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### SUMMARY

High performance 32-bit/40-bit floating-point processor optimized for high performance audio processing

Code compatibility—at assembly level, uses the same instruction set as other SHARC DSPs

Processes high performance audio while enabling low system costs

Audio decoders and postprocessor algorithms support nonvolatile memory that can be configured to contain a combination of PCM 96 kHz, Dolby Digital, Dolby Digital Surround EX, DTS-ES Discrete 6.1, DTS-ES Matrix 6.1, DTS 96/24 5.1, MPEG2 AAC LC, MPEG2 BC 2ch, WMA-PRO V7.1, Dolby Pro Logic II, Dolby Pro Logic 2x, and DTS Neo:6

Various multichannel surround sound decoders are contained in ROM. For configurations of decoder algorithms, see [Table 3 on Page 4](#).

Single-instruction multiple-data (SIMD) computational architecture—two 32-bit IEEE floating-point/32-bit fixed-point/40-bit extended precision floating-point computational units, each with a multiplier, ALU, shifter, and register file

High bandwidth I/O—a parallel port, an SPI port, 6 serial ports, a Digital application interface (DAI), and JTAG

DAI incorporates two precision clock generators (PCGs), an input data port (IDP) that includes a parallel data acquisition port (PDAP), and 3 programmable timers, all under software control by the signal routing unit (SRU)

On-chip memory—up to 2M bits on-chip SRAM and a dedicated 4M bits on-chip mask-programmable ROM

The ADSP-2126x processors are available with a 150 MHz or a 200 MHz core instruction rate. For complete ordering information, see [Ordering Guide on Page 45](#).

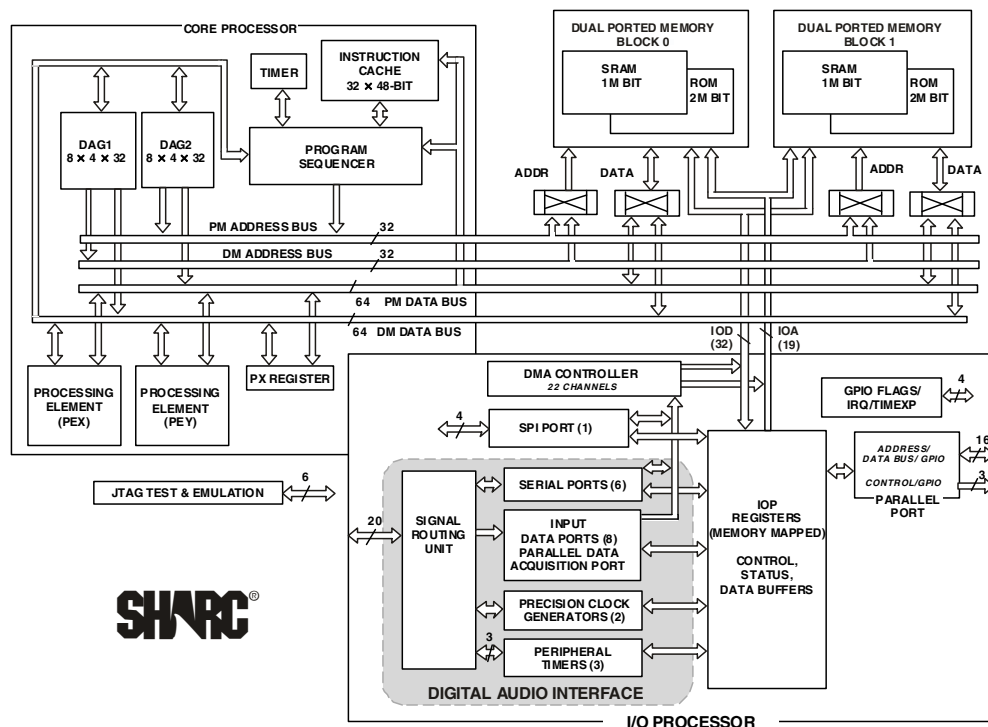


Figure 1. Functional Block Diagram

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### Rev. G

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# ADSP-21261/ADSP-21262/ADSP-21266

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## REVISION HISTORY

### 12/12—Rev. F to Rev. G

|   |    |
|---|----|
| Corrected Long Word Memory Space in Table 4 in<br>Memory and I/O Interface Features .....   | 4  |
| Updated Development Tools .....   | 8  |
| Added section, Related Signal Chains .....  | 9  |
| Changed the package designator in Figure 36 from BC-136 to<br>BC-136-1. This change in no way affects form, fit, or function.<br>See Outline Dimensions ..... | 43 |
| Updated Ordering Guide .....  | 45 |



## GENERAL DESCRIPTION

The ADSP-21261/ADSP-21262/ADSP-21266 SHARC® DSPs are members of the SIMD SHARC family of DSPs featuring Analog Devices, Inc., Super Harvard Architecture. The ADSP-2126x is source code compatible with the ADSP-21160 and ADSP-21161 DSPs as well as with first generation ADSP-2106x SHARC processors in SISD (single-instruction, single-data) mode. Like other SHARC DSPs, the ADSP-2126x are 32-bit/40-bit floating-point processors optimized for high performance audio applications with dual-ported on-chip SRAM, mask-programmable ROM, multiple internal buses to eliminate I/O bottlenecks, and an innovative digital application interface.

Table 1 shows performance benchmarks for the processors running at 200 MHz. Table 2 shows the features of the individual product offerings.

**Table 1. Processor Benchmarks (at 200 MHz)**

| Benchmark Algorithm                             | Speed (at 200 MHz) |
|---|--------------------|
| 1024 Point Complex FFT (Radix 4, with reversal) | 61.3 μs            |
| FIR Filter (per tap) <sup>1</sup>               | 3.3 ns             |
| IIR Filter (per biquad) <sup>1</sup>            | 13.3 ns            |
| Matrix Multiply (pipelined)                     |                    |
| [3×3] × [3×1]                                   | 30 ns              |
| [4×4] × [4×1]                                   | 53.3 ns            |
| Divide (y/x)                                    | 20 ns              |
| Inverse Square Root                             | 30 ns              |

<sup>1</sup> Assumes two files in multichannel SIMD mode.

As shown in the functional block diagram in Figure 1 on Page 1, the ADSP-2126x uses two computational units to deliver a 5 to 10 times performance increase over previous SHARC processors on a range of DSP algorithms. Fabricated in a state-of-the-art, high speed, CMOS process, the ADSP-2126x DSPs achieve an instruction cycle time of 5 ns at 200 MHz or 6.6 ns at 150 MHz. With its SIMD computational hardware, the ADSP-2126x can perform 1200 MFLOPS running at 200 MHz, or 900 MFLOPS running at 150 MHz.

**Table 2. ADSP-2126x SHARC Processor Features**

| Feature                            | ADSP-21261                    | ADSP-21262                    | ADSP-21266                    |
|------------------------------------|-------------------------------|-------------------------------|-------------------------------|
| RAM                                | 1M bit                        | 2M bit                        | 2M bit                        |
| ROM                                | 3M bit                        | 4M bit                        | 4M bit                        |
| Audio Decoders in ROM <sup>1</sup> | No                            | No                            | Yes                           |
| DMA Channels                       | 18                            | 22                            | 22                            |
| SPORTs                             | 4                             | 6                             | 6                             |
| Package                            | 136-ball BGA<br>144-lead LQFP | 136-ball BGA<br>144-lead LQFP | 136-ball BGA<br>144-lead LQFP |

<sup>1</sup> For information on available audio decoding algorithms, see Table 3 on Page 4.

The ADSP-2126x continues the SHARC family's industry-leading standards of integration for DSPs, combining a high performance 32-bit DSP core with integrated, on-chip system features. These features include 2M bit dual-ported SRAM memory, 4M bit dual-ported ROM, an I/O processor that supports 22 DMA channels, six serial ports, an SPI interface, external parallel bus, and digital application interface.

The block diagram of the ADSP-2126x on Page 1 illustrates the following architectural features:

- Two processing elements, each containing an ALU, multiplier, shifter, and data register file
- Data address generators (DAG1, DAG2)
- Program sequencer with instruction cache
- PM and DM buses capable of supporting four 32-bit data transfers between memory and the core at every core processor cycle
- Three programmable interval timers with PWM generation, PWM capture/pulse width measurement, and external event counter capabilities
- On-chip dual-ported SRAM (up to 2M bit)
- On-chip dual-ported, mask-programmable ROM (up to 4M bit)
- JTAG test access port
- 8- or 16-bit parallel port that supports interfaces to off-chip memory peripherals
- DMA controller
- Six full-duplex serial ports (four on the ADSP-21261)
- SPI-compatible interface
- Digital application interface that includes two precision clock generators (PCG), an input data port (IDP), six serial ports, eight serial interfaces, a 20-bit synchronous parallel input port, 10 interrupts, six flag outputs, six flag inputs, three programmable timers, and a flexible signal routing unit (SRU)

## FAMILY CORE ARCHITECTURE

The ADSP-2126x is code compatible at the assembly level with the ADSP-2136x and ADSP-2116x, and with the first generation ADSP-2106x SHARC DSPs. The ADSP-2126x shares architectural features with the ADSP-2136x and ADSP-2116x SIMD SHARC family of DSPs, as detailed in the following sections.

### SIMD Computational Engine

The ADSP-2126x contain two computational processing elements that operate as a single-instruction multiple-data (SIMD) engine. The processing elements are referred to as PEX and PEY and each contains an ALU, multiplier, shifter, and register file. PEX is always active, and PEY can be enabled by setting the PEYEN mode bit in the MODE1 register. When this mode is enabled, the same instruction is executed in both processing

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elements, but each processing element operates on different data. This architecture is efficient at executing math intensive audio algorithms.

Entering SIMD mode also has an effect on the way data is transferred between memory and the processing elements. When in SIMD mode, twice the data bandwidth is required to sustain computational operation in the processing elements. Because of this requirement, entering SIMD mode also doubles the bandwidth between memory and the processing elements. When using the DAGs to transfer data in SIMD mode, two data values are transferred with each access of memory or the register file.

## Independent, Parallel Computation Units

Within each processing element is a set of computational units. The computational units consist of an arithmetic/logic unit (ALU), multiplier, and shifter. These units perform all operations in a single cycle. The three units within each processing element are arranged in parallel, maximizing computational throughput. Single multifunction instructions execute parallel ALU and multiplier operations. In SIMD mode, the parallel ALU and multiplier operations occur in both processing elements. These computation units support IEEE 32-bit single precision floating-point, 40-bit extended precision floating-point, and 32-bit fixed-point data formats.

## Data Register File

A general-purpose data register file is contained in each processing element. The register files transfer data between the computation units and the data buses, and store intermediate results. These 10-port, 32-register (16 primary, 16 secondary) register files, combined with the ADSP-2126x enhanced Harvard architecture, allow unconstrained data flow between computation units and internal memory. The registers in PEX are referred to as R0–R15 and in PEY as S0–S15.

## Single-Cycle Fetch of Instruction and Four Operands

The ADSP-2126x features an enhanced Harvard architecture in which the data memory (DM) bus transfers data and the program memory (PM) bus transfers both instructions and data (see [Figure 1 on Page 1](#)). With the ADSP-2126x's separate program and data memory buses and on-chip instruction cache, the processor can simultaneously fetch four operands (two over each data bus) and one instruction (from the cache), all in a single cycle.

## Instruction Cache

The ADSP-2126x includes an on-chip instruction cache that enables three-bus operation to fetch an instruction and four data values. The cache is selective—only the instructions whose fetches conflict with PM bus data accesses are cached. This cache allows full-speed execution of core, looped operations such as digital filter multiply-accumulates, and FFT butterfly processing.

