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Understanding Embedded - DSP (Digital Signal Processors)

Embedded - DSP (Digital Signal Processors) are specialized microprocessors designed to perform complex mathematical computations on digital signals in real-time. Unlike general-purpose processors, DSPs are optimized for high-speed numeric processing tasks, making them ideal for applications that require efficient and precise manipulation of digital data. These processors are fundamental in converting and processing signals in various forms, including audio, video, and communication signals, ensuring that data is accurately interpreted and utilized in embedded systems.

Applications of Embedded - DSP (Digital Signal Processors)

Details	
Product Status	Obsolete
Type	Floating Point
Interface	DAI, SPI
Clock Rate	333MHz
Non-Volatile Memory	ROM (512kB)
On-Chip RAM	384kB
Voltage - I/O	3.30V
Voltage - Core	1.20V
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	144-LQFP Exposed Pad
Supplier Device Package	144-LQFP-EP (20x20)
Purchase URL	https://www.e-xfl.com/product-detail/analog-devices/adsp-21366bswz-1aa

GENERAL DESCRIPTION

The ADSP-2136x SHARC® processor is a member of the SIMD SHARC family of DSPs that feature Analog Devices, Inc., Super Harvard Architecture. The processor is source code-compatible with the ADSP-2126x and ADSP-2116x DSPs, as well as with first generation ADSP-2106x SHARC processors in SISD (single-instruction, single-data) mode. The ADSP-2136x are 32-/40-bit floating-point processors optimized for high performance automotive audio applications. They contain a large on-chip SRAM and ROM, multiple internal buses to eliminate I/O bottlenecks, and an innovative digital audio interface (DAI).

As shown in the functional block diagram on Page 1, the ADSP-2136x uses two computational units to deliver a significant performance increase over the previous SHARC processors on a range of signal processing algorithms. With its SIMD computational hardware, the ADSP-2136x can perform two GFLOPS running at 333 MHz.

Table 1 shows performance benchmarks for these devices. Table 2 shows the features of the individual product offerings.

Table 1. Benchmarks (at 333 MHz)

Benchmark Algorithm	Speed (at 333 MHz)
1024 Point Complex FFT (Radix 4, with reversal)	27.9 µs
FIR Filter (per tap)[1]	1.5 ns
IIR Filter (per biquad)[1]	6.0 ns
Matrix Multiply (pipelined)	
[3×3] × [3×1]	13.5 ns
[4×4] × [4×1]	23.9 ns
Divide (y/x)	10.5 ns
Inverse Square Root	16.3 ns

[1] Assumes two files in multichannel SIMD mode.

Table 2. ADSP-2136x Family Features

Feature	ADSP-21362	ADSP-21363	ADSP-21364	ADSP-21365	ADSP-21366
RAM	3M bit	3M bit	3M bit	3M bit	3M bit
ROM	4M bit	4M bit	4M bit	4M bit	4M bit
Audio Decoders in ROM[1]	No	No	No	Yes	Yes
Pulse-Width Modulation	Yes	Yes	Yes	Yes	Yes
S/PDIF	Yes	No	Yes	Yes	Yes
DTCP[2]	Yes	No	No	Yes	No
SRC SNR Performance	–128 dB	No SRC	–140 dB	–128 dB	–128 dB

[1] Audio decoding algorithms include PCM, Dolby Digital EX, Dolby Pro Logic IIx, DTS 96/24, Neo:6, DTS ES, MPEG-2 AAC, MP3, and functions like bass management, delay, speaker equalization, graphic equalization, and more. Decoder/post-processor algorithm combination support varies depending upon the chip version and the system configurations. Please visit www.analog.com for complete information.

[2] The ADSP-21362 and ADSP-21365 processors provide the Digital Transmission Content Protection protocol, a proprietary security protocol. Contact your Analog Devices sales office for more information.

The diagram on Page 1 shows the two clock domains that make up the ADSP-2136x processors. The core clock domain contains the following features:

- Two processing elements, each of which comprises 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
- One periodic interval timer with pinout
- On-chip SRAM (3M bit)
- On-chip mask-programmable ROM (4M bit)
- JTAG test access port for emulation and boundary scan. The JTAG provides software debug through user breakpoints, which allow flexible exception handling.

The diagram on Page 1 also shows the following architectural features:

- I/O processor that handles 32-bit DMA for the peripherals
- Six full duplex serial ports
- Two SPI-compatible interface ports—primary on dedicated pins, secondary on DAI pins
- 8-bit or 16-bit parallel port that supports interfaces to off-chip memory peripherals
- Digital audio interface that includes two precision clock generators (PCG), an input data port with eight serial interfaces (IDP), an S/PDIF receiver/transmitter, 8-channel asynchronous sample rate converter (ASRC), DTCP cipher, six serial ports, a 20-bit parallel input data port (PDAP), 10 interrupts, six flag outputs, six flag inputs, three timers, and a flexible signal routing unit (SRU)

audio channels in I2S, left-justified sample pair, or right-justified mode. One frame sync cycle indicates one 64-bit left/right pair, but data is sent to the FIFO as 32-bit words (that is, one-half of a frame at a time). The processor supports 24- and 32-bit I^2S, 24- and 32-bit left-justified, and 24-, 20-, 18- and 16-bit right-justified formats.

Precision Clock Generator (PCG)

The precision clock generators (PCG) consist of two units, each of which generates a pair of signals (clock and frame sync) derived from a clock input signal. The units, A and B, are identical in functionality and operate independently of each other. The two signals generated by each unit are normally used as a serial bit clock/frame sync pair.

Peripheral Timers

The following three general-purpose timers 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

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.

I/O PROCESSOR FEATURES

The processor's I/O provides many channels of DMA and controls the extensive set of peripherals described in the previous sections.

DMA Controller

The processor's on-chip DMA controllers allow 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 processor's internal memory and its serial ports, the SPI-compatible (serial peripheral interface) ports, the IDP (input data port), the parallel data acquisition port (PDAP), or the parallel port (PP). See Table 4.

Table 4. DMA Channels

Peripheral	ADSP-2136x
SPORTs	12
IDP/PDAP	8
SPI	2
MTM/DTCP	2
Parallel Port	1
Total DMA Channels	25

SYSTEM DESIGN

The following sections provide an introduction to system design options and power supply issues.

Program Booting

The internal memory of the processor 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 in Table 5. Selection of the boot source is controlled via the SPI as either a master or slave device, or it can immediately begin executing from ROM.

Table 5. Boot Mode Selection

BOOT_CFG1–0	Booting Mode
00	SPI Slave Boot
01	SPI Master Boot
10	Parallel Port Boot via EPROM
11	No booting occurs. Processor executes from internal ROM after reset.

