Read <sup>1, 2</sup>		ns
$t_{HKH}$	$\overline{HACK}$ Hold after End of Write or Read <sup>3, 4</sup>		ns
$t_{HDE}$	Data Enabled after Start of Read <sup>2</sup>		ns
$t_{HDD}$	Data Valid after Start of Read <sup>2</sup>		ns
$t_{HRDH}$	Data Hold after End of Read <sup>4</sup>		ns
$t_{HRDD}$	Data Disabled after End of Read <sup>4</sup>		ns

**NOTES**

<sup>1</sup>Start of Write =  $\overline{HWR}$  Low and  $\overline{HSEL}$  Low.

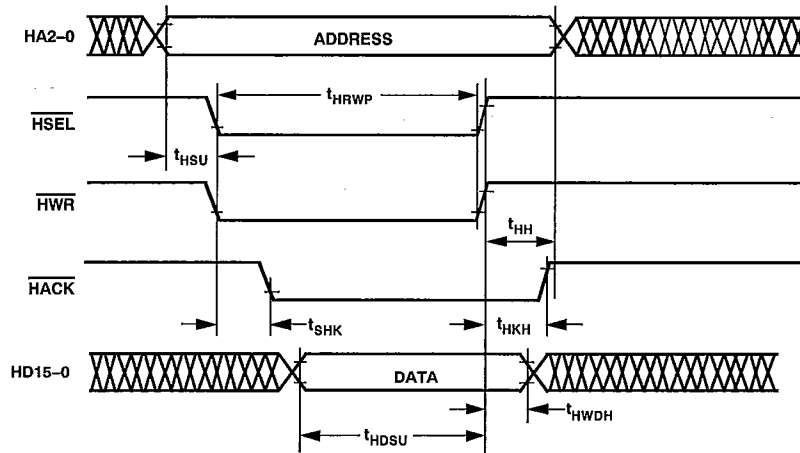
<sup>2</sup>Start of Read =  $\overline{HRD}$  Low and  $\overline{HSEL}$  Low.

<sup>3</sup>End of Write =  $\overline{HWR}$  High or  $\overline{HSEL}$  High.

<sup>4</sup>End of Read =  $\overline{HRD}$  High or  $\overline{HSEL}$  High.

<sup>5</sup>Read Pulse Width =  $\overline{HRD}$  Low and  $\overline{HSEL}$  Low, Write Pulse Width =  $\overline{HWR}$  Low and  $\overline{HSEL}$  Low.

Host Write Cycle



Host Read Cycle

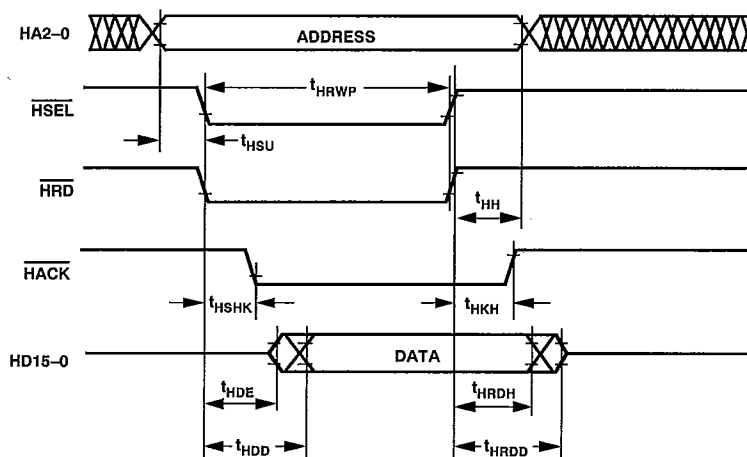


Figure 21. Host Interface Port (HMD1 = 0, HMD0 = 0)

**ADSP-21msp50/55/56**

Parameter	Min	Max	Unit
<b>Host Interface Port</b>			
Separate Data and Address (HMD1 = 0)			
Read/Write Strobe and Data Strobe (HMD0 = 1)			
Timing Requirement:			
$t_{HSU}$	HA2-0, HRW Setup before Start of Write or Read <sup>1</sup>		8 ns
$t_{HDSU}$	Data Setup before End of Write <sup>2</sup>		8 ns
$t_{HWDH}$	Data Hold after End of Write <sup>2</sup>		3 ns
$t_{HH}$	HA2-0, HRW Hold after End of Write or Read <sup>2</sup>		3 ns
$t_{HRWP}$	Read or Write Pulse Width <sup>3</sup>		30 ns
Switching Characteristic:			
$t_{HSHK}$	$\overline{HACK}$ Low after Start of Write or Read <sup>1</sup>		0 ns
$t_{HKH}$	$\overline{HACK}$ Hold after End of Write or Read <sup>2</sup>		20 ns
$t_{HDE}$	Data Enabled after Start of Read <sup>1</sup>		0 ns
$t_{HDD}$	Data Valid after Start of Read <sup>1</sup>		23 ns
$t_{HRDH}$	Data Hold after End of Read <sup>2</sup>		0 ns
$t_{HRDD}$	Data Disabled after End of Read <sup>2</sup>		10 ns

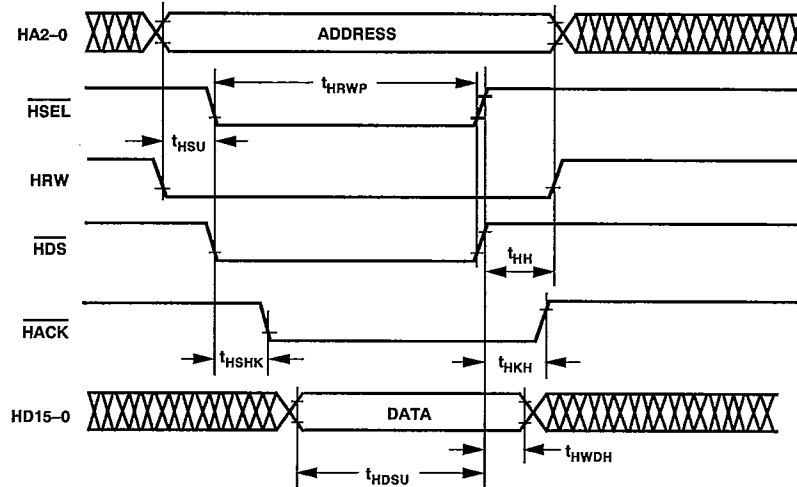
**NOTES**

<sup>1</sup>Start of Write or Read =  $\overline{HDS}$  Low and  $\overline{HSEL}$  Low.