## Data Address Generators with Zero-Overhead Hardware Circular Buffer Support

The ADSP-2126x's two data address generators (DAGs) are used for indirect addressing and implementing circular data buffers in hardware. Circular buffers allow efficient programming of delay lines and other data structures required in digital signal processing, and are commonly used in digital filters and Fourier transforms. The two DAGs of the ADSP-2126x contain sufficient registers to allow the creation of up to 32 circular buffers (16 primary register sets, 16 secondary). The DAGs automatically handle address pointer wraparound, reduce overhead, increase performance, and simplify implementation. Circular buffers can start and end at any memory location.

## Flexible Instruction Set

The 48-bit instruction word accommodates a variety of parallel operations for concise programming. For example, the ADSP-2126x can conditionally execute a multiply, an add, and a subtract in both processing elements while branching and fetching up to four 32-bit values from memory—all in a single instruction.

## MEMORY AND I/O INTERFACE FEATURES

The ADSP-2126x adds the following architectural features to the SIMD SHARC family core:

### Dual-Ported On-Chip Memory

The ADSP-21262 and ADSP-21266 contain two megabits of internal SRAM and four megabits of internal mask-programmable ROM. The ADSP-21261 contain one megabit of internal SRAM and three megabits of internal mask-programmable ROM. Each block can be configured for different combinations of code and data storage (see memory maps, [Table 4](#) and [Table 5](#)). Each memory block is dual-ported for single-cycle, independent accesses by the core processor and I/O processor. The dual-ported memory, in combination with three separate on-chip buses, allows two data transfers from the core and one from the I/O processor, in a single cycle.

The ADSP-2126x is available with a variety of multichannel surround sound decoders, preprogrammed in ROM memory. [Table 3](#) shows the configuration of decoder algorithms.

**Table 3. Multichannel Surround Sound Decoder Algorithms in On-Chip ROM**

| Algorithms         | B ROM | C ROM | D ROM             |
|--------------------|-------|-------|-------------------|
| PCM                | Yes   | Yes   | Yes               |
| AC-3               | Yes   | Yes   | Yes               |
| DTS 96/24          | v2.2  | v2.3  | v2.3              |
| AAC (LC)           | Yes   | Yes   | Coefficients only |
| WMA PRO 7.1 96 KHz | No    | No    | Yes               |
| MPEG2 BC 2ch       | Yes   | Yes   | No                |
| Noise              | Yes   | Yes   | Yes               |
| DPL2x/EX           | DPL2  | Yes   | Yes               |
| Neo:6/ES (v2.5046) | Yes   | Yes   | Yes               |

The ADSP-2126x's SRAM can be configured as a maximum of 64K words of 32-bit data, 128K words of 16-bit data, 42K words of 48-bit instructions (or 40-bit data), or combinations of different word sizes up to two megabits. All of the memory can be accessed as 16-bit, 32-bit, 48-bit, or 64-bit words. A 16-bit floating-point storage format is supported that effectively doubles the amount of data that can be stored on-chip. Conversion between the 32-bit floating-point and 16-bit floating-point formats is performed in a single instruction. While each memory block can store combinations of code and data, accesses are most efficient when one block stores data using the DM bus for transfers, and the other block stores instructions and data using the PM bus for transfers.

Using the DM bus and PM buses, with one dedicated to each memory block, assures single-cycle execution with two data transfers. In this case, the instruction must be available in the cache.

### DMA Controller

The ADSP-2126x's on-chip DMA controller allows zero-overhead data transfers without processor intervention. The DMA controller operates independently and invisibly to the processor core, allowing DMA operations to occur while the core is simultaneously executing its program instructions. DMA transfers can occur between the ADSP-2126x's internal memory and its serial ports, the SPI-compatible (serial peripheral interface) port, the IDP (input data port), parallel data acquisition port (PDAP), or the parallel port. Up to 22 channels of DMA are available on the ADSP-2126x—one for the SPI interface, 12 via the serial ports, eight via the input data port, and one via the processor's parallel port. Programs can be downloaded to the ADSP-2126x using DMA transfers. Other DMA features include interrupt generation upon completion of DMA transfers, and DMA chaining for automatic linked DMA transfers.

**Table 4. Internal Memory Space (ADSP-21261)**

| <b>IOP Registers 0x0000 0000–0003 FFFF</b> |  |   |   |
|--|--|---|---|
| <b>Long Word (64 Bits)</b>                 | <b>Extended Precision Normal or Instruction Word (48 Bits)</b> | <b>Normal Word (32 Bits)</b>            | <b>Short Word (16 Bits)</b>             |
| Block 0 SRAM<br>0x0004 0000–0x0004 1FFF    | Block 0 SRAM<br>0x0008 0000–0x0008 2AAA                        | Block 0 SRAM<br>0x0008 0000–0x0008 3FFF | Block 0 SRAM<br>0x0010 0000–0x0010 7FFF |
| Reserved<br>0x0004 2000–0x0005 7FFF        | Reserved   | Reserved<br>0x0008 4000–0x000A FFFF     | Reserved<br>0x0010 8000–0x0015 FFFF     |
| Block 0 ROM<br>0x0005 8000–0x0005 DFFF     | Block 0 ROM<br>0x000A 0000–0x000A 7FFF                         | Block 0 ROM<br>0x000B 0000–0x000B BFFF  | Block 0 ROM<br>0x0016 0000–0x0017 7FFF  |
| Reserved<br>0x0005 E000–0x0005 FFFF        | Reserved   | Reserved<br>0x000B C000–0x000B FFFF     | Reserved<br>0x0017 8FFF–0x0017 FFFF     |
| Block 1 SRAM<br>0x0006 0000–0x0006 1FFF    | Block 1 SRAM<br>0x000C 0000–0x000C 2AAA                        | Block 1 SRAM<br>0x000C 0000–0x000C 3FFF | Block 1 SRAM<br>0x0018 0000–0x0018 7FFF |
| Reserved<br>0x0006 2000–0x0007 7FFF        | Reserved   | Reserved<br>0x000C 4000–0x000E FFFF     | Reserved<br>0x0018 8000–0x001D FFFF     |
| Block 1 ROM<br>0x0007 8000–0x0007 DFFF     | Block 1 ROM<br>0x000E 0000–0x000E 7FFF                         | Block 1 ROM<br>0x000F 0000–0x000F BFFF  | Block 1 ROM<br>0x001E 0000–0x001F 7FFF  |
| Reserved<br>0x0007 E000–0x0007 FFFF        | Reserved   | Reserved<br>0x000F C000–0x000F FFFF     | Reserved<br>0x0000                      |

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Table 5. Internal Memory Space (ADSP-21262/ADSP-21266)

| IOP Registers 0x0000 0000–0003 FFFF     |   |   |   |
|---|---|---|---|
| Long Word (64 Bits)                     | Extended Precision Normal or Instruction Word (48 Bits) | Normal Word (32 Bits)                   | Short Word (16 Bits)                    |
| Block 0 SRAM<br>0x0004 0000–0x0004 3FFF | Block 0 SRAM<br>0x0008 0000–0x0008 5555                 | Block 0 SRAM<br>0x0008 0000–0x0008 7FFF | Block 0 SRAM<br>0x0010 0000–0x0010 FFFF |
| Reserved<br>0x0004 4000–0x0005 7FFF     | Reserved  | Reserved<br>0x0008 8000–0x000A FFFF     | Reserved<br>0x0011 0000–0x0015 FFFF     |
| Block 0 ROM<br>0x0005 8000–0x0005 FFFF  | Block 0 ROM<br>0x000A 0000–0x000A AAAA                  | Block 0 ROM<br>0x000B 0000–0x000B FFFF  | Block 0 ROM<br>0x0016 0000–0x0017 FFFF  |
| Block 1 SRAM<br>0x0006 0000–0x0006 3FFF | Block 1 SRAM<br>0x000C 0000–0x000C 5555                 | Block 1 SRAM<br>0x000C 0000–0x000C 7FFF | Block 1 SRAM<br>0x0018 0000–0x0018 FFFF |
| Reserved<br>0x0006 4000–0x0007 7FFF     | Reserved  | Reserved<br>0x000C 8000–0x000E FFFF     | Reserved<br>0x0019 0000–0x001D FFFF     |
| Block 1 ROM<br>0x0007 8000–0x0007 FFFF  | Block 1 ROM<br>0x000E 0000–0x000E AAAA                  | Block 1 ROM<br>0x000F 0000–0x000F FFFF  | Block 1 ROM<br>0x001E 0000–0x001F FFFF  |

## Digital Application Interface (DAI)

The Digital application interface provides the ability to connect various peripherals to any of the SHARC DSP's DAI pins (DAI\_P20–1).

Connections are made using the signal routing unit (SRU), shown in the block diagram on Page 1).

The SRU is a matrix routing unit (or group of multiplexers) that enables the peripherals provided by the DAI to be interconnected under software control. This allows easy use of the DAI associated peripherals for a much wider variety of applications by using a larger set of algorithms than is possible with nonconfigurable signal paths.

The DAI also includes six serial ports, two precision clock generators (PCGs), an input data port (IDP), six flag outputs and six flag inputs, and three timers. The IDP provides an additional input path to the ADSP-2126x core, configurable as either eight channels of I<sup>2</sup>S or serial data, or as seven channels plus a single 20-bit wide synchronous parallel data acquisition port. Each data channel has its own DMA channel that is independent from the ADSP-2126x's serial ports.

For complete information on using the DAI, see the *ADSP-2126x SHARC DSP Peripherals Manual*.

## Serial Ports

The ADSP-2126x features six full duplex synchronous serial ports that provide an inexpensive interface to a wide variety of digital and mixed-signal peripheral devices such as the Analog Devices AD183x family of audio codecs, ADCs, and DACs. The serial ports are made up of two data lines, a clock, and frame sync. The data lines can be programmed to either transmit or receive and each data line has its own dedicated DMA channel.

Serial ports are enabled via 12 programmable and simultaneous receive or transmit pins that support up to 24 transmit or 24 receive channels of audio data when all six SPORTs are enabled, or six full duplex TDM streams of 128 channels per frame.

The serial ports operate at up to one-quarter of the DSP core clock rate, providing each with a maximum data rate of 50M bits/sec for a 200 MHz core and 37.5M bits/sec for a 150 MHz core. Serial port data can be automatically transferred to and from on-chip memory via a dedicated DMA. Each of the serial ports can work in conjunction with another serial port to provide TDM support. One SPORT provides two transmit signals while the other SPORT provides two receive signals. The frame sync and clock are shared.

Serial ports operate in four modes:

- Standard DSP serial mode
- Multichannel (TDM) mode
- I<sup>2</sup>S mode
- Left-justified sample pair mode

Left-justified sample pair mode is a mode where in each frame sync cycle, two samples of data are transmitted/received—one sample on the high segment of the frame sync, the other on the low segment of the frame sync. Programs have control over various attributes of this mode.

Each of the serial ports supports the left-justified sample-pair and I<sup>2</sup>S protocols (I<sup>2</sup>S is an industry-standard interface commonly used by audio codecs, ADCs, and DACs) with two data pins, allowing four left-justified sample-pair or I<sup>2</sup>S channels (using two stereo devices) per serial port with a maximum of up to 24 audio channels. The serial ports permit little-endian or big-endian transmission formats and word lengths selectable from 3 bits to 32 bits. For the left-justified sample pair and I<sup>2</sup>S modes, data-word lengths are selectable between 8 bits and 32 bits. Serial ports offer selectable synchronization and transmit modes as well as optional  $\mu$ -law or A-law companding selection on a per channel basis. Serial port clocks and frame syncs can be internally or externally generated.