Phase-Locked Loop

The processors use 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 32:1, 16:1, and 6:1. 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 1, 2, 4, and 8.

Power Supplies

The processor has a separate power supply connection 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 for K, B, and Y grade models, and the 1.0 V requirement for Y models. (For information on the temperature ranges offered for this product, see Operating Conditions on Page 14, Package Information on Page 16, and Ordering Guide on Page 56.) 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 processor'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 3. (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 3 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.

PACKAGE INFORMATION

The information presented in Figure 4 provides details about the package branding for the ADSP-2136x processor. For a complete listing of product availability, see Ordering Guide on Page 56.

Figure 4. Typical Package Brand

Table 7. Package Brand Information

Brand Key	Field Description
t	Temperature Range
pp	Package Type
Z	RoHS Compliant Designation
cc	See Ordering Guide
vvvvvv.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 the Engineer-to-Engineer Note *"Estimating Power for the ADSP-21362 SHARC Processors"* (EE-277) for detailed thermal and power information regarding maximum power dissipation. For information on package thermal specifications, see Thermal Characteristics on Page 47.

ABSOLUTE MAXIMUM RATINGS

Stresses greater than those listed in Table 8 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 8. Absolute Maximum Ratings

Parameter	Rating
Internal (Core) Supply Voltage (V_{DDINT})	–0.3 V to +1.5 V
Analog (PLL) Supply Voltage (A_{VDD})	–0.3 V to +1.5 V
External (I/O) Supply Voltage (V_{DDEXT})	–0.3 V to +4.6 V
Input Voltage	–0.5 V to +3.8 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 While Biased	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. For voltage reference levels, see Figure 39 on Page 46 under Test Conditions.

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.

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.

Core Clock Requirements

The processor's internal clock (a multiple of CLKIN) provides the clock signal for timing internal memory, processor core, and serial ports. During reset, program the ratio between the processor's internal clock frequency and external (CLKIN) clock frequency with the CLK_CFG1–0 pins.

The processor's internal clock switches at higher frequencies than the system input clock (CLKIN). To generate the internal clock, the processor uses an internal phase-locked loop (PLL, see Figure 5). This PLL-based clocking minimizes the skew between the system clock (CLKIN) signal and the processor's internal clock.

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 11.

- The product of CLKIN and PLLM must never exceed 1/2 f_{VCO} (max) in Table 11 if the input divider is not enabled (INDIV = 0).
- The product of CLKIN and PLLM must never exceed f_{VCO} (max) in Table 11 if the input divider is enabled (INDIV = 1).

The VCO frequency is calculated as follows:

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

where:

f_{VCO} = 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.

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

f_{INPUT} = 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 the clock periods that are a function of CLKIN and the appropriate ratio control shown in Table 9. All of the timing specifications for the ADSP-2136x peripherals are defined in relation to t_{PCLK}. Refer to the peripheral specific section for each peripheral's timing information.

Table 9. Clock Periods

Timing Requirements	Description
t_{CK}	CLKIN Clock Period
t_{CCLK}	Processor Core Clock Period
t_{PCLK}	Peripheral Clock Period = 2 × t_{CCLK}

Figure 5 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, refer to the *ADSP-2136x SHARC Processor Hardware Reference*.

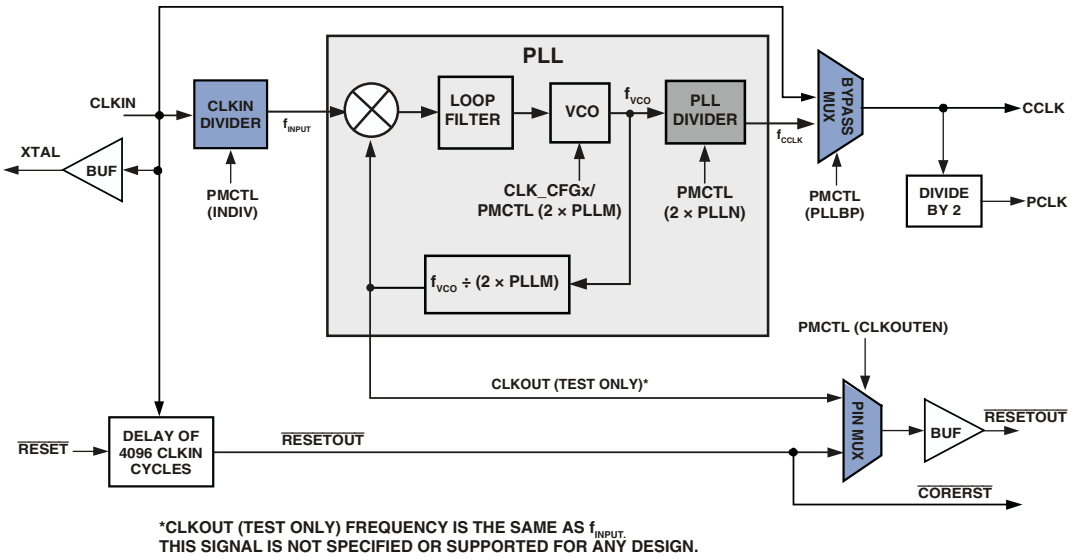


Figure 5. Core Clock and System Clock Relationship to CLKIN

Clock Input

Table 11. Clock Input

Parameter		200 MHz[1]		333 MHz[2]		Unit
		Min	Max	Min	Max	
Timing Requirements						
t_{CK}	CLKIN Period	30[3]	100	18	100	ns
t_{CKL}	CLKIN Width Low	12.5		7.5		ns
t_{CKH}	CLKIN Width High	12.5		7.5		ns
t_{CKRF}	CLKIN Rise/Fall (0.4 V to 2.0 V)		3		3	ns
t_{CCLK}[4]	CCLK Period	5.0	10	3.0	10	ns
t_{VCO}[5]	VCO Frequency	200	600	200	800	MHz
t_{CKJ}[6, 7]	CLKIN Jitter Tolerance	–250	+250	–250	+250	ps

[1] Applies to all 200 MHz models. See Ordering Guide on Page 56.
[2] Applies to all 333 MHz models. See Ordering Guide on Page 56.
[3] Applies only for CLK_CFG1–0 = 00 and default values for PLL control bits in the PMCTL register.
[4] Any changes to PLL control bits in the PMCTL register must meet core clock timing specification t_{CCLK}.
[5] See Figure 5 on Page 17 for VCO diagram.
[6] Actual input jitter should be combined with AC specifications for accurate timing analysis.
[7] Jitter specification is maximum peak-to-peak time interval error (TIE) jitter.