<sup>2</sup>End of Write or Read =  $\overline{HDS}$  High or  $\overline{HSEL}$  High.

<sup>3</sup>Read or Write Pulse Width =  $\overline{HDS}$  Low and  $\overline{HSEL}$  Low.

*Host Write Cycle*



*Host Read Cycle*

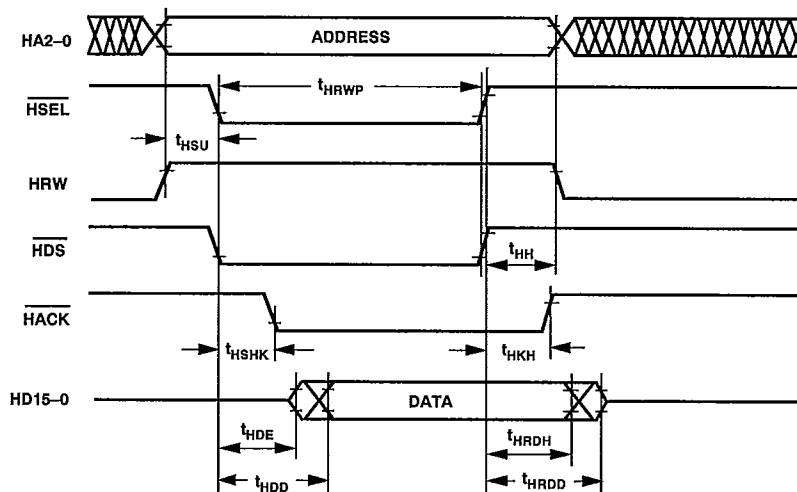


Figure 22. Host Interface Port (HMD1 = 0, HMD0 = 1)

# ADSP-21msp50/55/56

Parameter		Min	Max	Unit
<b>Host Interface Port</b>				
Multiplexed Data and Address (HMD1 = 1)				
Read Strobe and Write Strobe (HMD0 = 0)				
Timing Requirement:				
$t_{HALP}$	ALE Pulse Width	15		ns
$t_{HASU}$	HAD15-0 Address Setup before ALE Low	0		ns
$t_{HAH}$	HAD15-0 Address Hold after ALE Low	12		ns
$t_{HALS}$	Start of Write or Read after ALE Low <sup>1, 2</sup>	15		ns
$t_{HDSU}$	HAD15-0 Data Setup before End of Write <sup>3</sup>	8		ns
$t_{HWDH}$	HAD15-0 Data Hold after End of Write <sup>3</sup>	3		ns
$t_{HRWP}$	Read or Write Pulse Width <sup>5</sup>	30		ns
Switching Characteristic:				
$t_{HSHK}$	$\overline{HACK}$ Low after Start of Write or Read <sup>1, 2</sup>	0	20	ns
$t_{HKH}$	$\overline{HACK}$ Hold after End of Write or Read <sup>3, 4</sup>	0	20	ns
$t_{HDE}$	HAD15-0 Data Enabled after Start of Read <sup>2</sup>	0		ns
$t_{HDD}$	HAD15-0 Data Valid after Start of Read <sup>2</sup>		23	ns
$t_{HRDH}$	HAD15-0 Data Hold after End of Read <sup>4</sup>	0		ns
$t_{HRDD}$	HAD15-0 Data Disabled after End of Read <sup>4</sup>		10	ns

**NOTES**

<sup>1</sup>Start of Write =  $\overline{HWR}$  Low and  $\overline{HSEL}$  Low.

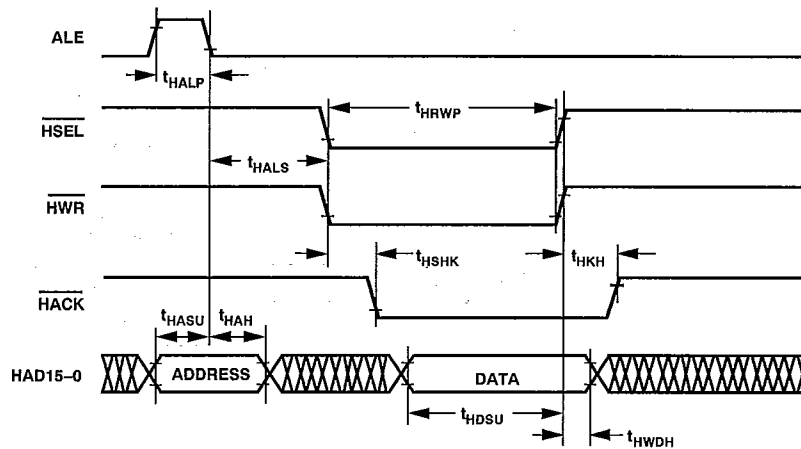
<sup>2</sup>Start of Read =  $\overline{HRD}$  Low and  $\overline{HSEL}$  Low.

<sup>3</sup>End of Write =  $\overline{HWR}$  High or  $\overline{HSEL}$  High.

<sup>4</sup>End of Read =  $\overline{HRD}$  High or  $\overline{HSEL}$  High.

<sup>5</sup>Read Pulse Width =  $\overline{HRD}$  Low and  $\overline{HSEL}$  Low, Write Pulse Width =  $\overline{HWR}$  Low and  $\overline{HSEL}$  Low.