## Serial Peripheral (Compatible) Interface

The serial peripheral interface is an industry-standard synchronous serial link, enabling the ADSP-2126x SPI-compatible port to communicate with other SPI-compatible devices. SPI is an interface consisting of two data pins, one device select pin, and one clock pin. It is a full-duplex synchronous serial interface, supporting both master and slave modes. The SPI port can operate in a multimaster environment by interfacing with up to four other SPI-compatible devices, either acting as a master or slave device. The ADSP-2126x SPI-compatible peripheral implementation also features programmable baud rates at up to 50 MHz for a core clock of 200 MHz and up to 37.5 MHz for a core clock of 150 MHz, clock phases, and polarities. The ADSP-2126x SPI-compatible port uses open-drain drivers to support a multimaster configuration and to avoid data contention.

## Parallel Port

The parallel port provides interfaces to SRAM and peripheral devices. The multiplexed address and data pins (AD15–0) can access 8-bit devices with up to 24 bits of address, or 16-bit devices with up to 16 bits of address. In either mode, 8- or 16-bit, the maximum data transfer rate is one-third the core clock speed. As an example, a clock rate of 200 MHz is equivalent to 66M byte/sec, and a clock rate of 150 MHz is equivalent to 50M byte/sec.

DMA transfers are used to move data to and from internal memory. Access to the core is also facilitated through the parallel port register read/write functions. The  $\overline{RD}$ ,  $\overline{WR}$ , and ALE (address latch enable) pins are the control pins for the parallel port.

## Timers

The ADSP-2126x has a total of four timers: a core timer able to generate periodic software interrupts, and three general-purpose timers that can generate periodic interrupts and be independently set to operate in one of three modes:

- Pulse waveform generation mode
- Pulse width count/capture mode
- External event watchdog mode

The core timer can be configured to use FLAG3 as a timer expired output signal, and each general-purpose timer has one bidirectional pin and four registers that implement its mode of operation: a 6-bit configuration register, a 32-bit count register, a 32-bit period register, and a 32-bit pulse width register. A single control and status register enables or disables all three general-purpose timers independently.

## ROM-Based Security

The ADSP-2126x has a ROM security feature that provides hardware support for securing user software code by preventing unauthorized reading from the internal code when enabled. When using this feature, the DSP does not boot-load any external code, executing exclusively from internal SRAM/ROM. Additionally, the DSP is not freely accessible via the JTAG port. Instead, a unique 64-bit key, which must be scanned in through

the JTAG or test access port, will be assigned to each customer. The device will ignore a wrong key. Emulation features and external boot modes are only available after the correct key is scanned.

## Program Booting

The internal memory of the ADSP-2126x boots at system power-up from an 8-bit EPROM via the parallel port, an SPI master, an SPI slave, or an internal boot. Booting is determined by the boot configuration (BOOT\_CFG1–0) pins.

## Phase-Locked Loop

The ADSP-2126x uses an on-chip phase-locked loop (PLL) to generate the internal clock for the core. On power-up, the CLK\_CFG1–0 pins are used to select ratios of 16:1, 8:1, and 3:1. After booting, numerous other ratios can be selected via software control. The ratios are made up of software configurable numerator values from 1 to 64 and software configurable divisor values of 2, 4, 8, and 16.

## Power Supplies

The ADSP-2126x has separate power supply connections for the internal ( $V_{DDINT}$ ), external ( $V_{DDEXT}$ ), and analog ( $A_{VDD}/A_{VSS}$ ) power supplies. The internal and analog supplies must meet the 1.2 V requirement. The external supply must meet the 3.3 V requirement. All external supply pins must be connected to the same power supply.

Note that the analog supply pin ( $A_{VDD}$ ) powers the ADSP-2126x's internal clock generator PLL. To produce a stable clock, it is recommended that PCB designs use an external filter circuit for the  $A_{VDD}$  pin. Place the filter components as close as possible to the  $A_{VDD}/A_{VSS}$  pins. For an example circuit, see Figure 2. (A recommended ferrite chip is the muRata BLM18AG102SN1D). To reduce noise coupling, the PCB should use a parallel pair of power and ground planes for  $V_{DDINT}$  and GND. Use wide traces to connect the bypass capacitors to the analog power ( $A_{VDD}$ ) and ground ( $A_{VSS}$ ) pins. Note that the  $A_{VDD}$  and  $A_{VSS}$  pins specified in Figure 2 are inputs to the processor and not the analog ground plane on the board—the  $A_{VSS}$  pin should connect directly to digital ground (GND) at the chip.

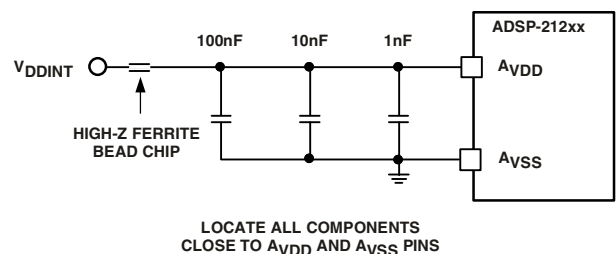


Figure 2. Analog Power Filter Circuit



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## TARGET BOARD JTAG EMULATOR CONNECTOR

Analog Devices DSP Tools product line of JTAG emulators uses the IEEE 1149.1 JTAG test access port of the ADSP-2126x processor to monitor and control the target board processor during emulation. Analog Devices DSP Tools product line of JTAG emulators provides emulation at full processor speed, allowing inspection and modification of memory, registers, and processor stacks. The processor's JTAG interface ensures that the emulator will not affect target system loading or timing.

For complete information on Analog Devices SHARC DSP Tools product line of JTAG emulator operation, see the appropriate emulator hardware user's guide.

## DEVELOPMENT TOOLS

Analog Devices supports its processors with a complete line of software and hardware development tools, including integrated development environments (which include CrossCore<sup>®</sup> Embedded Studio and/or VisualDSP++<sup>®</sup>), evaluation products, emulators, and a wide variety of software add-ins.

### Integrated Development Environments (IDEs)

For C/C++ software writing and editing, code generation, and debug support, Analog Devices offers two IDEs.

The newest IDE, CrossCore Embedded Studio, is based on the Eclipse™ framework. Supporting most Analog Devices processor families, it is the IDE of choice for future processors, including multicore devices. CrossCore Embedded Studio seamlessly integrates available software add-ins to support real time operating systems, file systems, TCP/IP stacks, USB stacks, algorithmic software modules, and evaluation hardware board support packages. For more information visit [www.analog.com/cces](http://www.analog.com/cces).

The other Analog Devices IDE, VisualDSP++, supports processor families introduced prior to the release of CrossCore Embedded Studio. This IDE includes the Analog Devices VDK real time operating system and an open source TCP/IP stack. For more information visit [www.analog.com/visualdsp](http://www.analog.com/visualdsp). Note that VisualDSP++ will not support future Analog Devices processors.

### EZ-KIT Lite Evaluation Board

For processor evaluation, Analog Devices provides wide range of EZ-KIT Lite<sup>®</sup> evaluation boards. Including the processor and key peripherals, the evaluation board also supports on-chip emulation capabilities and other evaluation and development features. Also available are various EZ-Extenders<sup>®</sup>, which are daughter cards delivering additional specialized functionality, including audio and video processing. For more information visit [www.analog.com](http://www.analog.com) and search on “ezkit” or “ezextender”.

### EZ-KIT Lite Evaluation Kits

For a cost-effective way to learn more about developing with Analog Devices processors, Analog Devices offer a range of EZ-KIT Lite evaluation kits. Each evaluation kit includes an EZ-KIT Lite evaluation board, directions for downloading an evaluation version of the available IDE(s), a USB cable, and a power supply.

The USB controller on the EZ-KIT Lite board connects to the USB port of the user's PC, enabling the chosen IDE evaluation suite to emulate the on-board processor in-circuit. This permits the customer to download, execute, and debug programs for the EZ-KIT Lite system. It also supports in-circuit programming of the on-board Flash device to store user-specific boot code, enabling standalone operation. With the full version of CrossCore Embedded Studio or VisualDSP++ installed (sold separately), engineers can develop software for supported EZ-KITs or any custom system utilizing supported Analog Devices processors.

### Software Add-Ins for CrossCore Embedded Studio

Analog Devices offers software add-ins which seamlessly integrate with CrossCore Embedded Studio to extend its capabilities and reduce development time. Add-ins include board support packages for evaluation hardware, various middleware packages, and algorithmic modules. Documentation, help, configuration dialogs, and coding examples present in these add-ins are viewable through the CrossCore Embedded Studio IDE once the add-in is installed.

### Board Support Packages for Evaluation Hardware

Software support for the EZ-KIT Lite evaluation boards and EZ-Extender daughter cards is provided by software add-ins called Board Support Packages (BSPs). The BSPs contain the required drivers, pertinent release notes, and select example code for the given evaluation hardware. A download link for a specific BSP is located on the web page for the associated EZ-KIT or EZ-Extender product. The link is found in the *Product Download* area of the product web page.

### Middleware Packages

Analog Devices separately offers middleware add-ins such as real time operating systems, file systems, USB stacks, and TCP/IP stacks. For more information see the following web pages:

- [www.analog.com/ucos3](http://www.analog.com/ucos3)
- [www.analog.com/ucfs](http://www.analog.com/ucfs)
- [www.analog.com/ucusb](http://www.analog.com/ucusb)
- [www.analog.com/lwip](http://www.analog.com/lwip)

### Algorithmic Modules

To speed development, Analog Devices offers add-ins that perform popular audio and video processing algorithms. These are available for use with both CrossCore Embedded Studio and VisualDSP++. For more information visit [www.analog.com](http://www.analog.com) and search on “Blackfin software modules” or “SHARC software modules”.

### Designing an Emulator-Compatible DSP Board (Target)

For embedded system test and debug, Analog Devices provides a family of emulators. On each JTAG DSP, Analog Devices supplies an IEEE 1149.1 JTAG Test Access Port (TAP). In-circuit emulation is facilitated by use of this JTAG interface. The emulator accesses the processor's internal features via the processor's TAP, allowing the developer to load code, set

breakpoints, and view variables, memory, and registers. The processor must be halted to send data and commands, but once an operation is completed by the emulator, the DSP system is set to run at full speed with no impact on system timing. The emulators require the target board to include a header that supports connection of the DSP's JTAG port to the emulator.

For details on target board design issues including mechanical layout, single processor connections, signal buffering, signal termination, and emulator pod logic, see the *EE-68: Analog Devices JTAG Emulation Technical Reference* on the Analog Devices website ([www.analog.com](http://www.analog.com))—use site search on “EE-68.” This document is updated regularly to keep pace with improvements to emulator support.

## ADDITIONAL INFORMATION

This data sheet provides a general overview of the ADSP-2126x architecture and functionality. For detailed information on the ADSP-2126x family core architecture and instruction set, refer to the *ADSP-2126x SHARC DSP Core Manual* and the *ADSP-21160 SHARC DSP Instruction Set Reference*.

## RELATED SIGNAL CHAINS

A *signal chain* is a series of signal-conditioning electronic components that receive input (data acquired from sampling either real-time phenomena or from stored data) in tandem, with the output of one portion of the chain supplying input to the next. Signal chains are often used in signal processing applications to gather and process data or to apply system controls based on analysis of real-time phenomena. For more information about this term and related topics, see the “signal chain” entry in [Wikipedia](#) or the [Glossary of EE Terms](#) on the Analog Devices website.