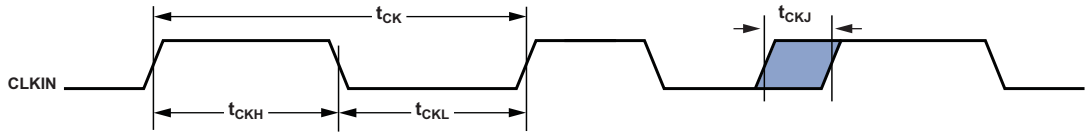


Figure 7. Clock Input

Clock Signals

The processor can use an external clock or a crystal. Refer to the CLKIN pin description in Table 6 on Page 11. The user application program can configure the processor to use its internal clock generator by connecting the necessary components to the CLKIN and XTAL pins. Figure 8 shows the component connections used for a fundamental frequency crystal operating in parallel mode.

Note that the clock rate is achieved using a 16.67 MHz crystal and a PLL multiplier ratio 16:1. (CCLK:CLKIN achieves a clock speed of 266.72 MHz.) To achieve the full core clock rate, programs need to configure the multiplier bits in the PMCTL register.

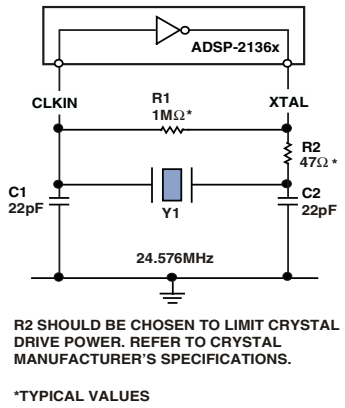


Figure 8. Recommended Circuit for Fundamental Mode Crystal Operation

Core Timer

The following timing specification applies to FLAG3 when it is configured as the core timer (TMREXP pin).

Table 14. Core Timer

Parameter		Min	Unit
Switching Characteristic			
t_{WCTIM}	TMREXP Pulse Width	$2 \times t_{PCLK} - 1$	ns

Figure 11. Core Timer

Timer PWM_OUT Cycle Timing

The following timing specification applies to Timer0, Timer1, and Timer2 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 15. Timer PWM_OUT Timing

Parameter		Min	Max	Unit
Switching Characteristic				
t_{PWMO}	Timer Pulse Width Output	$2 \times t_{PCLK} - 1$	$2 \times (2^{31} - 1) \times t_{PCLK}$	ns

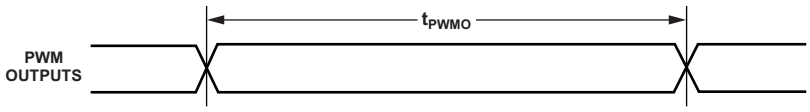


Figure 12. Timer PWM_OUT Timing

Memory Read—Parallel Port

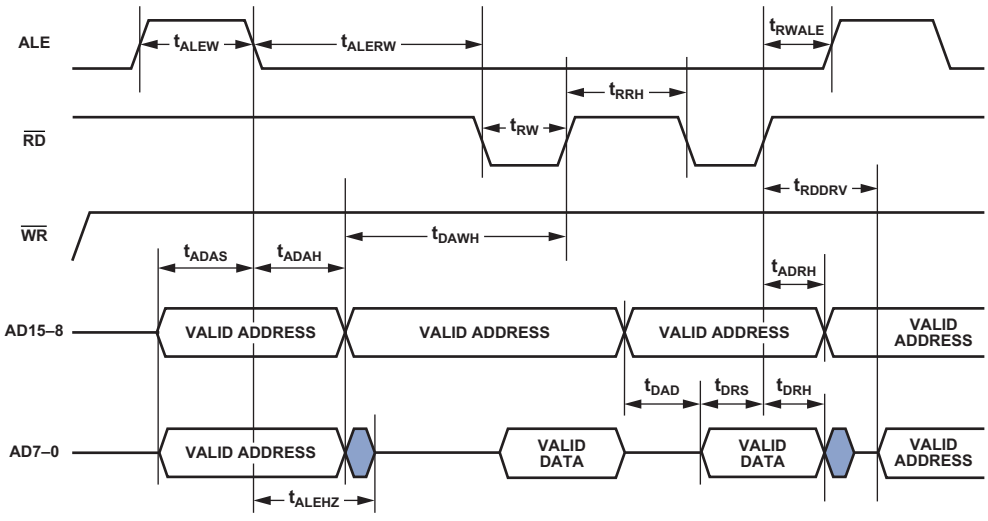
Use these specifications for asynchronous interfacing to memories (and memory-mapped peripherals) when the processor is accessing external memory space.

Table 20. 8-Bit Memory Read Cycle

Parameter		K and B Grade Min	K and B Grade Max	Y Grade Min	Y Grade Max	Unit
Timing Requirements						
t_{DRS}	AD7–0 Data Setup Before $\overline{RD}$ High	3.3		4.5		ns
t_{DRH}	AD7–0 Data Hold After $\overline{RD}$ High	0		0		ns
t_{DAD}	AD15–8 Address to AD7–0 Data Valid		D + t_{PCLK} – 5.0		D + t_{PCLK} – 5.0	ns
Switching Characteristics						
t_{ALEW}	ALE Pulse Width	2 × t_{PCLK} – 2.0		2 × t_{PCLK} – 2.0		ns
t_{ADAS}[1]	AD15–0 Address Setup Before ALE Deasserted	t_{PCLK} – 2.5		t_{PCLK} – 2.5		ns
t_{RRH}	Delay Between $\overline{RD}$ Rising Edge to Next Falling Edge	H + t_{PCLK} – 1.4		H + t_{PCLK} – 1.4		ns
t_{ALERW}	ALE Deasserted to Read Asserted	2 × t_{PCLK} – 3.8		2 × t_{PCLK} – 3.8		ns
t_{RWALE}	Read Deasserted to ALE Asserted	F + H + 0.5		F + H + 0.5		ns
t_{ADAH}[1]	AD15–0 Address Hold After ALE Deasserted	t_{PCLK} – 2.3		t_{PCLK} – 2.3		ns
t_{ALEHZ}[1]	ALE Deasserted to AD7–0 Address in High-Z	t_{PCLK}	t_{PCLK} + 3.0	t_{PCLK}	t_{PCLK} + 3.8	ns
t_{RW}	$\overline{RD}$ Pulse Width	D – 2.0		D – 2.0		ns
t_{RDDRV}	AD7–0 ALE Address Drive After Read High	F + H + t_{PCLK} – 2.3		F + H + t_{PCLK} – 2.3		ns
t_{ADRH}	AD15–8 Address Hold After $\overline{RD}$ High	H		H		ns
t_{DAWH}	AD15–8 Address to $\overline{RD}$ High	D + t_{PCLK} – 4.0		D + t_{PCLK} – 4.0		ns

D = (The value set by the PPDUR Bits (5–1) in the PPCTL register) × t_{PCLK}
H = t_{PCLK} (if a hold cycle is specified, else H = 0)
F = 7 × t_{PCLK} (if FLASH_MODE is set, else F = 0)

[1] On reset, ALE is an active high cycle. However, it can be configured by software to be active low.