Host Write Cycle



Host Read Cycle

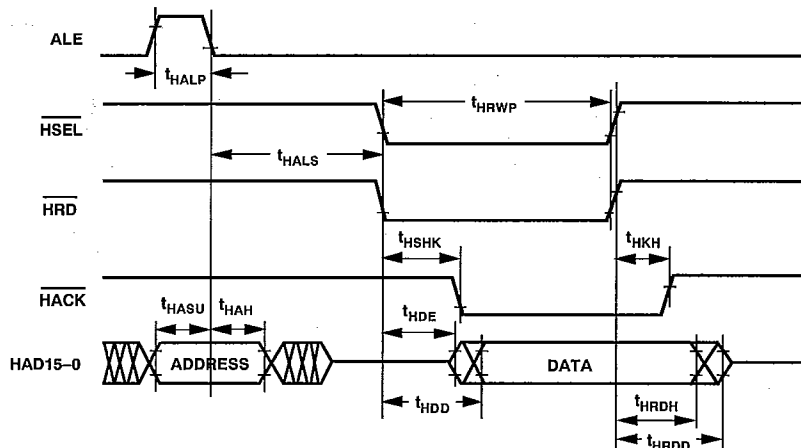


Figure 23. Host Interface Port (HMD1 = 1, HMD0 = 0)

ADSP-21msp50/55/56

Parameter	Min	Max	Unit
<b>Host Interface Port</b>			
Multiplexed Data and Address (HMD1 = 1)			
Read/Write Strobe and Data Strobe (HMD0 = 1)			
Timing Requirement:			
$t_{HALP}$	ALE Pulse Width	15	ns
$t_{HASU}$	HAD15-0 Address Setup before ALE Low	0	ns
$t_{HAH}$	HAD15-0 Address Hold after ALE Low	12	ns
$t_{HALS}$	Start of Write or Read after ALE Low <sup>1</sup>	15	ns
$t_{HSU}$	HRW Setup before Start of Write or Read <sup>2</sup>	8	ns
$t_{HDSU}$	HAD15-0 Data Setup before End of Write <sup>2</sup>	5	ns
$t_{HWDH}$	HAD15-0 Data Hold after End of Write <sup>2</sup>	3	ns
$t_{HH}$	HRW Hold after End of Write or Read <sup>2</sup>	3	ns
$t_{HRWP}$	Read or Write Pulse Width <sup>3</sup>	30	ns
Switching Characteristic:			
$t_{HSHK}$	$\overline{HACK}$ Low after Start of Write or Read <sup>1</sup>	0	20
$t_{HKH}$	$\overline{HACK}$ Hold after End of Write or Read <sup>2</sup>	0	20
$t_{HDE}$	HAD15-0 Data Enabled after Start of Read <sup>1</sup>	0	ns
$t_{HDD}$	HAD15-0 Data Valid after Start of Read <sup>1</sup>	0	23
$t_{HRDH}$	HAD15-0 Data Hold after End of Read <sup>2</sup>	0	ns
$t_{HRDD}$	HAD15-0 Data Disabled after End of Read <sup>2</sup>	0	10

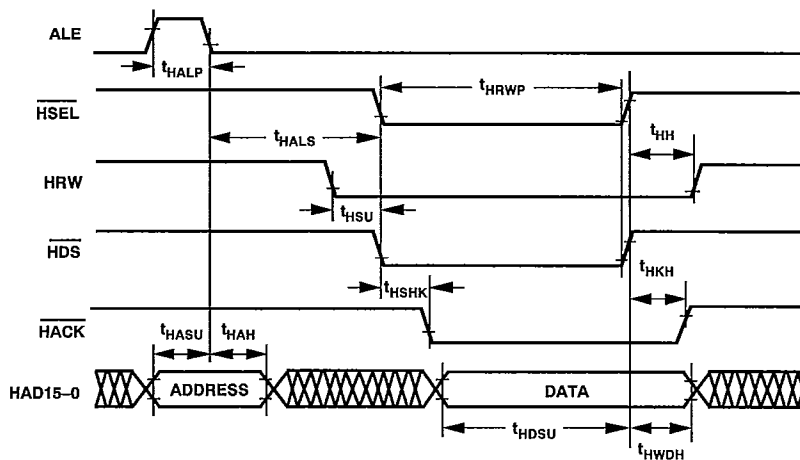
NOTES

<sup>1</sup>Start of Write or Read =  $\overline{HDS}$  Low and  $\overline{HSEL}$  Low.

<sup>2</sup>End of Write or Read =  $\overline{HDS}$  High or  $\overline{HSEL}$  High.

Read or Write Pulse Width =  $\overline{HDS}$  Low and  $\overline{HSEL}$  Low.

Host Write Cycle



Host Read Cycle

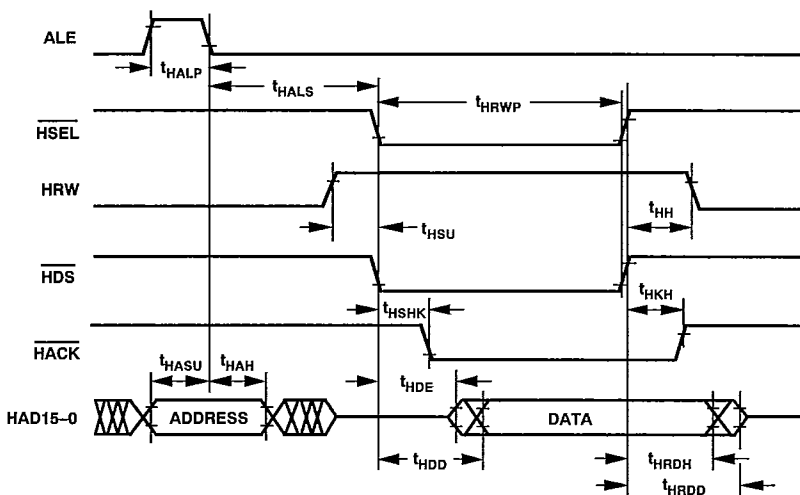


Figure 24. Host Interface Port (HMD1 = 1, HMD0 = 1)

# ADSP-21msp50/55/56

## ENVIRONMENTAL CONDITIONS

Ambient Temperature Rating:

$$T_{amb} = T_{case} - (PD \times \theta_{CA})$$

$T_{case}$  = Case temp in °C

PD = Power dissipation in W

$\theta_{CA}$  = Thermal resistance (case-to-ambient)

$\theta_{JA}$  = Thermal resistance (junction-to-ambient)

$\theta_{JC}$  = Thermal resistance (junction-to-case)

Package	$\theta_{JA}$	$\theta_{JC}$	$\theta_{CA}$
PGA	20°C/W	6°C/W	14°C/W
QFP-100 Lead	50°C/W	28°C/W	22°C/W

## Power Dissipation

To determine total power dissipation in a specific application, the following equation should be applied for each output:

$$C \times V_{DD}^2 \times f$$

C = load capacitance, f = output switching frequency.