Analog Devices eases signal processing system development by providing signal processing components that are designed to work together well. A tool for viewing relationships between specific applications and related components is available on the [www.analog.com](http://www.analog.com) website.

The Application Signal Chains page in the Circuits from the Lab™ site ([http://www.analog.com/signal\\_chains](http://www.analog.com/signal_chains)) provides:

- Graphical circuit block diagram presentation of signal chains for a variety of circuit types and applications
- Drill down links for components in each chain to selection guides and application information
- Reference designs applying best practice design techniques

# ADSP-21261/ADSP-21262/ADSP-21266

## PIN FUNCTION DESCRIPTIONS

The ADSP-2126x pin definitions are listed below. Inputs identified as synchronous (S) must meet timing requirements with respect to CLKIN (or with respect to TCK for TMS, TDI). Inputs identified as asynchronous (A) can be asserted asynchronously to CLKIN (or to TCK for TRST). Tie or pull unused inputs to  $V_{DDEXT}$  or GND, except for the following:

DAI\_Px, SPICLK, MISO, MOSI,  $\overline{EMU}$ , TMS,  $\overline{TRST}$ , TDI and AD15–0 (NOTE: These pins have internal pull-up resistors.)

The following symbols appear in the Type column of [Table 6](#): A = asynchronous, G = ground, I = input, O = output, P = power supply, S = synchronous, (A/D) = active drive, (O/D) = open-drain, and T = three-state.

**Table 6. Pin Descriptions**

| Pin             | Type  | State During and After Reset   | Function   |
|-----------------|-------|--|--|
| AD15–0          | I/O/T | Rev. 0.1 silicon—AD15–0 pins are driven low both during and after reset.<br>Rev. 0.2 silicon—AD15–0 pins are three-stated and pulled high both during and after reset. | <b>Parallel Port Address/Data.</b> The parallel port and its corresponding DMA unit output addresses and data for peripherals on these multiplexed pins. The multiplex state is determined by the ALE pin. The parallel port can operate in either 8-bit or 16-bit mode. Each AD pin has a 22.5 k $\Omega$ internal pull-up resistor. See <a href="#">Address Data Modes on Page 13</a> for details of the AD pin operation.<br>For 8-bit mode: ALE is automatically asserted whenever a change occurs in the upper 16 external address bits, A23–8; ALE is used in conjunction with an external latch to retain the values of the A23–8.<br>For 16-bit mode: ALE is automatically asserted whenever a change occurs in the address bits, A15–0; ALE is used in conjunction with an external latch to retain the values of the A15–0. To use these pins as flags (FLAG15–0), set (= 1) Bit 20 of the SYSCTL register and disable the parallel port. See <a href="#">Table 7 on Page 13</a> for a list of how the AD15–0 pins map to the flag pins. When configured in the IDP_PDAP_CTL register, the IDP Channel 0 can use these pins for parallel input data. |
| $\overline{RD}$ | O     | Output only, driven high <sup>1</sup>  | <b>Parallel Port Read Enable.</b> $\overline{RD}$ is asserted low whenever the DSP reads 8-bit or 16-bit data from an external memory device. When AD15–0 are flags, this pin remains deasserted.  |
| $\overline{WR}$ | O     | Output only, driven high <sup>1</sup>  | <b>Parallel Port Write Enable.</b> $\overline{WR}$ is asserted low whenever the DSP writes 8-bit or 16-bit data to an external memory device. When AD15–0 are flags, this pin remains deasserted.  |
| ALE             | O     | Output only, driven low <sup>1</sup>   | <b>Parallel Port Address Latch Enable.</b> ALE is asserted whenever the DSP drives a new address on the parallel port address pin. On reset, ALE is active high. However, it can be reconfigured using software to be active low. When AD15–0 are flags, this pin remains deasserted.  |
| FLAG3–0         | I/O/A | Three-state  | <b>Flag Pins.</b> Each FLAG pin is configured via control bits as either an input or output. As an input, it can be tested as a condition. As an output, it can be used to signal external peripherals. These pins can be used as an SPI interface slave select output during SPI mastering. These pins are also multiplexed with the $\overline{IRQx}$ and the TIMEXP signals.<br>In SPI master boot mode, FLAG0 is the slave select pin that must be connected to an SPI EPROM. FLAG0 is configured as a slave select during SPI master boot. When Bit 16 is set (= 1) in the SYSCTL register, FLAG0 is configured as $\overline{IRQ0}$ .<br>When Bit 17 is set (= 1) in the SYSCTL register, FLAG1 is configured as $\overline{IRQ1}$ .<br>When Bit 18 is set (= 1) in the SYSCTL register, FLAG2 is configured as $\overline{IRQ2}$ .<br>When Bit 19 is set (= 1) in the SYSCTL register, FLAG3 is configured as TIMEXP, which indicates that the system timer has expired.  |
| DAI_P20–1       | I/O/T | Three-state with programmable pull-up  | <b>Digital Application Interface Pins.</b> These pins provide the physical interface to the SRU. The SRU configuration registers define the combination of on-chip peripheral inputs or outputs connected to the pin and to the pin's output enable. The configuration registers of these peripherals then determine the exact behavior of the pin. Any input or output signal present in the SRU can be routed to any of these pins. The SRU provides the connection from the serial ports, input data port, precision clock generators, and timers to the DAI_P20–1 pins. These pins have internal 22.5 k $\Omega$ pull-up resistors which are enabled on reset. These pull-ups can be disabled in the DAI_PIN_PULLUP register.  |

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**Table 6. Pin Descriptions (Continued)**

| Pin                       | Type      | State During and After Reset  | Function   |
|---------------------------|-----------|---|--|
| SPICLK                    | I/O       | Three-state with pull-up enabled, driven high in SPI-master boot mode | <b>Serial Peripheral Interface Clock Signal.</b> Driven by the master, this signal controls the rate at which data is transferred. The master can transmit data at a variety of baud rates. SPICLK cycles once for each bit transmitted. SPICLK is a gated clock that is active during data transfers, only for the length of the transferred word. Slave devices ignore the serial clock if the slave select input is driven inactive (HIGH). SPICLK is used to shift out and shift in the data driven on the MISO and MOSI lines. The data is always shifted out on one clock edge and sampled on the opposite edge of the clock. Clock polarity and clock phase relative to data are programmable into the SPICLK control register and define the transfer format. SPICLK has a 22.5 k $\Omega$ internal pull-up resistor. If SPI master boot mode is selected, MOSI and SPICLK pins are driven during reset. These pins are not three-stated during reset in SPI master boot mode. |
| $\overline{\text{SPIDS}}$ | I         | Input only  | <b>Serial Peripheral Interface Slave Device Select.</b> An active low signal used to select the DSP as an SPI slave device. This input signal behaves like a chip select, and is provided by the master device for the slave devices. In multimaster mode, the DSP's $\overline{\text{SPIDS}}$ signal can be driven by a slave device to signal to the DSP (as SPI master) that an error has occurred, as some other device is also trying to be the master device. If asserted low when the device is in master mode, it is considered a multimaster error. For a single master, multiple-slave configuration where flag pins are used, this pin must be tied or pulled high to $V_{\text{DDEXT}}$ on the master device. For ADSP-2126x to ADSP-2126x SPI interaction, any of the master ADSP-2126x's flag pins can be used to drive the $\overline{\text{SPIDS}}$ signal on the ADSP-2126x SPI slave device.   |
| MOSI                      | I/O (O/D) | Three-state with pull-up enabled, driven low in SPI-master boot mode  | <b>SPI Master Out Slave In.</b> If the ADSP-2126x is configured as a master, the MOSI pin becomes a data transmit (output) pin, transmitting output data. If the ADSP-2126x is configured as a slave, the MOSI pin becomes a data receive (input) pin, receiving input data. In an ADSP-2126x SPI interconnection, the data is shifted out from the MOSI output pin of the master and shifted into the MOSI input(s) of the slave(s). MOSI has a 22.5 k $\Omega$ internal pull-up resistor. If SPI master boot mode is selected, MOSI and SPICLK pins are driven during reset. These pins are not three-stated during reset in SPI master boot mode.   |
| MISO                      | I/O (O/D) | Three-state with pull-up enabled                                      | <b>SPI Master In Slave Out.</b> If the ADSP-2126x is configured as a master, the MISO pin becomes a data receive (input) pin, receiving input data. If the ADSP-2126x is configured as a slave, the MISO pin becomes a data transmit (output) pin, transmitting output data. In an ADSP-2126x SPI interconnection, the data is shifted out from the MISO output pin of the slave and shifted into the MISO input pin of the master. MISO has a 22.5 k $\Omega$ internal pull-up resistor. MISO can be configured as O/D by setting the OPD bit in the SPICLK register.<br><b>Note:</b> Only one slave is allowed to transmit data at any given time. To enable broadcast transmission to multiple SPI slaves, the DSP's MISO pin can be disabled by setting (= 1) Bit 5 (DMISO) of the SPICLK register.  |
| BOOT_CFG1-0               | I         | Input only  | <b>Boot Configuration Select.</b> Selects the boot mode for the DSP. The BOOT_CFG pins must be valid before reset is asserted. See <a href="#">Table 8 on Page 13</a> for a description of the boot modes.   |
| CLKIN                     | I         | Input only  | <b>Local Clock In.</b> Used in conjunction with XTAL. CLKIN is the ADSP-2126x clock input. It configures the ADSP-2126x to use either its internal clock generator or an external clock source. Connecting the necessary components to CLKIN and XTAL enables the internal clock generator. Connecting the external clock to CLKIN while leaving XTAL unconnected configures the ADSP-2126x to use the external clock source such as an external clock oscillator. The core is clocked either by the PLL output or this clock input depending on the CLK_CFG1-0 pin settings. CLKIN should not be halted, changed, or operated below the specified frequency.  |
| XTAL                      | O         | Output only <sup>2</sup>  | <b>Crystal Oscillator Terminal.</b> Used in conjunction with CLKIN to drive an external crystal.   |



