TigerSHARC® DSP Microcomputer

Preliminary Technical Data ADSP-TS101S

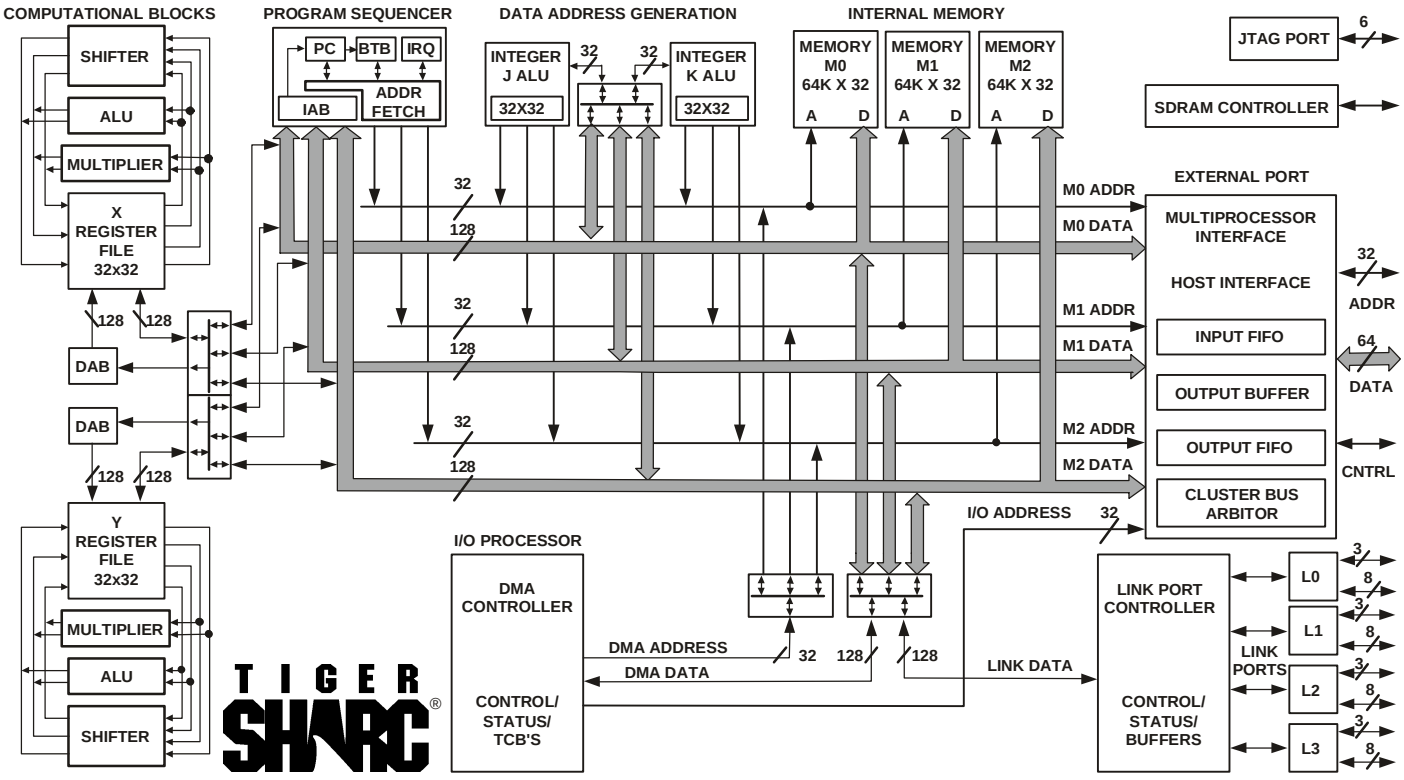
KEY FEATURES

- Operates at 250 MHz, 4.0 ns Instruction Cycle Rate
- Has 6M Bits of Internal—On-Chip—SRAM Memory
- Comes in Either a 19×19 mm (484-Ball) or 27×27 mm (625-Ball) PBGA Package
- Contains Dual Computation Blocks—Each Containing an ALU, a Multiplier, a Shifter, and a Register File
- Contains Dual Integer ALUs, providing Data Addressing and Pointer Manipulation
- Includes an External Port, Four Link Ports, SDRAM Controller, Programmable Flag Pins, Two Timers, and Timer Expired Pin for System Integration
- Includes 1149.1 IEEE Compliant JTAG Test Access Port for On-Chip Emulation
- Has On-Chip Arbitration for Glueless Multiprocessing With up to Eight TigerSHARC DSPs on a Common Bus