Example:

In an application where external data memory is used and no other outputs are active, power dissipation is calculated as follows.

Assumptions:

- External data memory is accessed every cycle with 50% of address pins switching.
- External data memory writes occur every other cycle with 50% of address pins switching.
- Each address and data pin has a 10 pF total load at the pin.
- The application operates at  $V_{DD} = 5.0$  V and  $t_{CK} = 76.9$  ns.

$$\text{Total Power Dissipation} = P_{INT} + (C \times V_{DD}^2 \times f)$$

$P_{INT}$  = internal power dissipation, from Power vs. Frequency graph.  $C \times V_{DD}^2 \times f$  is calculated for each output:

	# of Pins	$\times C$	$\times V_{DD}^2$	$\times f$	
Address, $\overline{DMS}$	8	$\times 10$ pF	$\times 5^2$ V	$\times 13.0$ MHz	= 26 mW
Data Output, $\overline{WR}$	9	$\times 10$ pF	$\times 5^2$ V	$\times 6.5$ MHz	= 15 mW
RD	1	$\times 10$ pF	$\times 5^2$ V	$\times 6.5$ MHz	= 2 mW
CLKOUT	1	$\times 10$ pF	$\times 5^2$ V	$\times 13.0$ MHz	= 3 mW
					46 mW

Total power dissipation for this example is  $P_{INT} + 46$  mW.

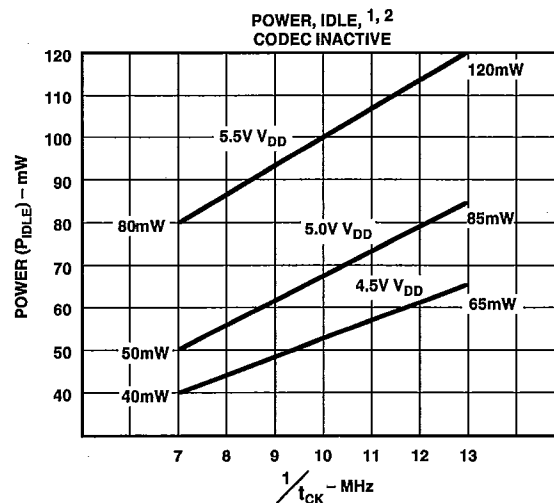
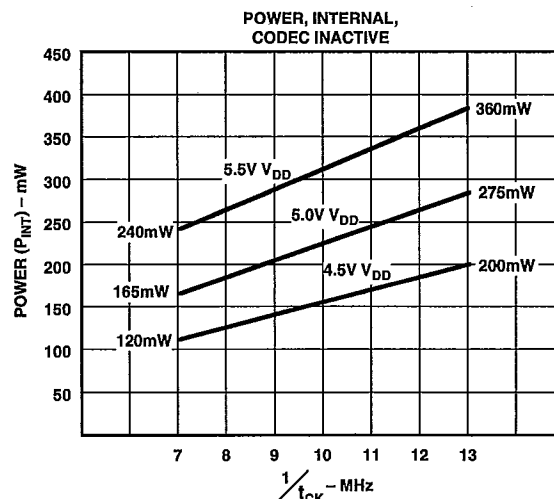
## Typical Power Consumption

The typical power consumption can be calculated from the following data, taken at 5.0 V and +25°C executing type 1 multi-function instructions, on worst case data.

Parameter	Typ
$I_{DD}$ Digital Supply Current (IDLE)	15 mA
$I_{DD}$ Digital Supply Current (Dynamic, Codec Powered Up)	70 mA
$I_{DD}$ Digital Supply Current (Powerdown)	10 $\mu$ A
$I_{CC}$ Analog Supply Current (Dynamic)	13 mA

A typical application of the ADSP-21msp50 may be the speech coder for the European DMR standard, GSM. This algorithm uses the processor for 25% of the available speech frame. If other system level functions are taken into account, then this usage may increase to 40%. Assuming that the part is in IDLE, for the other 60% of the time, then the typical power consumption is calculated to be about 250 mW.

If the Powerdown state can be entered, rather than the IDLE instruction, then the typical power consumption can decrease further.



VALID FOR ALL TEMPERATURE GRADES  
 1 POWER REFLECTS DEVICE OPERATING WITH NO OUTPUT LOADS.  
 2 IDLE REFERS TO ADSP-21msp5x STATE OF OPERATION DURING EXECUTION OF IDLE INSTRUCTION. DEASSERTED PINS ARE DRIVEN TO EITHER  $V_{DD}$  OR GND.

Figure 25. Power vs. Frequency

Analog Devices recommends that the ADSP-21msp5x is used with a 13.0 MHz input clock. Below this input clock frequency, the codec performance will change and the enclosed performance figures cannot be guaranteed. The codec filter characteristics will, however, scale approximately linearly with frequency.

If the codec is disabled, then the processor can be used at any allowed input clock frequency. The power consumption of the ADSP-21msp5x at these frequencies is shown above.



**ADSP-21msp50/55/56**

**CAPACITIVE LOADING**

Figures 26 and 27 show capacitive loading characteristics for the ADSP-21msp5x.