NOTE: MEMORY READS ALWAYS OCCUR IN GROUPS OF FOUR BETWEEN ALE CYCLES. THIS FIGURE SHOWS ONLY TWO MEMORY READS TO PROVIDE THE NECESSARY TIMING INFORMATION.

Figure 17. Read Cycle for 8-Bit Memory Timing

Serial Ports

To determine whether communication is possible between two devices at clock speed n, the following specifications must be confirmed: 1) frame sync (FS) delay and frame sync setup and hold, 2) data delay and data setup and hold, and 3) serial clock (SCLK) width.

Serial port signals are routed to the DAI_P20–1 pins using the SRU. Therefore, the timing specifications provided below are valid at the DAI_P20–1 pins.

Table 24. Serial Ports—External Clock

Parameter		K and B Grade Min	K and B Grade Max	Y Grade Max	Unit
Timing Requirements					
t_{SFSE}[1]	Frame Sync Setup Before SCLK (Externally Generated Frame Sync in Either Transmit or Receive Mode)	2.5			ns
t_{HFSE}[1]	Frame Sync Hold After SCLK (Externally Generated Frame Sync in Either Transmit or Receive Mode)	2.5			ns
t_{SDRE}[1]	Receive Data Setup Before Receive SCLK	2.5			ns
t_{HDRE}[1]	Receive Data Hold After SCLK	2.5			ns
t_{SCLKW}	SCLK Width	$(t_{PCLK} \times 4) \div 2 - 2$			ns
t_{SCLK}	SCLK Period	$t_{PCLK} \times 4$			ns
Switching Characteristics					
t_{DFSE}[2]	Frame Sync Delay After SCLK (Internally Generated Frame Sync in Either Transmit or Receive Mode)		9.5	11	ns
t_{HOFSE}[2]	Frame Sync Hold After SCLK (Internally Generated Frame Sync in Either Transmit or Receive Mode)	2			ns
t_{DDTE}[2]	Transmit Data Delay After Transmit SCLK		9.5	11	ns
t_{HDTE}[2]	Transmit Data Hold After Transmit SCLK	2			ns

[1] Referenced to sample edge.
[2] Referenced to drive edge.

Table 25. Serial Ports—Internal Clock

Parameter		K and B Grade Min	K and B Grade Max	Y Grade Max	Unit
Timing Requirements					
t_{SFSI}[1]	Frame Sync Setup Before SCLK (Externally Generated Frame Sync in Either Transmit or Receive Mode)	7			ns
t_{HFSI}[1]	Frame Sync Hold After SCLK (Externally Generated Frame Sync in Either Transmit or Receive Mode)	2.5			ns
t_{SDRI}[1]	Receive Data Setup Before SCLK	7			ns
t_{HDRI}[1]	Receive Data Hold After SCLK	2.5			ns
Switching Characteristics					
t_{DFSI}[2]	Frame Sync Delay After SCLK (Internally Generated Frame Sync in Transmit Mode)		3	3.5	ns
t_{HOFSI}[2]	Frame Sync Hold After SCLK (Internally Generated Frame Sync in Transmit Mode)	–1.0			ns
t_{DFSIR}[2]	Frame Sync Delay After SCLK (Internally Generated Frame Sync in Receive Mode)		8	9.5	ns
t_{HOFSIR}[2]	Frame Sync Hold After SCLK (Internally Generated Frame Sync in Receive Mode)	–1.0			ns
t_{DDTI}[2]	Transmit Data Delay After SCLK		3	4.0	ns
t_{HDTI}[2]	Transmit Data Hold After SCLK	–1.0			ns
t_{SCLKIW}	Transmit or Receive SCLK Width	$2 \times t_{PCLK} - 2$	$2 \times t_{PCLK} + 2$	$2 \times t_{PCLK} + 2$	ns

[1] Referenced to the sample edge.
[2] Referenced to drive edge.