KEY BENEFITS

- Provides High-Performance Static Superscalar DSP Operations, Optimized for Telecommunications Infrastructure and Other Large, Demanding Multiprocessor DSP Applications
- Performs Exceptionally Well on DSP Algorithm and I/O Benchmarks (See Benchmarks in Table 1 and Table 2)
- Includes DMA Controller Support on 14 DMA Channels, Performing Low-Overhead DMA Transfers Between Internal Memory, External Memory, Memory-Mapped Peripherals, Link Ports, Host Processors, and Other (Multiprocessor) DSPs
- Eases DSP Programming Through Extremely Flexible Instruction Set and High-Level-Language Friendly DSP Architecture

FUNCTIONAL BLOCK DIAGRAM



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One Technology Way, P.O.Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel:781/329-4700 www.analog.com
Fax:781/326-8703

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GENERAL DESCRIPTION

The ADSP-TS101S TigerSHARC DSP is an ultra-high performance, static superscalar processor optimized for large signal processing tasks and communications infrastructure. The DSP combines very wide memory widths with dual computation blocks—supporting 32-bit floating-point and supporting 8-, 16-, 32-, and 64-bit fixed-point processing—to set a new standard of performance for digital signal processors. The TigerSHARC static superscalar architecture lets the DSP execute up to four instructions each cycle, performing twenty-four 16-bit fixed-point operations or six floating-point operations.

Three independent 128-bit wide internal data buses, each connecting to one of the three 2M bit memory banks, enable quad-word data, instruction, and I/O accesses and provide 12G bytes per second of internal memory bandwidth. Operating at 250 MHz, the ADSP-TS101S's core has a 4.0 ns instruction cycle time. Using its Single-Instruction, Multiple-Data (SIMD) features, the ADSP-TS101S can perform 2 billion 40-bit MACs or 500 million 80-bit MACs per second. Table 1 and Table 2 show the DSP's performance benchmarks.

Table 1. General Purpose Algorithm Benchmarks at 250 MHz

Benchmark	Speed	Clock Cycles
32-bit Algorithm, 500 million MACs/s peak performance		
1024 Point Complex FFT (Radix 2)	39.34 µs	9,835
50-tap FIR on 1024 input	110 µs	27,500
Single FIR MAC	2.2 ns	0.55
16-bit Algorithm, 2 billion MACs/s peak performance		
256 Point Complex FFT (Radix 2)	4.4 µs	1,100
50-tap FIR on 1024 input	28.8 µs	7,200
Single FIR MAC	0.56 ns	0.14
Single Complex FIR MAC	2.28 ns	0.57
I/O DMA Transfer Rate		
External port	800M bytes/s	n/a
Link ports (each)	250M bytes/s	n/a

Table 2. 3G Wireless Algorithm Benchmarks

Benchmark	Execution (MIPS)[1]
Turbo Decode 384 kbps Data Channel	51 MIPS
Viterbi Decode 12.2 kbps AMR[2] Voice Channel	0.86 MIPS
Complex Correlation 3.84 Mcps[3] with a Spreading Factor of 256	0.27 MIPS

[1]The Execution Speed is in Instruction Cycles Per Second.
[2]Adaptive Multi Rate (AMR)
[3]Megachips per second (Mcps)

The ADSP-TS101S is code-compatible with the other TigerSHARC processors.