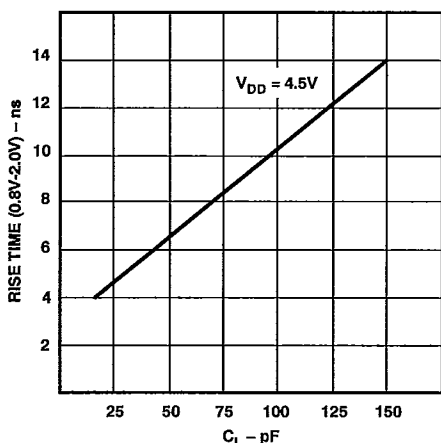


Figure 26. Typical Output Rise Time vs. Load Capacitance,  $C_L$  (at Maximum Ambient Operating Temperature)

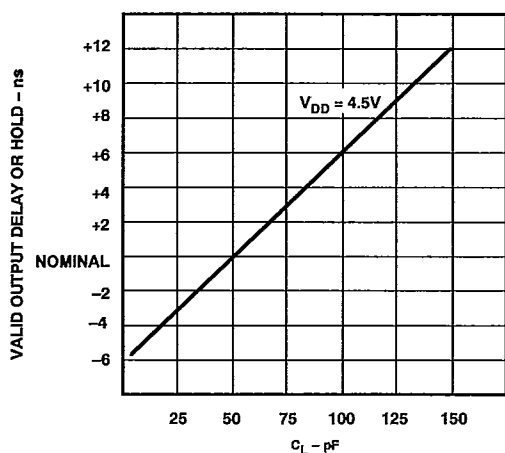


Figure 27. Typical Output Valid Delay or Hold vs. Load Capacitance,  $C_L$  (at Maximum Ambient Operating Temperature)

**TEST CONDITIONS**

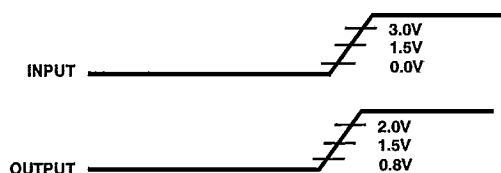


Figure 28. Voltage Reference Levels for AC Measurements (Except Output Enable/Disable)

**Output Disable Time**

Output pins are considered to be disabled when they have stopped driving and started a transition from the measured output high or low voltage to a high-impedance state. The output disable time ( $t_{DIS}$ ) is the difference of  $t_{MEASURED}$  and  $t_{DECAY}$ , as shown in the Output Enable/Disable diagram. The time,  $t_{MEASURED}$ , is the interval from when a reference signal reaches a high or low voltage level to when the output voltages have changed by 0.5 V from the measured output high or low voltage. The decay time,  $t_{DECAY}$ , is dependent on the capacitive load,  $C_L$ , and the current load,  $i_L$ , on the output pin. It can be approximated by the following equation:

$$t_{DECAY} = \frac{C_L \cdot 0.5 V}{i_L}$$

from which

$$t_{DIS} = t_{MEASURED} - t_{DECAY}$$

is calculated. If multiple pins (such as the data bus) are disabled, the measurement value is that of the last pin to stop driving.

**Output Enable Time**

Output pins are considered to be enabled when they have made a transition from a high-impedance state to when they start driving. The output enable time ( $t_{ENA}$ ) is the interval from when a reference signal reaches a high or low voltage level to when the output has reached a specified high or low trip point, as shown in the Output Enable/Disable diagram. If multiple pins (such as the data bus) are enabled, the measurement value is that of the first pin to start driving.