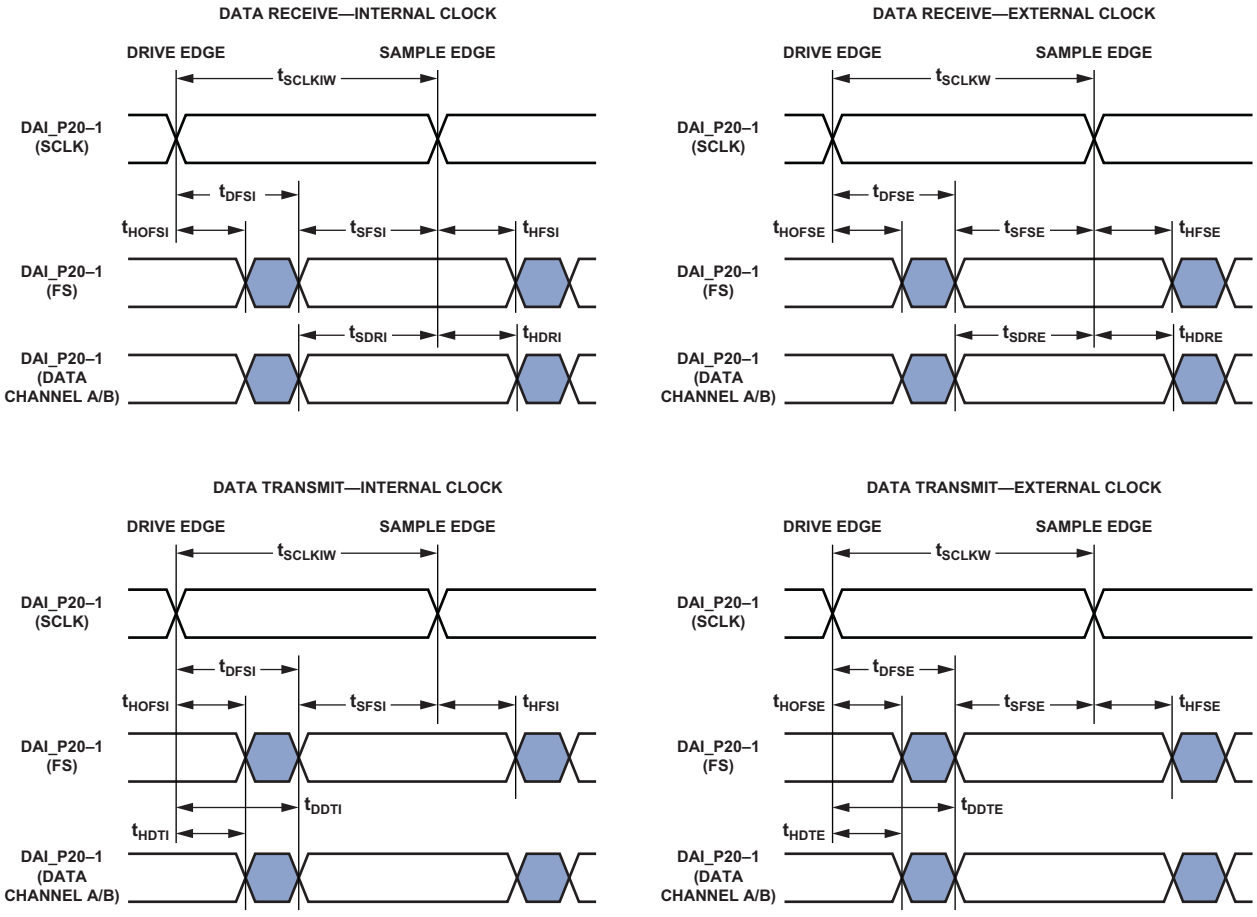


Figure 21. Serial Ports

Table 27. Serial Ports—Enable and Three-State

Parameter		K and B Grade Min	K and B Grade Max	Y Grade Max	Unit
Switching Characteristics					
t_{DDTEN}[1]	Data Enable from External Transmit SCLK	2			ns
t_{DDTTE}[1]	Data Disable from External Transmit SCLK		7	8.5	ns
t_{DDTIN}[1]	Data Enable from Internal Transmit SCLK	–1			ns

[1] Referenced to drive edge.

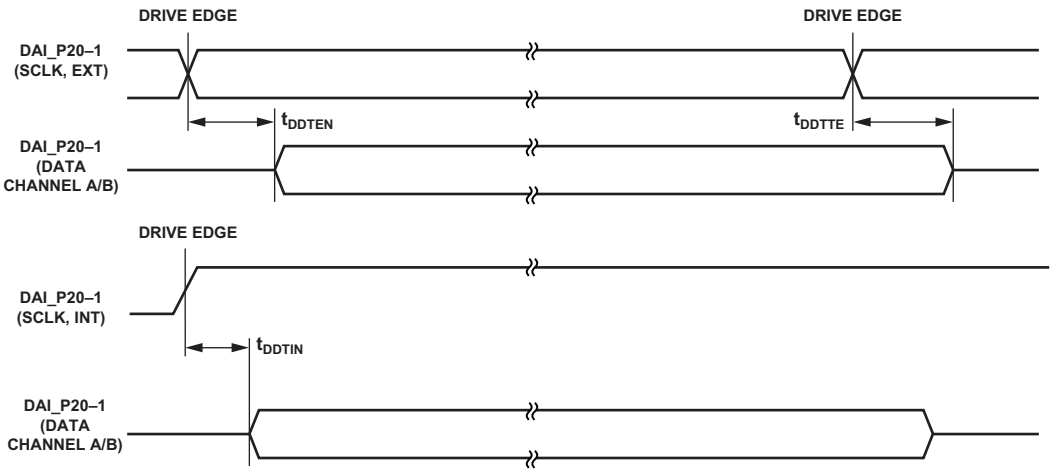


Figure 23. Enable and Three-State

S/PDIF Transmitter

Serial data input to the S/PDIF transmitter can be formatted as left justified, I^{2}S, or right justified with word widths of 16-, 18-, 20-, or 24-bits. The following sections provide timing for the transmitter.

S/PDIF Transmitter-Serial Input Waveforms

Figure 29 shows the right-justified mode. Frame sync is high for the left channel and low for the right channel. Data is valid on the rising edge of serial clock. The MSB is delayed the minimum in 24-bit output mode or the maximum in 16-bit output mode from a frame sync transition, so that when there are 64 serial clock periods per frame sync period, the LSB of the data is right-justified to the next frame sync transition.

Table 33. S/PDIF Transmitter Right-Justified Mode

Parameter		Nominal	Unit
Timing Requirement			
t_{RJD}	FS to MSB Delay in Right-Justified Mode		
	16-Bit Word Mode	16	SCLK
	18-Bit Word Mode	14	SCLK
	20-Bit Word Mode	12	SCLK
	24-Bit Word Mode	8	SCLK

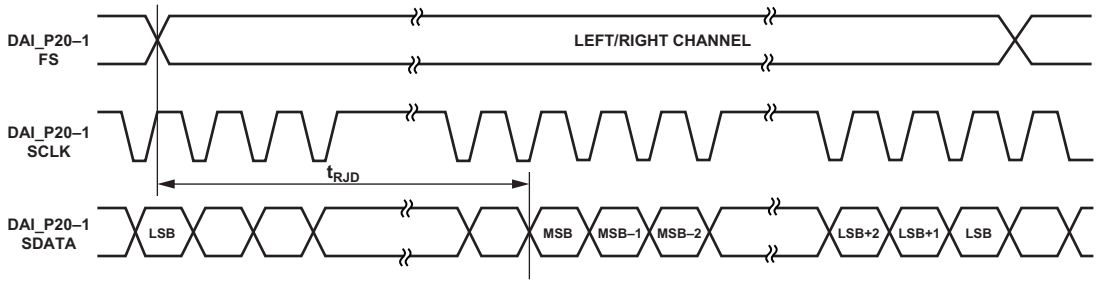


Figure 29. Right-Justified Mode

Figure 30 shows the default I²S-justified mode. The frame sync is low for the left channel and high for the right channel. Data is valid on the rising edge of serial clock. The MSB is left-justified to the frame sync transition but with a delay.

Table 34. S/PDIF Transmitter I²S Mode

Parameter		Nominal	Unit
Timing Requirement			
t_{I2SD}	FS to MSB Delay in I²S Mode	1	SCLK

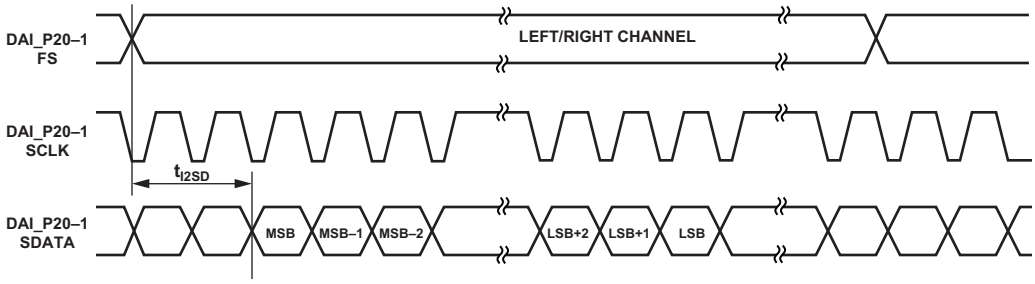


Figure 30. I²S-Justified Mode

Figure 31 shows the left-justified mode. The frame sync is high for the left channel and low for the right channel. Data is valid on the rising edge of serial clock. The MSB is left-justified to the frame sync transition with no delay.