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Table 6. Pin Descriptions (Continued)

| Pin                          | Type    | State During and After Reset     | Function   |
|------------------------------|---------|----------------------------------|--|
| CLK_CFG1-0                   | I       | Input only                       | <b>Core/CLKIN Ratio Control.</b> These pins set the start up clock frequency. See <a href="#">Table 9</a> for a description of the clock configuration modes.<br>Note that the operating frequency can be changed by programming the PLL multiplier and divider in the PMCTL register at any time after the core comes out of reset. |
| $\overline{\text{RESETOUT}}$ | O       | Output only                      | <b>Reset Out.</b> Drives out the core reset signal to an external device.  |
| $\overline{\text{RESET}}$    | I/A     | Input only                       | <b>Processor Reset.</b> Resets the ADSP-2126x to a known state. Upon deassertion, there is a 4096 CLKIN cycle latency for the PLL to lock. After this time, the core begins program execution from the hardware reset vector address. The $\overline{\text{RESET}}$ input must be asserted (low) at power-up.                        |
| TCK                          | I       | Input only <sup>3</sup>          | <b>Test Clock (JTAG).</b> Provides a clock for JTAG boundary scan. TCK must be asserted (pulsed low) after power-up or held low for proper operation of the ADSP-2126x.  |
| TMS                          | I/S     | Three-state with pull-up enabled | <b>Test Mode Select (JTAG).</b> Used to control the test state machine. TMS has a 22.5 k $\Omega$ internal pull-up resistor.   |
| TDI                          | I/S     | Three-state with pull-up enabled | <b>Test Data Input (JTAG).</b> Provides serial data for the boundary scan logic. TDI has a 22.5 k $\Omega$ internal pull-up resistor.  |
| TDO                          | O       | Three-state <sup>4</sup>         | <b>Test Data Output (JTAG).</b> Serial scan output of the boundary scan path.  |
| $\overline{\text{TRST}}$     | I/A     | Three-state with pull-up enabled | <b>Test Reset (JTAG).</b> Resets the test state machine. $\overline{\text{TRST}}$ must be asserted (pulsed low) after power-up or held low for proper operation of the ADSP-2126x. $\overline{\text{TRST}}$ has a 22.5 k $\Omega$ internal pull-up resistor.   |
| $\overline{\text{EMU}}$      | O (O/D) | Three-state with pull-up enabled | <b>Emulation Status.</b> Must be connected to the ADSP-2126x Analog Devices DSP Tools product line of JTAG emulators target board connector only. $\overline{\text{EMU}}$ has a 22.5 k $\Omega$ internal pull-up resistor.   |
| $V_{\text{DDINT}}$           | P       |                                  | <b>Core Power Supply.</b> Nominally +1.2 V dc and supplies the DSP's core processor (13 pins on the BGA package, 32 pins on the LQFP package).   |
| $V_{\text{DDEXT}}$           | P       |                                  | <b>I/O Power Supply.</b> Nominally +3.3 V dc (6 pins on the BGA package, 10 pins on the LQFP package).   |
| $A_{\text{VDD}}$             | P       |                                  | <b>Analog Power Supply.</b> Nominally +1.2 V dc and supplies the DSP's internal PLL (clock generator). This pin has the same specifications as $V_{\text{DDINT}}$ , except that added filtering circuitry is required. <a href="#">For more information, see Power Supplies on Page 7.</a>   |
| $A_{\text{VSS}}$             | G       |                                  | <b>Analog Power Supply Return.</b>   |
| GND                          | G       |                                  | <b>Power Supply Return.</b> (54 pins on the BGA package, 39 pins on the LQFP package).   |

<sup>1</sup>  $\overline{\text{RD}}$ ,  $\overline{\text{WR}}$ , and ALE are continuously driven by the DSP and will not be three-stated.

<sup>2</sup> Output only is a three-state driver with its output path always enabled.

<sup>3</sup> Input only is a three-state driver, with both output path and pull-up disabled.

<sup>4</sup> Three-state is a three-state driver, with pull-up disabled.

## ADDRESS DATA PINS AS FLAGS

To use these pins as flags (FLAG15–0), set (= 1) Bit 20 of the SYSCCTL register and disable the parallel port.

**Table 7. AD15–0 to FLAG Pin Mapping**

| AD Pin | Flag Pin | AD Pin | Flag Pin |
|--------|----------|--------|----------|
| AD0    | FLAG8    | AD8    | FLAG0    |
| AD1    | FLAG9    | AD9    | FLAG1    |
| AD2    | FLAG10   | AD10   | FLAG2    |
| AD3    | FLAG11   | AD11   | FLAG3    |
| AD4    | FLAG12   | AD12   | FLAG4    |
| AD5    | FLAG13   | AD13   | FLAG5    |
| AD6    | FLAG14   | AD14   | FLAG6    |
| AD7    | FLAG15   | AD15   | FLAG7    |

## Boot Modes

**Table 8. Boot Mode Selection**

| BOOT_CFG1–0 | Booting Mode                 |
|-------------|------------------------------|
| 00          | SPI Slave Boot               |
| 01          | SPI Master Boot              |
| 10          | Parallel Port Boot via EPROM |
| 11          | Reserved                     |

## CORE INSTRUCTION RATE TO CLKIN RATIO MODES

**Table 9. Core Instruction Rate/CLKIN Ratio Selection**

| CLK_CFG1–0 | Core to CLKIN Ratio |
|------------|---------------------|
| 00         | 3:1                 |
| 01         | 16:1                |
| 10         | 8:1                 |
| 11         | Reserved            |

## ADDRESS DATA MODES

Table 10 shows the functionality of the AD pins for 8-bit and 16-bit transfers to the parallel port. For 8-bit data transfers, ALE latches address bits A23–A8 when asserted, followed by address bits A7–A0 and data bits D7–D0 when deasserted. For 16-bit data transfers, ALE latches address bits A15–A0 when asserted, followed by data bits D15–D0 when deasserted.

**Table 10. Address/Data Mode Selection**

| EP Data Mode | ALE        | AD7–0 Function | AD15–8 Function |
|--------------|------------|----------------|-----------------|
| 8-bit        | Asserted   | A15–8          | A23–16          |
| 8-bit        | Deasserted | D7–0           | A7–0            |
| 16-bit       | Asserted   | A7–0           | A15–8           |
| 16-bit       | Deasserted | D7–0           | D15–8           |

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## PRODUCT SPECIFICATIONS

### OPERATING CONDITIONS

| Parameter <sup>1</sup>   | Description  | Min  | Max                      | Unit |
|--------------------------|--|------|--------------------------|------|
| V <sub>DDINT</sub>       | Internal (Core) Supply Voltage                                   | 1.14 | 1.26                     | V    |
| A <sub>VDD</sub>         | Analog (PLL) Supply Voltage                                      | 1.14 | 1.26                     | V    |
| V <sub>DDEXT</sub>       | External (I/O) Supply Voltage                                    | 3.13 | 3.47                     | V    |
| V <sub>IH</sub>          | High Level Input Voltage <sup>2</sup> @ V <sub>DDEXT</sub> = Max | 2.0  | V <sub>DDEXT</sub> + 0.5 | V    |
| V <sub>IL</sub>          | Low Level Input Voltage <sup>2</sup> @ V <sub>DDEXT</sub> = Min  | -0.5 | +0.8                     | V    |
| V <sub>IH_CLKIN</sub>    | High Level Input Voltage <sup>3</sup> @ V <sub>DDEXT</sub> = Max | 1.74 | V <sub>DDEXT</sub> + 0.5 | V    |
| V <sub>IL_CLKIN</sub>    | Low Level Input Voltage @ V <sub>DDEXT</sub> = Min               | -0.5 | +1.19                    | V    |
| T <sub>AMB</sub> K Grade | Ambient Operating Temperature <sup>4, 5</sup>                    | 0    | +70                      | °C   |
| T <sub>AMB</sub> B Grade | Ambient Operating Temperature <sup>4, 5</sup>                    | -40  | +85                      | °C   |

<sup>1</sup> Specifications subject to change without notice.

<sup>2</sup> Applies to input and bidirectional pins: AD15-0, FLAG3-0, DAI\_Px, SPICLK, MOSI, MISO,  $\overline{\text{SPIDS}}$ , BOOT\_CFGx, CLK\_CFGx,  $\overline{\text{RESET}}$ , TCK, TMS, TDI,  $\overline{\text{TRST}}$ .

<sup>3</sup> Applies to input pin CLKIN.

<sup>4</sup> See [Thermal Characteristics on Page 38](#) for information on thermal specifications.

<sup>5</sup> See Engineer-to-Engineer Note (No. EE-216) for further information.

### ELECTRICAL CHARACTERISTICS

| Parameter <sup>1</sup> | Description                                      | Test Conditions  | Min | Max | Unit |
|------------------------|--|--|-----|-----|------|
| V <sub>OH</sub>        | High Level Output Voltage <sup>2</sup>           | @ V <sub>DDEXT</sub> = Min, I <sub>OH</sub> = -1.0 mA <sup>3</sup>               | 2.4 |     | V    |
| V <sub>OL</sub>        | Low Level Output Voltage <sup>2</sup>            | @ V <sub>DDEXT</sub> = Min, I <sub>OL</sub> = 1.0 mA <sup>3</sup>                |     | 0.4 | V    |
| I <sub>IH</sub>        | High Level Input Current <sup>4, 5</sup>         | @ V <sub>DDEXT</sub> = Max, V <sub>IN</sub> = V <sub>DDEXT</sub> Max             |     | 10  | μA   |
| I <sub>IL</sub>        | Low Level Input Current <sup>4</sup>             | @ V <sub>DDEXT</sub> = Max, V <sub>IN</sub> = 0 V                                |     | 10  | μA   |
| I <sub>ILPU</sub>      | Low Level Input Current Pull-Up <sup>5</sup>     | @ V <sub>DDEXT</sub> = Max, V <sub>IN</sub> = 0 V                                |     | 200 | μA   |
| I <sub>OZH</sub>       | Three-State Leakage Current <sup>6, 7, 8</sup>   | @ V <sub>DDEXT</sub> = Max, V <sub>IN</sub> = V <sub>DDEXT</sub> Max             |     | 10  | μA   |
| I <sub>OZL</sub>       | Three-State Leakage Current <sup>6</sup>         | @ V <sub>DDEXT</sub> = Max, V <sub>IN</sub> = 0 V                                |     | 10  | μA   |
| I <sub>OZLPU</sub>     | Three-State Leakage Current Pull-Up <sup>7</sup> | @ V <sub>DDEXT</sub> = Max, V <sub>IN</sub> = 0 V                                |     | 200 | μA   |
| I <sub>DD-INTYP</sub>  | Supply Current (Internal) <sup>9, 10, 11</sup>   | t <sub>CCLK</sub> = 5.0 ns, V <sub>DDINT</sub> = 1.2 V, T <sub>AMB</sub> = +25°C |     | 500 | mA   |
| I <sub>AVDD</sub>      | Supply Current (Analog) <sup>11</sup>            | A <sub>VDD</sub> = Max   |     | 10  | mA   |
| C <sub>IN</sub>        | Input Capacitance <sup>12, 13</sup>              | f <sub>IN</sub> = 1 MHz, T <sub>CASE</sub> = 25°C, V <sub>IN</sub> = 1.2 V       |     | 4.7 | pF   |

<sup>1</sup> Specifications subject to change without notice.

<sup>2</sup> Applies to output and bidirectional pins: AD15-0,  $\overline{\text{RD}}$ ,  $\overline{\text{WR}}$ , ALE, FLAG3-0, DAI\_Px, SPICLK, MOSI, MISO,  $\overline{\text{EMU}}$ , TDO, CLKOUT, XTAL.

<sup>3</sup> See [Output Drive Currents on Page 37](#) for typical drive current capabilities.

<sup>4</sup> Applies to input pins:  $\overline{\text{SPIDS}}$ , BOOT\_CFGx, CLK\_CFGx, TCK,  $\overline{\text{RESET}}$ , CLKIN.

<sup>5</sup> Applies to input pins with 22.5 kΩ internal pull-ups:  $\overline{\text{TRST}}$ , TMS, TDI.

<sup>6</sup> Applies to three-statable pins: FLAG3-0.

<sup>7</sup> Applies to three-statable pins with 22.5 kΩ pull-ups: AD15-0, DAI\_Px, SPICLK, MISO, MOSI.

<sup>8</sup> Applies to open-drain output pins:  $\overline{\text{EMU}}$ , MISO, MOSI.

<sup>9</sup> Typical internal current data reflects nominal operating conditions.

<sup>10</sup> See Engineer-to-Engineer Note (EE-216) for further information.

<sup>11</sup> Characterized, but not tested.

<sup>12</sup> Applies to all signal pins.

<sup>13</sup> Guaranteed, but not tested.