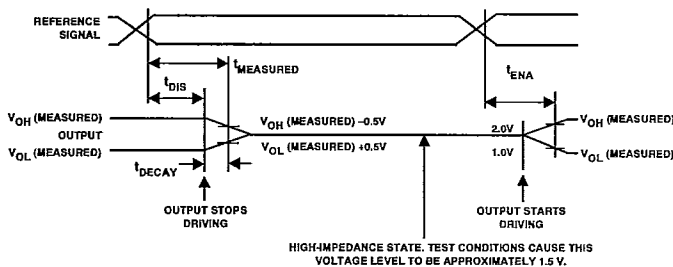


Figure 29. Output Enable/Disable

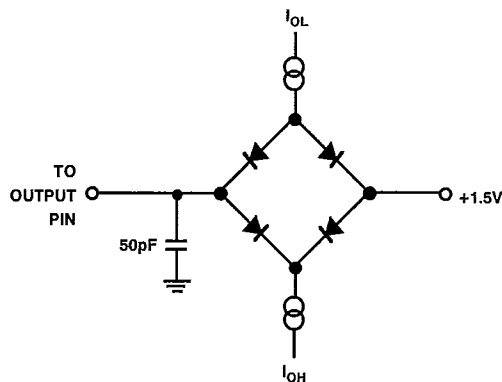
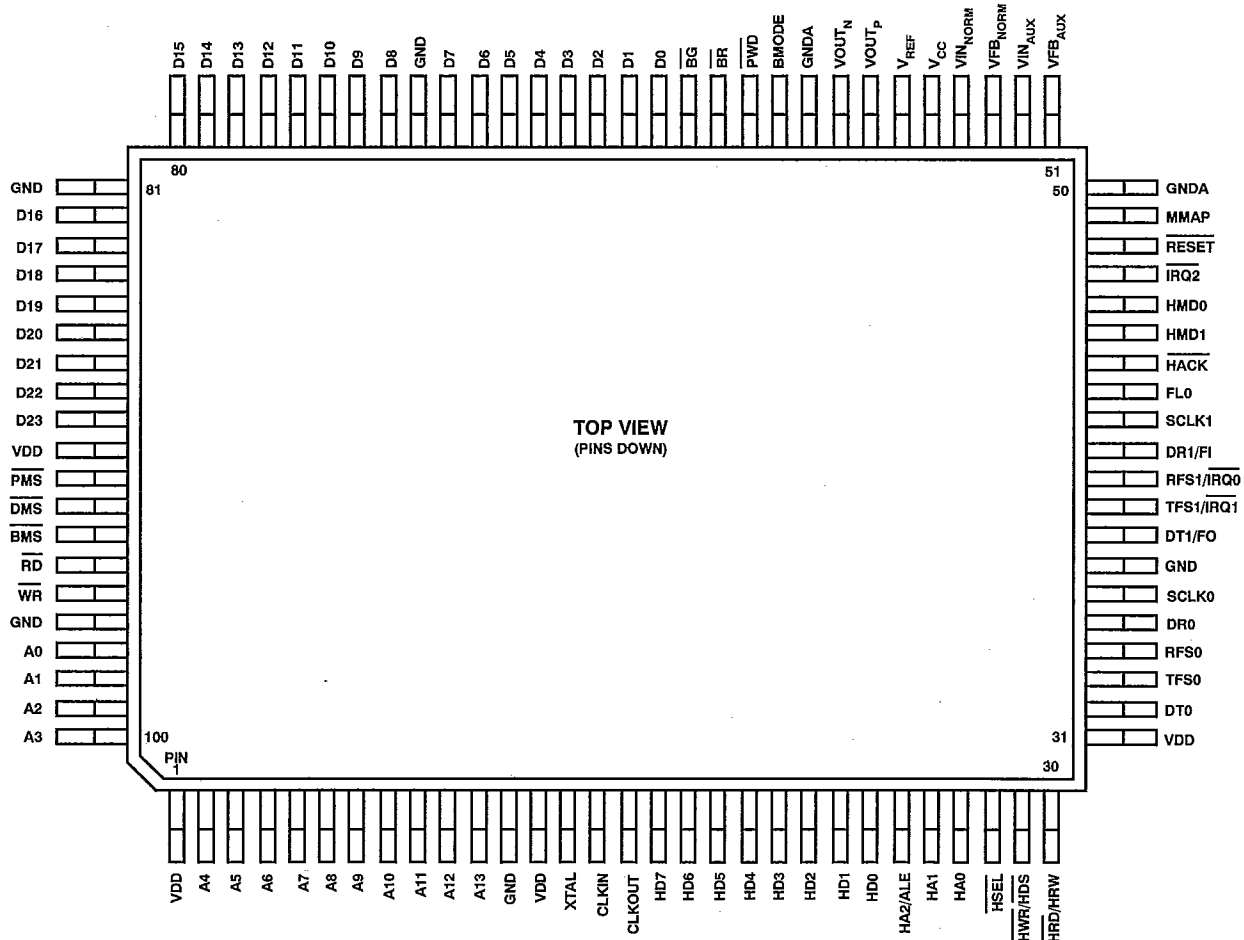


Figure 30. Equivalent Device Loading for AC Measurements (Includes All Fixtures)