Table 35. S/PDIF Transmitter Left-Justified Mode

Parameter		Nominal	Unit
Timing Requirement			
t_{LJD}	FS to MSB Delay in Left-Justified Mode	0	SCLK

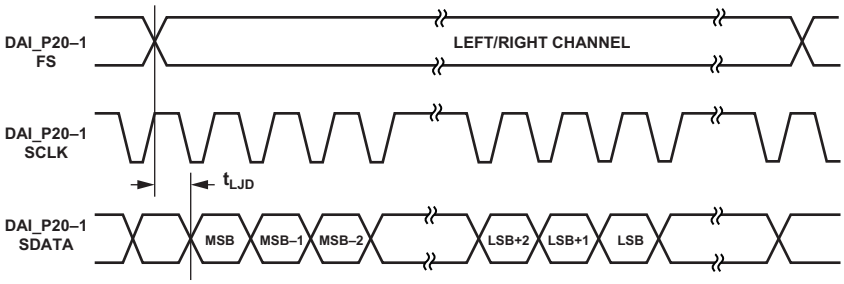


Figure 31. Left-Justified Mode

S/PDIF Transmitter Input Data Timing

The timing requirements for the S/PDIF transmitter are given in Table 36. Input signals are routed to the DAI_P20–1 pins using the SRU. Therefore, the timing specifications provided below are valid at the DAI_P20–1 pins.

Table 36. S/PDIF Transmitter Input Data Timing

Parameter		K Grade Min	K Grade Max	Y Grade Min	Y Grade Max	Unit
Timing Requirements						
t_{SISFS}[1]	Frame Sync Setup Before Serial Clock Rising Edge	3		3		ns
t_{SIHFS}[1]	Frame Sync Hold After Serial Clock Rising Edge	3		3		ns
t_{SISD}[1]	Data Setup Before Serial Clock Rising Edge	3		3		ns
t_{SIHD}[1]	Data Hold After Serial Clock Rising Edge	3		3		ns
$t_{SITXCLKW}$	Transmit Clock Width	9		9.5		ns
$t_{SITXCLK}$	Transmit Clock Period	20		20		ns
$t_{SISCLKW}$	Clock Width	36		36		ns
t_{SISCLK}	Clock Period	80		80		ns

[1] The serial clock, data and frame sync signals can come from any of the DAI pins.The serial clock and frame sync signals can also come via PCG or SPORTs. PCG's input can be either CLKIN or any of the DAI pins.

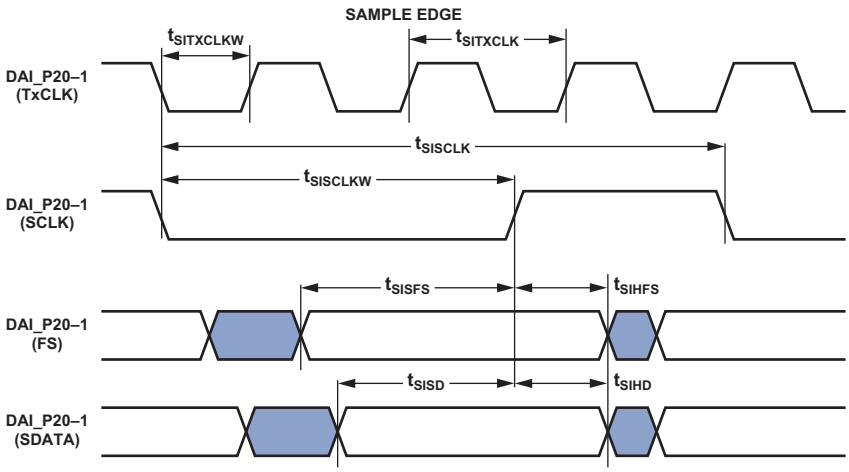


Figure 32. S/PDIF Transmitter Input Timing

Oversampling Clock (TxCLK) Switching Characteristics

The S/PDIF transmitter requires an oversampling clock input. This high frequency clock (TxCLK) input is divided down to generate the internal biphase clock.

Table 37. Oversampling Clock (TxCLK) Switching Characteristics

Parameter	Max	Unit
Frequency for TxCLK = 384 × Frame Sync	Oversampling Ratio × Frame Sync <= $1/t_{SITXCLK}$	MHz
Frequency for TxCLK = 256 × Frame Sync	49.2	MHz
Frame Rate (FS)	192.0	kHz

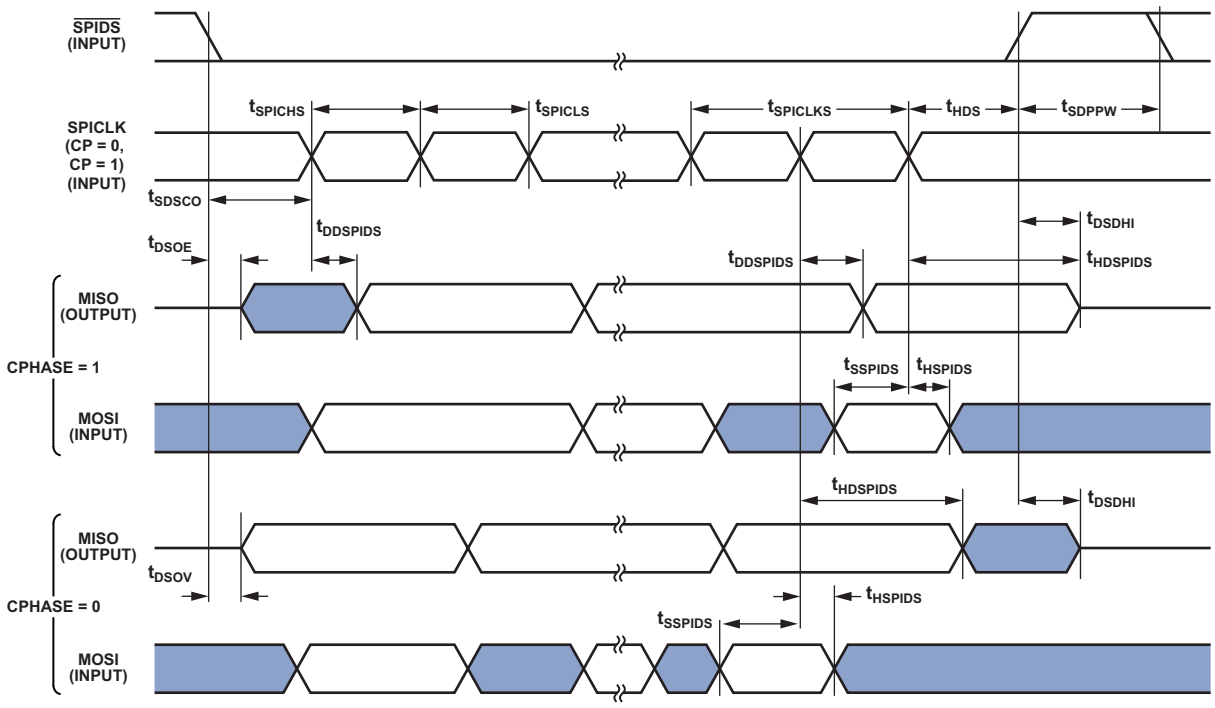


Figure 35. SPI Slave Timing

OUTPUT DRIVE CURRENTS

Figure 37 shows typical I-V characteristics for the output drivers of the processor. The curves represent the current drive capability of the output drivers as a function of output voltage.