The Functional Block Diagram on page 1 shows the ADSP-TS101S's architectural blocks. These blocks include:

- Dual compute blocks, each consisting of an ALU, multiplier, 64-bit shifter, and 32-word register file and associated Data Alignment Buffers (DABs)
- Dual integer ALUs (IALUs), each with its own 31-word register file for data addressing
- A program sequencer with Instruction Alignment Buffer (IAB), Branch Target Buffer (BTB), and interrupt controller
- Three 128-bit internal data buses, each connecting to one of three 2M bit memory banks
- On-chip SRAM (6M bit)
- An external port that provides the interface to host processors, multiprocessing space (DSPs), off-chip memory-mapped peripherals, and external SRAM and SDRAM
- A DMA controller
- Four link ports
- Two 32-bit interval timers and timer expired pin
- A 1149.1 IEEE compliant JTAG test access port for on-chip emulation

Figure 1 on page 3 shows a typical single-processor system with external SDRAM. Figure 3 on page 7 shows a typical multiprocessor system.

The TigerSHARC DSP uses a Static Superscalar[1] architecture. This architecture is superscalar in that the ADSP-TS101S's core can execute simultaneously from one to four 32-bit instructions encoded in a Very Large Instruction Word (VLIW) instruction line using the DSP's dual compute blocks. Because the DSP does not perform instruction re-ordering at runtime—the programmer selects which operations will execute in parallel prior to runtime, the order of instructions is static.

With few exceptions, an instruction line, whether it contains one, two, three, or four 32-bit instructions, executes with a throughput of one cycle in an eight-deep processor pipeline.

For optimal DSP program execution, programmers must follow the DSP's set of instruction parallelism rules when encoding an instruction line. In general, the selection of instructions that the DSP can execute in parallel each cycle depends on the instruction line resources each instruction requires and on the source and destination registers used in the instructions. The programmer has direct control of three core components—the IALUs, the compute blocks, and the program sequencer.

The ADSP-TS101S, in most cases, has a two-cycle execution pipeline that is fully interlocked, so whenever a computation result is unavailable for another operation dependent on it. The DSP automatically inserts one or more stall cycles as needed.

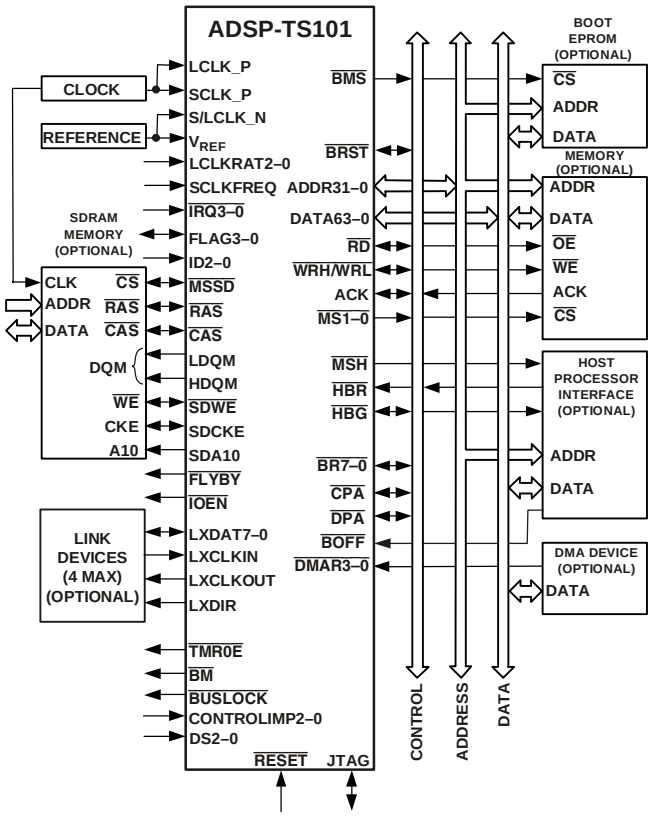


Figure 1. ADSP-TS101S single-processor system with external SDRAM

Efficient programming with dependency-free instructions can eliminate most computational and memory transfer data dependencies.

In addition, the ADSP-TS101S supports SIMD operations two ways—SIMD compute blocks and SIMD computations.The programmer can direct both compute blocks to operate on the same data (broadcast distribution) or on different data (merged distribution). In addition, each compute block can execute four 16-bit or eight 8-bit SIMD computations in parallel.