## PACKAGE INFORMATION

The information presented in [Figure 3](#) provides details about the package branding for the ADSP-21266 processors. For a complete listing of product availability, see [Ordering Guide on Page 45](#).



Figure 3. Typical Package Brand

Table 11. Package Brand Information

| Brand Key | Field Description                |
|-----------|----------------------------------|
| t         | Temperature Range                |
| pp        | Package Type                     |
| Z         | RoHS Compliant Option (optional) |
| cc        | See Ordering Guide               |
| vvvvv.x   | Assembly Lot Code                |
| n.n       | Silicon Revision                 |
| #         | RoHS Compliant Designation       |
| yyww      | Date Code                        |

## ESD CAUTION



**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

## MAXIMUM POWER DISSIPATION

See *Estimating Power for the ADSP-21262 SHARC Processors (EE-216)* for detailed thermal and power information regarding maximum power dissipation. For information on package thermal specifications, see [Thermal Characteristics on Page 38](#).

## ABSOLUTE MAXIMUM RATINGS

Stresses greater than those listed in [Table 12](#) may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions greater than 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.

Table 12. Absolute Maximum Ratings

| Parameter                                      | Rating           |
|--|------------------|
| Internal (Core) Supply Voltage ( $V_{DDINT}$ ) | -0.3 V to +1.4 V |
| Analog (PLL) Supply Voltage ( $A_{VDD}$ )      | -0.3 V to +1.4 V |
| External (I/O) Supply Voltage ( $V_{DDEXT}$ )  | -0.3 V to +3.8 V |
| Input Voltage -0.5 V to $V_{DDEXT}$            | +0.5 V           |
| Output Voltage Swing -0.5 V to $V_{DDEXT}$     | +0.5 V           |
| Load Capacitance                               | 200 pF           |
| Storage Temperature Range                      | -65°C to +150°C  |
| Junction Temperature Under Bias                | 125°C            |

## TIMING SPECIFICATIONS

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, it is not meaningful to add parameters to derive longer times.

*Timing requirements* apply to signals that are controlled by circuitry external to the processor, such as the data input for a read operation. Timing requirements guarantee that the processor operates correctly with other devices.

*Switching characteristics* specify how the processor changes its signals. Circuitry external to the processor must be designed for compatibility with these signal characteristics. Switching characteristics describe what the processor will do in a given circumstance. Use switching characteristics to ensure that any timing requirement of a device connected to the processor (such as memory) is satisfied.

## Core Clock Requirements

The processor's internal clock (a multiple of CLKIN) provides the clock signal for timing internal memory, processor core, serial ports, and parallel port (as required for read/write strobes in asynchronous access mode). During reset, program the ratio between the DSP's internal clock frequency and external (CLKIN) clock frequency with the CLK\_CFG1-0 pins. To determine switching frequencies for the serial ports, divide down the internal clock, using the programmable divider control of each port (DIVx for the serial ports).

The processor's internal clock switches at higher frequencies than the system input clock (CLKIN). To generate the internal clock, the DSP uses an internal phase-locked loop (PLL). This PLL-based clocking minimizes the skew between the system clock (CLKIN) signal and the DSP's internal clock (the clock source for the parallel port logic and I/O pads).



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## Voltage Controlled Oscillator

In application designs, the PLL multiplier value should be selected in such a way that the VCO frequency never exceeds  $f_{VCO}$  specified in Table 16.

- The product of CLKIN and PLLM must never exceed 1/2 of  $f_{VCO}$  (max) in Table 16 if the input divider is not enabled (INDIV = 0).
- The product of CLKIN and PLLM must never exceed  $f_{VCO}$  (max) in Table 16 if the input divider is enabled (INDIV = 1).

The VCO frequency is calculated as follows:

$$f_{VCO} = 2 \times PLLM \times f_{INPUT}$$

$$f_{CCLK} = (2 \times PLLM \times f_{INPUT}) \div (2 \times PLLD)$$

where:

$$f_{VCO} = \text{VCO output}$$

PLLM = Multiplier value programmed in the PMCTL register. During reset, the PLLM value is derived from the ratio selected using the CLK\_CFG pins in hardware.

PLLD = 2, 4, 8, 16 based on the PLLD value programmed on the PMCTL register. During reset this value is 1.

$f_{INPUT}$  = is the input frequency to the PLL.

$f_{INPUT}$  = CLKIN when the input divider is disabled or

$f_{INPUT}$  = CLKIN ÷ 2 when the input divider is enabled

Note the definitions of various clock periods that are a function of CLKIN and the appropriate ratio control shown in Table 13 and Table 14.

Table 13. CLKOUT and CCLK Clock Generation Operation

| Timing Requirements | Description | Calculation            |
|---------------------|-------------|------------------------|
| CLKIN               | Input Clock | $1/t_{CK}$             |
| CCLK                | Core Clock  | Variable, see equation |

Table 14. Clock Periods

| Timing Requirements | Description <sup>1</sup>                          |
|---------------------|---|
| $t_{CK}$            | CLKIN Clock Period                                |
| $t_{CCLK}$          | (Processor) Core Clock Period                     |
| $t_{MCLK}$          | Internal memory clock = $1/2 t_{CCLK}$            |
| $t_{SCLK}$          | Serial Port Clock Period = $(t_{CCLK}) \times SR$ |
| $t_{SPICLK}$        | SPI Clock Period = $(t_{CCLK}) \times SPIR$       |

<sup>1</sup> where:

SR = serial port-to-core clock ratio (wide range, determined by SPORT CLKDIV)

SPIR = SPI-to-core clock ratio (wide range, determined by SPIBAUD register)

SCLK = serial port clock

SPICLK = SPI clock

Figure 4 shows core to CLKIN relationships with external oscillator or crystal. The shaded divider/multiplier blocks denote where clock ratios can be set through hardware or software using the power management control register (PMCTL). For more information, see the ADSP-2126x SHARC Processor Peripherals Reference and Managing the Core PLL on Third-Generation SHARC Processors (EE-290).

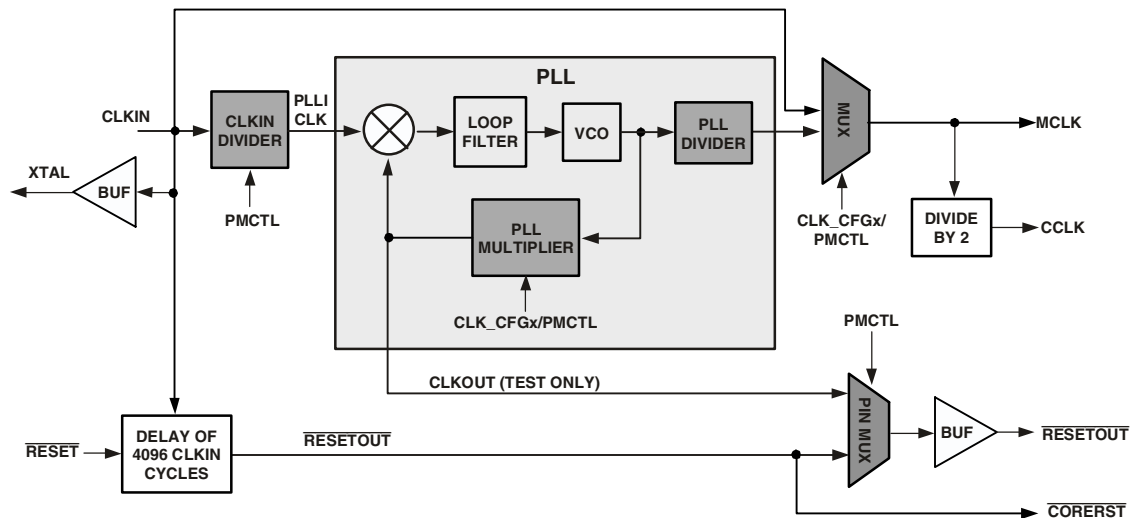


Figure 4. Core Clock and System Clock Relationship to CLKIN

## Power-Up Sequencing

The timing requirements for DSP startup are given in [Table 15](#) and [Figure 5](#). Note that during power-up, a leakage current of approximately 200  $\mu\text{A}$  may be observed on the  $\overline{\text{RESET}}$  pin. This leakage current results from the weak internal pull-up resistor on this pin being enabled during power-up.

**Table 15. Power-Up Sequencing (DSP Startup)**

| Parameter                        |   | Min                               | Max  | Unit          |
|----------------------------------|---|-----------------------------------|------|---------------|
| <i>Timing Requirements</i>       |   |                                   |      |               |
| $t_{\text{RSTVDD}}$              | $\overline{\text{RESET}}$ Low Before $V_{\text{DDINT}}/V_{\text{DDEXT}}$ On | 0                                 |      | ns            |
| $t_{\text{IVDDEVDD}}$            | $V_{\text{DDINT}}$ On Before $V_{\text{DDEXT}}$                             | -50                               | +200 | ms            |
| $t_{\text{CLKVDD}}$              | CLKIN Valid After $V_{\text{DDINT}}/V_{\text{DDEXT}}$ Valid <sup>1</sup>    | 0                                 | 200  | ms            |
| $t_{\text{CLKRST}}$              | CLKIN Valid Before $\overline{\text{RESET}}$ Deasserted                     | $10^2$                            |      | $\mu\text{s}$ |
| $t_{\text{PLLRST}}$              | PLL Control Setup Before $\overline{\text{RESET}}$ Deasserted               | $20^3$                            |      | $\mu\text{s}$ |
| <i>Switching Characteristics</i> |   |                                   |      |               |
| $t_{\text{CORERST}}$             | DSP Core Reset Deasserted After $\overline{\text{RESET}}$ Deasserted        | $4096 \times t_{\text{CK}}^{4,5}$ |      |               |

<sup>1</sup> Valid  $V_{\text{DDINT}}/V_{\text{DDEXT}}$  assumes that the supplies are fully ramped to their 1.2 V and 3.3 V rails. Voltage ramp rates can vary from microseconds to hundreds of milliseconds depending on the design of the power supply subsystem.

<sup>2</sup> Assumes a stable CLKIN signal, after meeting worst-case startup timing of crystal oscillators. Refer to the crystal oscillator manufacturer's data sheet for startup time. Assume a 25 ms maximum oscillator startup time if using the XTAL pin and internal oscillator circuit in conjunction with an external crystal.

<sup>3</sup> Based on CLKIN cycles.

<sup>4</sup> Applies after the power-up sequence is complete. Subsequent resets require a minimum of four CLKIN cycles for  $\overline{\text{RESET}}$  to be held low in order to properly initialize and propagate default states at all I/O pins.

<sup>5</sup> The 4096 cycle count depends on  $t_{\text{SRST}}$  specification in [Table 17](#). If setup time is not met, one additional CLKIN cycle can be added to the core reset time, resulting in 4097 cycles maximum.