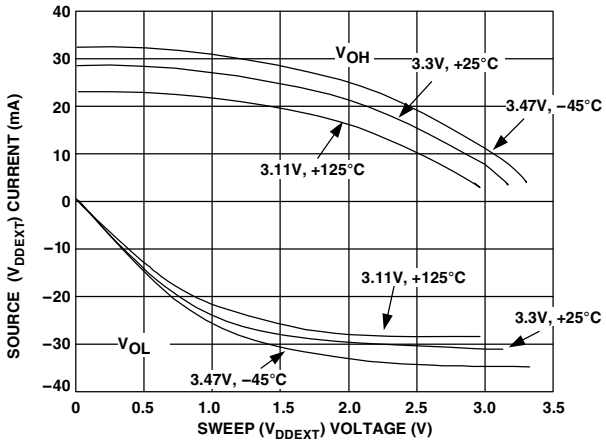


Figure 37. ADSP-2136x Typical Drive

TEST CONDITIONS

The ac signal specifications (timing parameters) appear in Table 12 on Page 20 through Table 41 on Page 45. These include output disable time, output enable time, and capacitive loading. The timing specifications for the SHARC apply for the voltage reference levels in Figure 38.

Timing is measured on signals when they cross the 1.5 V level as described in Figure 39. All delays (in nanoseconds) are measured between the point that the first signal reaches 1.5 V and the point that the second signal reaches 1.5 V.

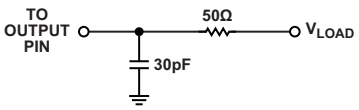


Figure 38. Equivalent Device Loading for AC Measurements (Includes All Fixtures)

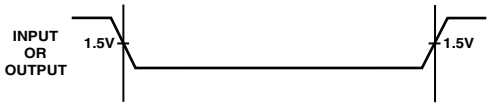


Figure 39. Voltage Reference Levels for AC Measurements

CAPACITIVE LOADING

Output delays and holds are based on standard capacitive loads: 30 pF on all pins (see Figure 38). Figure 42 shows graphically how output delays and holds vary with load capacitance. The graphs of Figure 40, Figure 41, and Figure 42 may not be linear outside the ranges shown for Typical Output Delay versus Load Capacitance and Typical Output Rise Time (20% to 80%, V = Min) versus Load Capacitance.

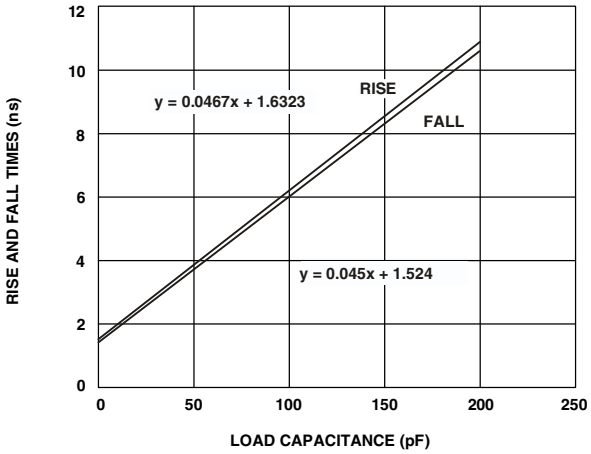


Figure 40. Typical Output Rise/Fall Time (20% to 80%, V_{DDEXT} = Max)

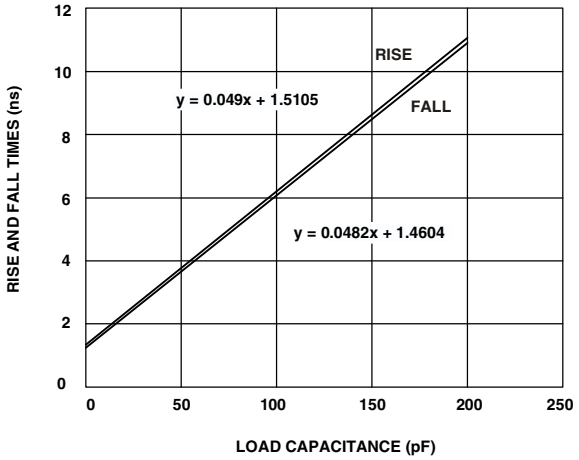


Figure 41. Typical Output Rise/Fall Time (20% to 80%, V_{DDEXT} = Min)

144-LEAD LQFP_EP PIN CONFIGURATIONS

The following table shows the processor's pin names and, when applicable, their default function after reset in parentheses.