# ADSP-21msp50/55/56

## 100-Lead PQFP Package Pinout

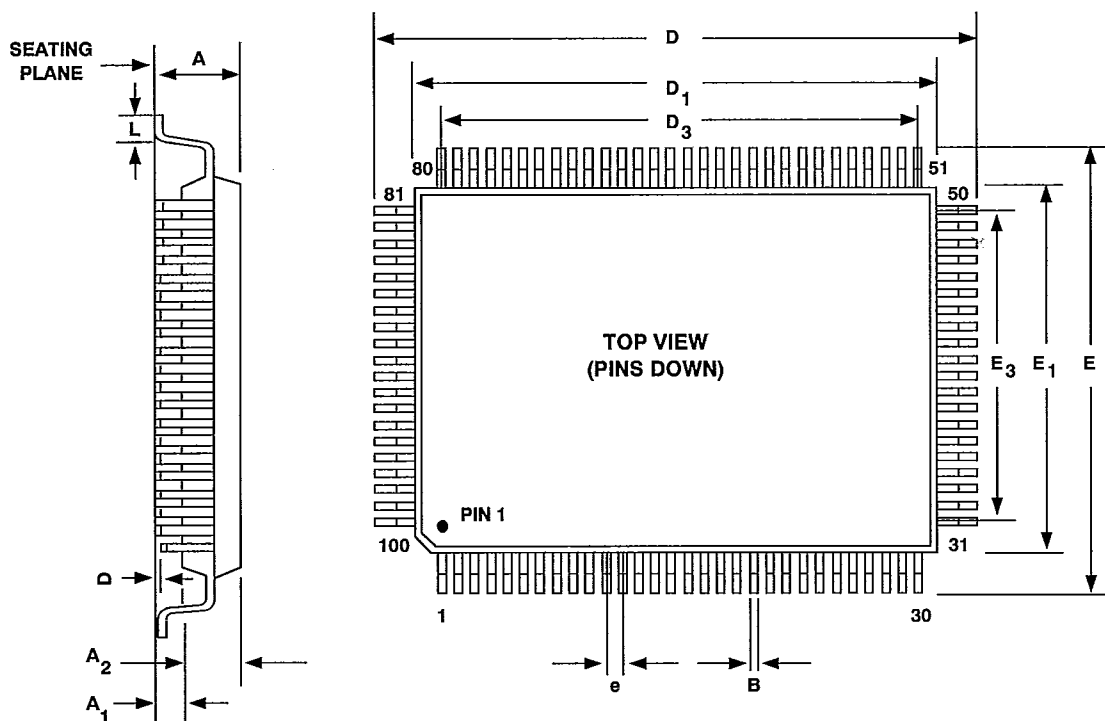


PQFP NUMBER	PIN NAME	PQFP NUMBER	PIN NAME	PQFP NUMBER	PIN NAME	PQFP NUMBER	PIN NAME
1	VDD	26	HA1	51	VFBAUX	76	D11
2	A4	27	HA0	52	VINAUX	77	D12
3	A5	28	HSEL	53	VFBNORM	78	D13
4	A6	29	HWR/HDS	54	VINNORM	79	D14
5	A7	30	HRD/HRW	55	VCC	80	D15
6	A8	31	VDD	56	VREF	81	GND
7	A9	32	DT0	57	VOUTP	82	D16
8	A10	33	TFS0	58	VOUTN	83	D17
9	A11	34	RFS0	59	GNDA	84	D18
10	A12	35	DR0	60	BMODE	85	D19
11	A13	36	SCLK0	61	PWD	86	D20
12	GND	37	GND	62	BR	87	D21
13	VDD	38	DT1/FO	63	BG	88	D22
14	XTAL	39	TFS1/IRQ1	64	D0	89	D23
15	CLKIN	40	RFS1/IRQ0	65	D1	90	VDD
16	CLKOUT	41	DR1/FI	66	D2	91	PMS
17	HD7	42	SCLK1	67	D3	92	DMS
18	HD6	43	FLO	68	D4	93	BMS
19	HD5	44	HACK	69	D5	94	RD
20	HD4	45	HMD1	70	D6	95	WR
21	HD3	46	HMD0	71	D7	96	GND
22	HD2	47	IRQ2	72	GND	97	A0
23	HD1	48	RESET	73	D8	98	A1
24	HD0	49	MMAP	74	D9	99	A2
25	HA2/ALE	50	GNDA	75	D10	100	A3

## ADSP-21msp50/55/56

## OUTLINE DIMENSIONS

100-Lead Metric Plastic Quad Flatpack (PQFP)



SYMBOL	MILLIMETERS			INCHES		
	MIN	TYP	MAX	MIN	TYP	MAX
A			3.40			0.134
A*			2.45			0.096
A <sub>1</sub>	0.25			0.010		
A <sub>2</sub>	2.60	2.70	2.80	0.102	0.106	0.110
B		0.30			0.012	
D	23.65	23.90	24.15	0.931	0.941	0.951
D <sub>1</sub>	19.90	20.00	20.10	0.783	0.787	0.791
D <sub>3</sub>		18.85	18.92		0.742	0.745
e	0.57	0.65	0.73	0.023	0.026	0.029
E	17.65	17.90	18.15	0.695	0.705	0.715
E <sub>1</sub>	13.90	14.00	14.10	0.547	0.551	0.555
E <sub>3</sub>		12.35	12.42		0.486	0.489
L	0.78	0.88	1.03	0.031	0.035	0.041
□			0.10			0.004

Packages with dimension A are available until September. After September 1993, these will be replaced by packages with dimension A\*.

ADSP-21msp50/55/56

144-Lead PGA Pinout

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
R	VFB AUX	VIN NORM	VREF	VOUT N	NC	NC	NC	NC	D0	D1	D5	D7	GND	D11	D15	R	
P	NC	NC	VFB NORM	NC	VOUT P	B MODE	PWD	BR	D2	D3	D6	D8	D10	D14	NC	P	
N	NC	MMAP	NC	VIN AUX	V <sub>CC</sub>	GNDA	NC	BG	NC	D4	D9	D12	D13	NC	NC	N	
M	IRQ2	RESET	GNDA	PGA PACKAGE BOTTOM VIEW (PINS UP)									NC	NC	D16	M	
L	HMD1	HMD0	NC										PWD ACK	GND	D19	L	
K	FL0	FL2	HACK										D17	D18	D22	K	
J	SCLK1	FL1	DR1/ FI										D21	D20	D23	J	
H	RFS1/ IRQ0	NC	NC										HSIZE	V <sub>DD</sub>	V <sub>DD</sub>	H	
G	TFS1/ IRQ1	GND	DT1/ FO										PMS	RD	DMS	G	
F	NC	DR0	NC										GND	WR	BMS	F	
E	SCLK0	TFS0	V <sub>DD</sub>										HD13	HD15	GND	E	
D	RFS0	NC	NC										INDEX (NC)	A3	A1	A0	D
C	DT0	NC	HSEL										HA0	HD0	HD6	XTAL	V <sub>DD</sub>
B	NC	HWR/ HDS	HA2/ ALE	HD1	HD4	HD7	CLK OUT	GND	A10	A8	A6	HD10	V <sub>DD</sub>	NC	HD12	B	
A	HRD/ HRW	HA1	HD2	HD3	HD5	CLKIN	NC	GND	A13	A12	A9	HD8	HD9	A4	NC	A	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		
R	D15	D11	GND	D7	D5	D1	D0	NC	NC	NC	NC	VOUT N	VREF	VIN NORM	VFB AUX	R	
P	NC	D14	D10	D8	D6	D3	D2	BR	PWD	B MODE	VOUT P	NC	VFB NORM	NC	NC	P	
N	NC	NC	D13	D12	D9	D4	NC	BG	NC	GNDA	V <sub>CC</sub>	VIN AUX	NC	MMAP	NC	N	
M	D16	NC	NC	PGA PACKAGE TOP VIEW (PINS DOWN)									GNDA	RESET	IRQ2	M	
L	D19	GND	PWD ACK										NC	HMD0	HMD1	L	
K	D22	D18	D17										HACK	FL2	FL0	K	
J	D23	D20	D21										DR1/ FI	FL1	SCLK1	J	
H	V <sub>DD</sub>	V <sub>DD</sub>	HSIZE										NC	NC	RFS1/ IRQ0	H	
G	DMS	RD	PMS										DT1/ FO	GND	TFS1/ IRQ1	G	
F	BMS	WR	GND										NC	DR0	NC	F	
E	GND	HD15	HD13										V <sub>DD</sub>	TFS0	SCLK0	E	
D	A0	A1	A3										INDEX (NC)	NC	NC	RFS0	D
C	HD14	A2	HD11										NC	A5	A7	A11	V <sub>DD</sub>
B	HD12	NC	V <sub>DD</sub>	HD10	A6	A8	A10	GND	CLK OUT	HD7	HD4	HD1	HA2/ ALE	HWR/ HDS	NC	B	
A	NC	A4	HD9	HD8	A9	A12	A13	GND	NC	CLKIN	HD5	HD3	HD2	HA1	HRD/ HRW	A	
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1		