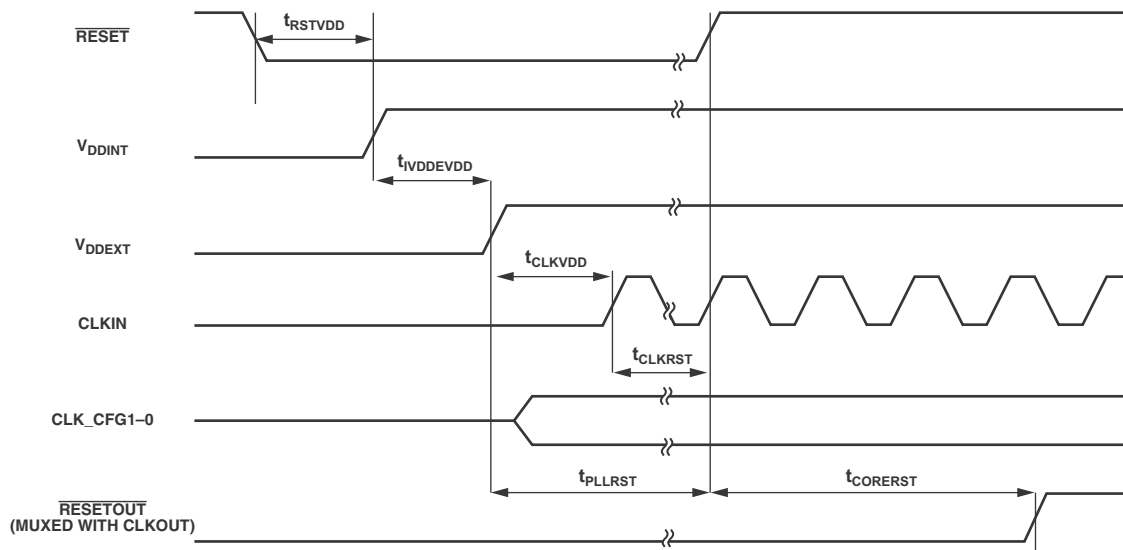


Figure 5. Power-Up Sequencing

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## Clock Input

See [Table 16](#) and [Figure 6](#).

**Table 16. Clock Input**

| Parameter                     | 150 MHz <sup>1</sup>             |     | 200 MHz <sup>2</sup> |                  | Unit |
|-------------------------------|----------------------------------|-----|----------------------|------------------|------|
|                               | Min                              | Max | Min                  | Max              |      |
| <i>Timing Requirements</i>    |                                  |     |                      |                  |      |
| t <sub>CK</sub>               | CLKIN Period                     |     | 15 <sup>3</sup>      | 160 <sup>4</sup> | ns   |
| t <sub>CKL</sub>              | CLKIN Width Low                  |     | 6 <sup>3</sup>       | 80 <sup>4</sup>  | ns   |
| t <sub>CKH</sub>              | CLKIN Width High                 |     | 6 <sup>3</sup>       | 80 <sup>4</sup>  | ns   |
| t <sub>CKRF</sub>             | CLKIN Rise/Fall (0.4 V to 2.0 V) |     |                      | 3                | ns   |
| f <sub>VCO</sub> <sup>5</sup> | VCO Frequency                    |     | 200                  | 800              | MHz  |
| t <sub>CCLK</sub>             | CCLK Period <sup>6</sup>         |     | 5                    | 10               | ns   |

<sup>1</sup> Applies to all 150 MHz models. See [Ordering Guide on Page 45](#).

<sup>2</sup> Applies to all 200 MHz models. See [Ordering Guide on Page 45](#).

<sup>3</sup> Applies only for CLK\_CFG1-0 = 00 and default values for PLL control bits in PMCTL.

<sup>4</sup> Applies only for CLK\_CFG1-0 = 01 and default values for PLL control bits in PMCTL.

<sup>5</sup> See [Figure 4 on Page 16](#) for VCO diagram.

<sup>6</sup> Any changes to PLL control bits in the PMCTL register must meet core clock timing specification t<sub>CCLK</sub>.

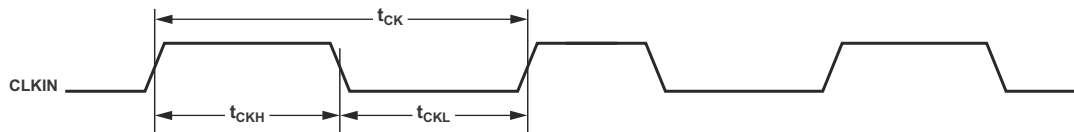
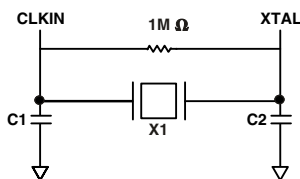


Figure 6. Clock Input

## Clock Signals

The ADSP-2126x can use an external clock or a crystal. See CLKIN pin description. The programmer can configure the ADSP-2126x to use its internal clock generator by connecting the necessary components to CLKIN and XTAL. [Figure 7](#) shows the component connections used for a crystal operating in fundamental mode. Note that the 200 MHz clock rate is achieved using a 12.5 MHz crystal and a PLL multiplier ratio 16:1 (CCLK:CLKIN).



NOTE: C1 AND C2 ARE SPECIFIC TO CRYSTAL SPECIFIED FOR X1. CONTACT CRYSTAL MANUFACTURER FOR DETAILS. CRYSTAL SELECTION MUST COMPLY WITH CLKCFG1-0 = 10 OR = 01.

Figure 7. 150 MHz or 200 MHz Operation with a 12.5 MHz Fundamental Mode Crystal

## Reset

See [Table 17](#) and [Figure 8](#).

**Table 17. Reset**

| Parameter  | Min               | Max | Unit |
|--|-------------------|-----|------|
| <i>Timing Requirements</i>                                 |                   |     |      |
| $t_{WRST}$ $\overline{RESET}$ Pulse Width Low <sup>1</sup> | $4 \times t_{CK}$ |     | ns   |
| $t_{SRST}$ $\overline{RESET}$ Setup Before CLKIN Low       | 8                 |     | ns   |

<sup>1</sup>Applies after the power-up sequence is complete. At power-up, the processor's internal phase-locked loop requires no more than 100  $\mu$ s while  $\overline{RESET}$  is low, assuming stable VDD and CLKIN (not including start-up time of external clock oscillator).

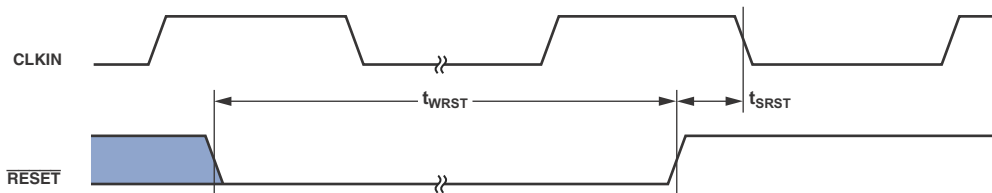


Figure 8. Reset

## Interrupts

The timing specification in [Table 18](#) and [Figure 9](#) applies to the FLAG0, FLAG1, and FLAG2 pins when they are configured as  $\overline{IRQ0}$ ,  $\overline{IRQ1}$ , and  $\overline{IRQ2}$  interrupts. Also applies to DAI\_P20-1 pins when configured as interrupts.

**Table 18. Interrupts**

| Parameter                               | Min             | Max | Unit |
|---|-----------------|-----|------|
| <i>Timing Requirements</i>              |                 |     |      |
| $t_{IPW}$ $\overline{IRQx}$ Pulse Width | $2 t_{CLK} + 2$ |     | ns   |

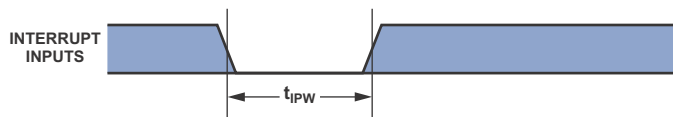


Figure 9. Interrupts



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## Core Timer

The timing specification in [Table 19](#) and [Figure 10](#) applies to FLAG3 when it is configured as the core timer (CTIMER).

**Table 19. Core Timer**

| Parameter                        | Min                     | Max | Unit |
|----------------------------------|-------------------------|-----|------|
| <i>Switching Characteristics</i> |                         |     |      |
| $t_{WCTIM}$ CTIMER Pulse Width   | $4 \times t_{CCLK} - 1$ |     | ns   |

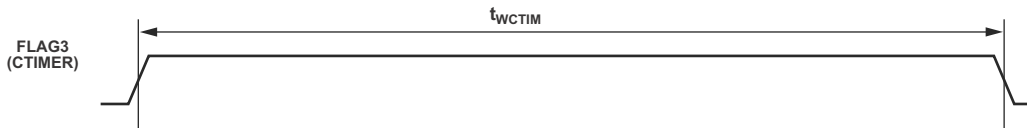


Figure 10. Core Timer

## Timer PWM\_OUT Cycle Timing

The timing specification in [Table 20](#) and [Figure 11](#) applies to Timer in PWM\_OUT (pulse-width modulation) mode. Timer signals are routed to the DAI\_P20-1 pins through the SRU. Therefore, the timing specifications provided below are valid at the DAI\_P20-1 pins.

**Table 20. Timer PWM\_OUT Timing**

| Parameter                           | Min                     | Max                             | Unit |
|-------------------------------------|-------------------------|---------------------------------|------|
| <i>Switching Characteristics</i>    |                         |                                 |      |
| $t_{PWMO}$ Timer Pulse Width Output | $2 \times t_{CCLK} - 1$ | $2(2^{31} - 1) \times t_{CCLK}$ | ns   |

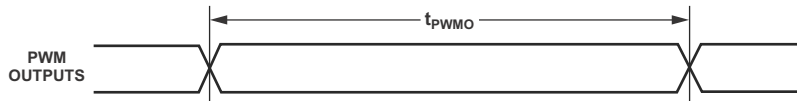


Figure 11. Timer PWM\_OUT Timing

## Timer WDT<sub>H</sub>\_CAP Timing

The timing specification in [Table 21](#) and [Figure 12](#) applies to Timer in WDT<sub>H</sub>\_CAP (pulse width count and capture) mode. Timer signals are routed to the DAI\_P20-1 pins through the SRU. Therefore, the timing specifications provided below are valid at the DAI\_P20-1 pins.

**Table 21. Timer Width Capture Timing**

| Parameter                   | Min                 | Max                             | Unit |
|-----------------------------|---------------------|---------------------------------|------|
| <i>Timing Requirements</i>  |                     |                                 |      |
| $t_{PWI}$ Timer Pulse Width | $2 \times t_{CCLK}$ | $2(2^{31} - 1) \times t_{CCLK}$ | ns   |

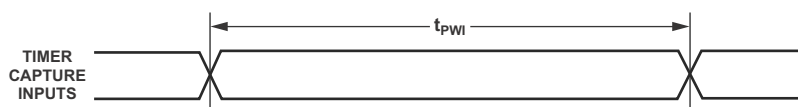


Figure 12. Timer Width Capture Timing

## DAI Pin-to-Pin Direct Routing

See [Table 22](#) and [Figure 13](#) for direct pin connections only (for example, DAI\_PB01\_I to DAI\_PB02\_O).

**Table 22. DAI Pin-to-Pin Routing**

| Parameter  | Min | Max | Unit |
|--|-----|-----|------|
| <i>Timing Requirements</i>                               |     |     |      |
| $t_{DPiO}$ Delay DAI Pin Input Valid to DAI Output Valid | 1.5 | 10  | ns   |

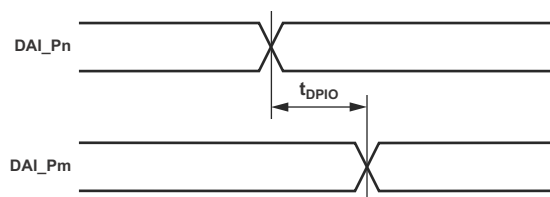


Figure 13. DAI Pin-to-Pin Direct Routing

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## Precision Clock Generator (Direct Pin Routing)

The timing in Table 23 and Figure 14 is valid only when the SRU is configured such that the precision clock generator (PCG) takes its inputs directly from the DAI pins (via pin buffers) and sends its outputs directly to the DAI pins. For the

other cases where the PCG's inputs and outputs are not directly routed to/from DAI pins (via pin buffers), there is no timing data available. All timing parameters and switching characteristics apply to external DAI pins (DAI\_P07–DAI\_P20).