Dual Compute Blocks

The ADSP-TS101S has compute blocks, that can execute computations either independently or together as a Single-Instruction, Multiple-Data (SIMD) engine. The DSP can issue up to two compute instructions per compute block each cycle, instructing the ALU, multiplier, or shifter to perform independent, simultaneous operations.

[1] Static Superscalar™ is a trademark of Analog Devices, Inc.

The compute blocks are referred to as CBX and CBY in assembly syntax, and each block contains three computational units—an ALU, a multiplier, a 64-bit shifter—and a 32-word register file.

- Register File—Each Compute Block has a multiported 32-word, fully orthogonal register file used for transferring data between the computation units and data buses and for storing intermediate results. Instructions can access the registers in the register file individually (word-aligned), or in sets of two (dual-aligned) or four (quad-aligned).
- ALU—The ALU performs a standard set of arithmetic operations in both fixed- and floating-point formats. It also performs logic operations.
- Multiplier—The multiplier performs both fixed- and floating-point multiplication and fixed-point multiply and accumulate.
- Shifter—The 64-bit shifter performs logical and arithmetic shifts, bit and bitstream manipulation, and field deposit and extraction operations.
- Accelerator—128-bit unit for Trellis Decoding (for example, Viterbi and Turbo decoders) and complex correlations for communication applications

Using these features, the compute blocks can:

- Provide 8 MACs per cycle peak and 7.1 MACs per cycle sustained 16-bit performance and provide 2 MACs per cycle peak and 1.8 MACs per cycle sustained 32-bit performance (based on FIR)
- Execute six single-precision floating-point or execute twenty-four 16-bit fixed-point operations per cycle, providing 1500 MFLOPS or 6.0 GOPS performance
- Performs two complex 16-bit MACs per cycle
- Executes eight Trellis butterflies in one cycle

Data Alignment Buffer (DAB)
The DAB is a two quad-word FIFO that enables loading of quad-word data from nonaligned addresses. Normally, load instructions must be aligned to their data size so that quad words are loaded from a quad-aligned address. Using the DAB significantly improves the efficiency of some applications, such as FIR filters.

Dual Integer ALUs (IALUs)
The ADSP-TS101S has two IALUs that provide powerful address generation capabilities and perform many general-purpose integer operations. The IALUs have the following features:

- Provides memory addresses for data and update pointers
- Supports circular buffering and bit-reverse addressing
- Performs general-purpose integer operations, increasing programming flexibility
- Includes a 31-word register file for each IALU

As address generators, the IALUs perform immediate or indirect (pre- and post-modify) addressing. They perform modulus and bit-reverse operations with no constraints placed on memory addresses for the modulus data buffer placement. Each IALU can specify either a single-, dual-, or quad-word access from memory.

The IALUs have hardware support for circular buffers, bit reverse, and zero-overhead looping. Circular buffers facilitate efficient programming of delay lines and other data structures required in digital signal processing, and they are commonly used in digital filters and Fourier transforms. Each IALU provides registers for four circular buffers, so applications can set up a total of eight circular buffers. The IALUs handle address pointer wrap-around automatically, reducing overhead, increasing performance, and simplifying implementation. Circular buffers can start and end at any memory location.

Because the IALU's computational pipeline is one cycle deep, in most cases integer results are available in the next cycle. Hardware (register dependency check) causes a stall if a result is unavailable in a given cycle.

Program Sequencer
The ADSP-TS101S's program sequencer supports the following:

- A fully interruptible programming model with flexible programming in assembly and C/C++ languages; handles hardware interrupts with high throughput and no aborted instruction cycles
- An eight-cycle instruction pipeline—three-cycle fetch pipe and five-cycle execution pipe—computation results available two cycles after operands are available
- Supply of instruction fetch memory addresses; the sequencer's Instruction Alignment Buffer (IAB) caches up to five fetched instruction lines waiting to execute; the program sequencer extracts an instruction line from the IAB and distributes it to the appropriate core component for execution.
- Management of program structures and program flow determined according to JUMP, CALL, RTI, RTS instructions, loop structures, conditions, interrupts, and software exceptions
- Branch prediction and a 128-entry branch target buffer (BTB) to reduce branch delays for efficient execution of conditional and unconditional branch instructions and zero-overhead looping; correctly predicted branches that are taken occur with zero-to-two overhead cycles, overcoming the three- to-six stage branch penalty
- Compact code without the requirement to align code in memory; the IAB handles alignment