NC = NO CONNECT

## ADSP-21msp50/55/56

## 144-Pin PGA Pinout

PGA NUMBER	PIN NAME	PGA NUMBER	PIN NAME	PGA NUMBER	PIN NAME	PGA NUMBER	PIN NAME
D3	NC	N4	VINAUX	M13	NC	C12	NC
C2	NC	P3	VFBNORM	N14	NC	B13	VDD
B1	NC	R2	VINNORM	P15	NC	A14	A4
D2	NC	P4	NC	M14	NC	B12	HD10
E3	VDD	N5	VCC	L13	PWDACK	C11	A5
C1	DT0	R3	VREF	N15	NC	A13	HD9
E2	TFS0	P5	VOU TP	L14	GND	B11	A6
D1	RFS0	R4	VOU TN	M15	D16	A12	HD8
F3	NC	N6	GNDA	K13	D17	C10	A7
F2	DR0	P6	BMODE	K14	D18	B10	A8
E1	SCLK0	R5	NC	L15	D19	A11	A9
G2	GND	P7	PWD	J14	D20	B9	A10
G3	DT1/FO	N7	NC	J13	D21	C9	A11
F1	NC	R6	NC	K15	D22	A10	A12
G1	TFS1/ $\overline{\text{IRO1}}$	R7	NC	J15	D23	A9	A13
H2	NC	P8	$\overline{\text{BR}}$	H14	VDD	B8	GND
H1	RFS1/ $\overline{\text{IRO0}}$	R8	NC	H15	VDD	A8	GND
H3	NC	N8	$\overline{\text{BG}}$	H13	HSIZE	C8	VDD
J3	DR1/FI	N9	NC	G13	$\overline{\text{PMS}}$	C7	XTAL
J1	SCLK1	R9	D0	G15	$\overline{\text{DMS}}$	A7	NC
K1	FL0	R10	D1	F15	$\overline{\text{BMS}}$	A6	CLKIN
J2	FL1	P9	D2	G14	$\overline{\text{RD}}$	B7	CLKOUT
K2	FL2	P10	D3	F14	$\overline{\text{WR}}$	B6	HD7
K3	$\overline{\text{HACK}}$	N10	D4	F13	GND	C6	HD6
L1	HMD1	R11	D5	E15	GND	A5	HD5
L2	HMD0	P11	D6	E14	HD15	B5	HD4
M1	$\overline{\text{IRO2}}$	R12	D7	D15	A0	A4	HD3
N1	NC	R13	GND	C15	HD14	A3	HD2
M2	$\overline{\text{RESET}}$	P12	D8	D14	A1	B4	HD1
L3	NC	N11	D9	E13	HD13	C5	HD0
N2	MMAP	P13	D10	C14	A2	B3	HA2/ALE
P1	NC	R14	D11	B15	HD12	A2	HA1
M3	GNDA	N12	D12	D13	A3	C4	HA0
N3	NC	N13	D13	C13	HD11	C3	$\overline{\text{HSEL}}$
P2	NC	P14	D14	B14	NC	B2	$\overline{\text{HWR/HDS}}$
R1	VFBAUX	R15	D15	A15	NC	A1	$\overline{\text{HRD/HWR}}$

INDEX D4

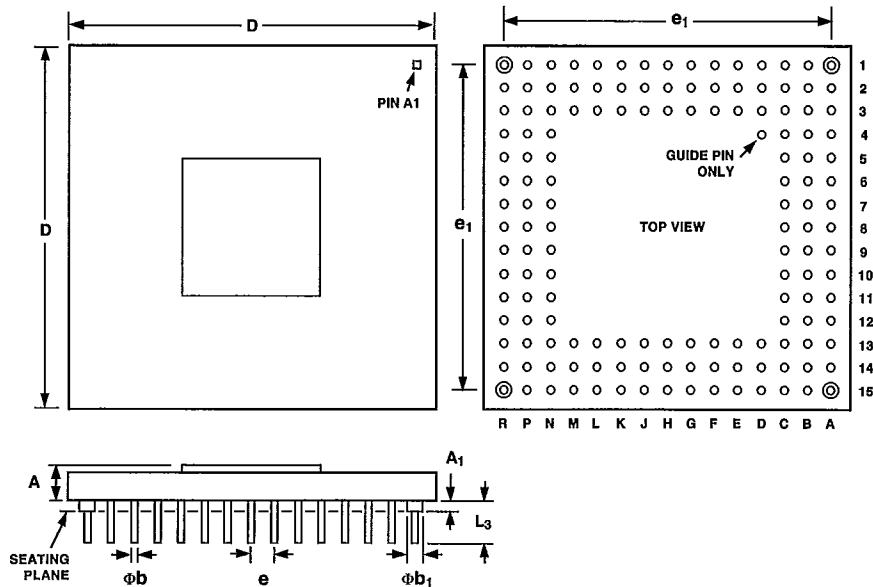
NC = NO CONNECT

# ADSP-21msp50/55/56

## OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

### 144-Pin Grid Array (PGA Package)



SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.841	0.859	21.36	21.82
A <sub>1</sub>	0.045	0.055	1.14	1.40
D	1.559	1.591	39.60	40.41
e	0.100 TYP		2.54 TYP	
e <sub>1</sub>	1.388	1.412	35.26	37.80
φb <sub>1</sub>	0.075 TYP		1.91 TYP	
φb	0.050 TYP		1.27 TYP	
L <sub>3</sub>	0.175	0.185	4.45	4.70

**ADSP-21msp50/55/56****ORDERING GUIDE**

<b>Part Number*</b>	<b>Ambient Temperature Range</b>	<b>Instruction Rate (MHz)</b>	<b>Package</b>
ADSP-21msp50KG-52	0°C to +70°C	13	144-Pin Grid Array
ADSP-21msp55KS-52	0°C to +70°C	13	100-Lead PQFP
ADSP-21msp56KS-52	0°C to +70°C	13	100-Lead PQFP
ADSP-21msp55BS-52	-40°C to +85°C	13	100-Lead PQFP
ADSP-21msp56BS-52	-40°C to +85°C	13	100-Lead PQFP

\*G = Ceramic Pin Grid Array; S = Plastic Quad Flatpack.