Table 23. Precision Clock Generator (Direct Pin Routing)

| Parameter                        |  | Min                          | Max                         | Unit |
|----------------------------------|--|------------------------------|-----------------------------|------|
| <i>Timing Requirements</i>       |  |                              |                             |      |
| $t_{PCGIW}$                      | Input Clock Pulse Width  | 20                           |                             | ns   |
| $t_{STRIG}$                      | PCG Trigger Setup Before Falling Edge of PCG Input Clock                             | 2                            |                             | ns   |
| $t_{HTRIG}$                      | PCG Trigger Hold After Falling Edge of PCG Input Clock                               | 2                            |                             | ns   |
| <i>Switching Characteristics</i> |  |                              |                             |      |
| $t_{DPCGIO}$                     | PCG Output Clock and Frame Sync Active Edge Delay After PCG Input Clock Falling Edge | 2.5                          | 10                          | ns   |
| $t_{DTRIG}$                      | PCG Output Clock and Frame Sync Delay After PCG Trigger                              | $2.5 + 2.5 \times t_{PCGOW}$ | $10 + 2.5 \times t_{PCGOW}$ | ns   |
| $t_{PCGOW}$                      | Output Clock Pulse Width   | 40                           |                             | ns   |

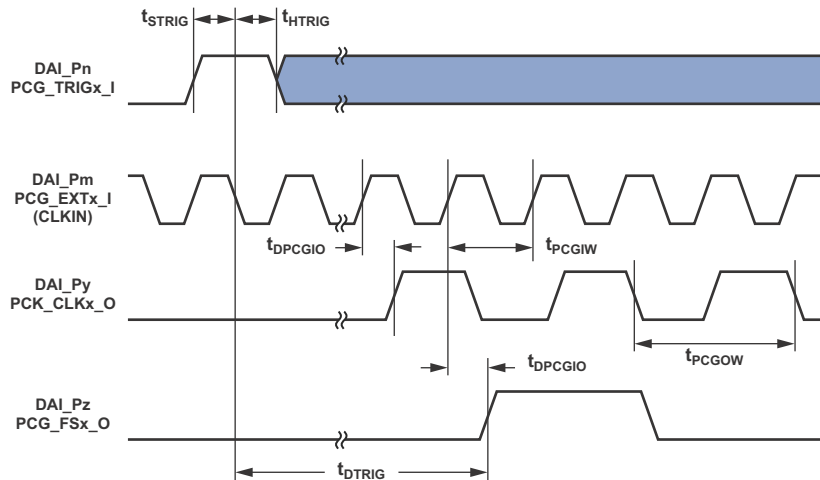


Figure 14. Precision Clock Generator (Direct Pin Routing)

## Flags

The timing specifications in [Table 24](#) and [Figure 15](#) apply to the FLAG3-0 and DAI\_P20-1 pins, the parallel port, and the serial peripheral interface. See [Table 6 on Page 10](#) for more information on flag use.

**Table 24. Flags**

| Parameter                          | Min                     | Max | Unit |
|------------------------------------|-------------------------|-----|------|
| <i>Timing Requirements</i>         |                         |     |      |
| $t_{FIPW}$ FLAG3-0 IN Pulse Width  | $2 \times t_{CCLK} + 3$ |     | ns   |
| <i>Switching Characteristics</i>   |                         |     |      |
| $t_{FOPW}$ FLAG3-0 OUT Pulse Width | $2 \times t_{CCLK} - 1$ |     | ns   |

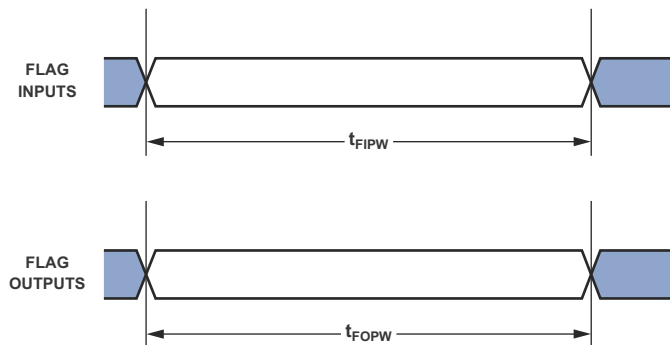


Figure 15. Flags

# ADSP-21261/ADSP-21262/ADSP-21266

## Memory Read—Parallel Port

The specifications in Table 25, Table 26, Figure 16, and Figure 17 are for asynchronous interfacing to memories (and memory-mapped peripherals) when the ADSP-2126x is accessing external memory space.

**Table 25. 8-Bit Memory Read Cycle**

| Parameter                        |  | Min                           | Max                             | Unit |
|----------------------------------|--|-------------------------------|---------------------------------|------|
| <i>Timing Requirements</i>       |  |                               |                                 |      |
| $t_{DRS}$                        | Address/Data 7–0 Setup Before $\overline{RD}$ High | 3.3                           |                                 | ns   |
| $t_{DRH}$                        | Address/Data 7–0 Hold After $\overline{RD}$ High   | 0                             |                                 | ns   |
| $t_{DAD}$                        | Address 15–8 to Data Valid                         |                               | $D + 0.5 \times t_{CCLK} - 3.5$ | ns   |
| <i>Switching Characteristics</i> |  |                               |                                 |      |
| $t_{ALEW}$                       | ALE Pulse Width                                    | $2 \times t_{CCLK} - 2$       |                                 | ns   |
| $t_{ALERW}$                      | ALE Deasserted to Read/Write Asserted              | $1 \times t_{CCLK} - 0.5$     |                                 | ns   |
| $t_{ADAS}^1$                     | Address/Data 15–0 Setup Before ALE Deasserted      | $2.5 \times t_{CCLK} - 2.0$   |                                 | ns   |
| $t_{ADAH}^1$                     | Address/Data 15–0 Hold After ALE Deasserted        | $0.5 \times t_{CCLK} - 0.8$   |                                 | ns   |
| $t_{ALEHZ}^1$                    | ALE Deasserted to Address/Data 7–0 in High-Z       | $0.5 \times t_{CCLK} - 0.8$   | $0.5 \times t_{CCLK} + 2.0$     | ns   |
| $t_{RW}$                         | $\overline{RD}$ Pulse Width                        | $D - 2$                       |                                 | ns   |
| $t_{ADRH}$                       | Address/Data 15–8 Hold After $\overline{RD}$ High  | $0.5 \times t_{CCLK} - 1 + H$ |                                 | ns   |

$D = (\text{The value set by the PPDUR Bits (5–1) in the PPCTL register}) \times t_{CCLK}$

$H = t_{CCLK}$  (if a hold cycle is specified, else  $H = 0$ )

<sup>1</sup> On reset, ALE is an active high cycle. However, it can be reconfigured by software to be active low.

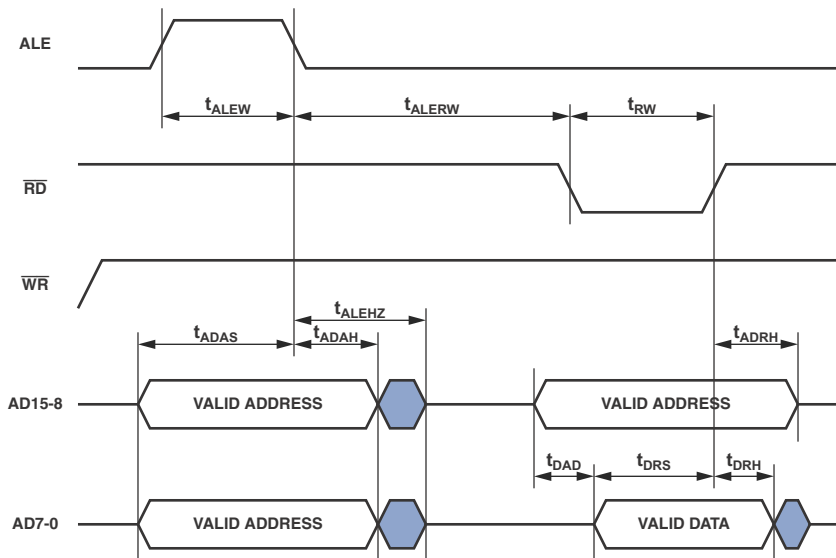


Figure 16. 8-Bit Memory Read Cycle



**Table 26. 16-Bit Memory Read Cycle**

| Parameter                        |   | Min                         | Max                         | Unit |
|----------------------------------|---|-----------------------------|-----------------------------|------|
| <i>Timing Requirements</i>       |   |                             |                             |      |
| $t_{DRS}$                        | Address/Data 15–0 Setup Before $\overline{RD}$ high | 3.3                         |                             | ns   |
| $t_{DRH}$                        | Address/Data 15–0 Hold After $\overline{RD}$ high   | 0                           |                             | ns   |
| <i>Switching Characteristics</i> |   |                             |                             |      |
| $t_{ALEW}$                       | ALE Pulse Width                                     | $2 \times t_{CCLK} - 2$     |                             | ns   |
| $t_{ALERW}$                      | ALE Deasserted to Read/Write Asserted               | $1 \times t_{CCLK} - 0.5$   |                             | ns   |
| $t_{ADAS}^1$                     | Address/Data 15–0 Setup Before ALE Deasserted       | $2.5 \times t_{CCLK} - 2.0$ |                             | ns   |
| $t_{ADAH}^1$                     | Address/Data 15–0 Hold After ALE Deasserted         | $0.5 \times t_{CCLK} - 0.8$ |                             | ns   |
| $t_{ALEHZ}^1$                    | ALE Deasserted to Address/Data 15–0 in High-Z       | $0.5 \times t_{CCLK} - 0.8$ | $0.5 \times t_{CCLK} + 2.0$ | ns   |
| $t_{RW}$                         | $\overline{RD}$ Pulse Width                         | D - 2                       |                             | ns   |

D = (The value set by the PPDUR Bits (5–1) in the PPCTL register)  $\times t_{CCLK}$

H =  $t_{CCLK}$  (if a hold cycle is specified, else H = 0)

<sup>1</sup> On reset, ALE is an active high cycle. However, it can be reconfigured by software to be active low.

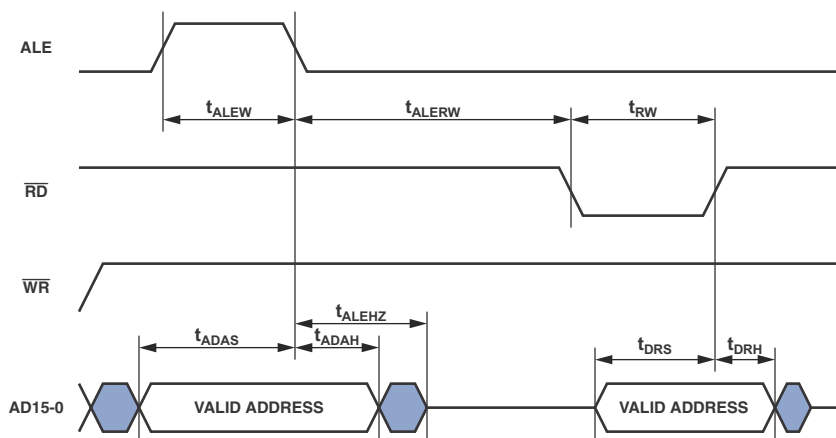


Figure 17. 16-Bit Memory Read Cycle