Table 45. LQFP_EP Pin Assignments

Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.
V_{DDINT}	1	V_{DDINT}	37	V_{DDEXT}	73	GND	109
CLK_CFG0	2	GND	38	GND	74	V_{DDINT}	110
CLK_CFG1	3	$\overline{RD}$	39	V_{DDINT}	75	GND	111
BOOT_CFG0	4	ALE	40	GND	76	V_{DDINT}	112
BOOT_CFG1	5	AD15	41	DAI_P10 (SD2B)	77	GND	113
GND	6	AD14	42	DAI_P11 (SD3A)	78	V_{DDINT}	114
V_{DDEXT}	7	AD13	43	DAI_P12 (SD3B)	79	GND	115
GND	8	GND	44	DAI_P13 (SCLK3)	80	V_{DDEXT}	116
V_{DDINT}	9	V_{DDEXT}	45	DAI_P14 (SFS3)	81	GND	117
GND	10	AD12	46	DAI_P15 (SD4A)	82	V_{DDINT}	118
V_{DDINT}	11	V_{DDINT}	47	V_{DDINT}	83	GND	119
GND	12	GND	48	GND	84	V_{DDINT}	120
V_{DDINT}	13	AD11	49	GND	85	$\overline{RESET}$	121
GND	14	AD10	50	DAI_P16 (SD4B)	86	$\overline{SPIDS}$	122
FLAG0	15	AD9	51	DAI_P17 (SD5A)	87	GND	123
FLAG1	16	AD8	52	DAI_P18 (SD5B)	88	V_{DDINT}	124
AD7	17	DAI_P1 (SD0A)	53	DAI_P19 (SCLK5)	89	SPICLK	125
GND	18	V_{DDINT}	54	V_{DDINT}	90	MISO	126
V_{DDINT}	19	GND	55	GND	91	MOSI	127
GND	20	DAI_P2 (SD0B)	56	GND	92	GND	128
V_{DDEXT}	21	DAI_P3 (SCLK0)	57	V_{DDEXT}	93	V_{DDINT}	129
GND	22	GND	58	DAI_P20 (SFS5)	94	V_{DDEXT}	130
V_{DDINT}	23	V_{DDEXT}	59	GND	95	A_{vdd}	131
AD6	24	V_{DDINT}	60	V_{DDINT}	96	A_{vss}	132
AD5	25	GND	61	FLAG2	97	GND	133
AD4	26	DAI_P4 (SFS0)	62	FLAG3	98	$\overline{RESETOUT}$	134
V_{DDINT}	27	DAI_P5 (SD1A)	63	V_{DDINT}	99	$\overline{EMU}$	135
GND	28	DAI_P6 (SD1B)	64	GND	100	TDO	136
AD3	29	DAI_P7 (SCLK1)	65	V_{DDINT}	101	TDI	137
AD2	30	V_{DDINT}	66	GND	102	$\overline{TRST}$	138
V_{DDEXT}	31	GND	67	V_{DDINT}	103	TCK	139
GND	32	V_{DDINT}	68	GND	104	TMS	140
AD1	33	GND	69	V_{DDINT}	105	GND	141
AD0	34	DAI_P8 (SFS1)	70	GND	106	CLKIN	142
$\overline{WR}$	35	DAI_P9 (SD2A)	71	V_{DDINT}	107	XTAL	143
V_{DDINT}	36	V_{DDINT}	72	V_{DDINT}	108	V_{DDEXT}	144
						GND	145*

*The ePAD is electrically connected to GND inside the chip (see Figure 43 and Figure 44), therefore connecting the pad to GND is optional. For better thermal performance the ePAD should be soldered to the board and thermally connected to the GND plane with vias.

Table 46. BGA Pin Assignments (Continued)

Ball Name	Ball No.	Ball Name	Ball No.	Ball Name	Ball No.	Ball Name	Ball No.
AD5	J01	AD3	K01	AD2	L01	AD0	M01
AD4	J02	V_{DDINT}	K02	AD1	L02	$\overline{WR}$	M02
GND	J04	GND	K04	GND	L04	GND	M03
GND	J05	GND	K05	GND	L05	GND	M12
GND	J06	GND	K06	GND	L06	DAI_P12 (SD3B)	M13
GND	J09	GND	K09	GND	L09	DAI_P13 (SCLK3)	M14
GND	J10	GND	K10	GND	L10		
GND	J11	GND	K11	GND	L11		
V_{DDINT}	J13	GND	K13	GND	L13		
DAI_P16 (SD4B)	J14	DAI_P15 (SD4A)	K14	DAI_P14 (SFS3)	L14		
AD15	N01	AD14	P01				
ALE	N02	AD13	P02				
$\overline{RD}$	N03	AD12	P03				
V_{DDINT}	N04	AD11	P04				
V_{DDEXT}	N05	AD10	P05				
AD8	N06	AD9	P06				
V_{DDINT}	N07	DAI_P1 (SD0A)	P07				
DAI_P2 (SD0B)	N08	DAI_P3 (SCLK0)	P08				
V_{DDEXT}	N09	DAI_P5 (SD1A)	P09				
DAI_P4 (SFS0)	N10	DAI_P6 (SD1B)	P10				
V_{DDINT}	N11	DAI_P7 (SCLK1)	P11				
V_{DDINT}	N12	DAI_P8 (SFS1)	P12				
GND	N13	DAI_P9 (SD2A)	P13				
DAI_P10 (SD2B)	N14	DAI_P11 (SD3A)	P14				

Figure 45 and Figure 46 show BGA pin assignments from the bottom and top, respectively.

Note: Use the center block of ground pins to provide thermal pathways to your printed circuit board's ground plane.

ORDERING GUIDE

Model[1]	Notes	Temperature Range[2]	Instruction Rate	On-Chip SRAM	ROM	Package Description	Package Option
ADSP-21363KBC-1AA		0°C to +70°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21363KBCZ-1AA		0°C to +70°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21363KSWZ-1AA		0°C to +70°C	333 MHz	3M Bit	4M Bit	144-Lead LQFP_EP	SW-144-1
ADSP-21363BBC-1AA		–40°C to +85°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21363BBCZ-1AA		–40°C to +85°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21363BSWZ-1AA		–40°C to +85°C	333 MHz	3M Bit	4M Bit	144-Lead LQFP_EP	SW-144-1
ADSP-21363YSWZ-2AA	3	–40°C to +105°C	200 MHz	3M Bit	4M Bit	144-Lead LQFP_EP	SW-144-1
ADSP-21364KBCZ-1AA		0°C to +70°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21364KSWZ-1AA		0°C to +70°C	333 MHz	3M Bit	4M Bit	144-Lead LQFP_EP	SW-144-1
ADSP-21364BBCZ-1AA		–40°C to +85°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21364BSWZ-1AA		–40°C to +85°C	333 MHz	3M Bit	4M Bit	144-Lead LQFP_EP	SW-144-1
ADSP-21364YSWZ-2AA		–40°C to +105°C	200 MHz	3M Bit	4M Bit	144-Lead LQFP_EP	SW-144-1
ADSP-21366KBCZ-1AR	3, 4, 5	0°C to +70°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21366KBCZ-1AA	3, 4	0°C to +70°C	333 MHz	3M Bit	4M Bit	136-Ball CSP_BGA	BC-136-1
ADSP-21366KSWZ-1AA	3, 4	0°C to +70°C	333 MHz	3M Bit	4M Bit	144-Lead LQFP_EP	SW-144-1

[1] Z = RoHS compliant part.

[2] Referenced temperature is ambient temperature. The ambient temperature is not a specification. Please see Operating Conditions on Page 14 for junction temperature (T_J) specification which is the only temperature specification.

[3] License from Dolby Laboratories, Inc., and Digital Theater Systems (DTS) required for these products.

[4] Available with a wide variety of audio algorithm combinations sold as part of a chipset and bundled with necessary software. For a complete list, visit our website at www.analog.com/sharc.

[5] R = Tape and reel.