Interrupt Controller
The DSP supports nested and nonnested interrupts. Each interrupt type has a register in the interrupt vector table. Also, each has a bit in both the interrupt latch register and the interrupt

mask register. All interrupts are fixed as either level-sensitive or edge-sensitive, except the $\overline{\text{IRQ3–0}}$ hardware interrupts, which are programmable.

The DSP distinguishes between hardware interrupts and software exceptions, handling them differently. When a software exception occurs, the DSP aborts all other instructions in the instruction pipe. When a hardware interrupt occurs, the DSP continues to execute instructions already in the instruction pipe.

Flexible Instruction Set

The 128-bit instruction line, which can contain up to four 32-bit instructions, accommodates a variety of parallel operations for concise programming. For example, one instruction line can direct the DSP to conditionally execute a multiply, an add, and a subtract in both computation blocks while it also branches to another location in the program. Some key features of the instruction set include:

- Enhanced instructions for communications infrastructure to govern Trellis Decoding (for example, Viterbi and Turbo decoders) and Despreading via complex correlations
- Algebraic assembly language syntax
- Direct support for all DSP, imaging, and video arithmetic types, eliminating hardware modes
- Branch prediction encoded in instruction, enables zero-overhead loops
- Parallelism encoded in instruction line
- Conditional execution optional for all instructions
- User defined partitioning between program and data memory

On-Chip SRAM Memory

The ADSP-TS101S has 6M bits of on-chip SRAM memory, divided into three blocks of 2M bits (64K words × 32 bits). Each block—M0, M1, and M2—can store program, data, or both, so applications can configure memory to suit specific needs. Placing program instructions and data in different memory blocks, however, enables the DSP to access data while performing an instruction fetch.

The DSP's internal and external memory is organized into a unified memory map, which defines the location (address) of all elements in the system, as shown in Figure 2.

The memory map is divided into four memory areas—host space, external memory, multiprocessor space, and internal memory—and each memory space, except host memory, is subdivided into smaller memory spaces.

Each internal memory block connects to one of the 128-bit wide internal buses—block M0 to bus MD0, block M1 to bus MD1, and block M2 to bus MD2—enabling the DSP to perform three memory transfers in the same cycle. The DSP's internal bus architecture provides a total memory bandwidth of 12G bytes per second, enabling the core and I/O to access eight 32-bit data words (256 bits) and four 32-bit instructions each cycle. The DSP's flexible memory structure enables:

- DSP core and I/O access different memory blocks in the same cycle
- DSP core access all three memory blocks in parallel—one instruction and two data accesses
- Programmable partitioning of program and data memory
- Program access of all memory as 32-, 64-, or 128-bit words—16-bit words with the DAB
- Complete context switch in less than 20 cycles (80 ns)

External Port (Off-Chip Memory/Peripherals Interface)

The ADSP-TS101S's external port provides the DSP's interface to off-chip memory and peripherals. The 4G word address space is included in the DSP's unified address space. The separate on-chip buses—three 128-bit data buses and three 32-bit address buses—are multiplexed at the external port to create an external system bus with a single 64-bit data bus and a single 32-bit address bus. The external port supports data transfer rates of 800M bytes per second over external bus.

The external bus can be configured for 32- or 64-bit operation. When the system bus is configured for 64-bit operation, the lower 32 bits of the external data bus connect to even addresses, and the upper 32 bits connect to odd addresses.

The external port supports pipelined, slow, and SDRAM protocols. Addressing of external memory devices and memory-mapped peripherals is facilitated by on-chip decoding of high-order address lines to generate memory bank select signals.

The ADSP-TS101S provides programmable memory, pipeline depth, and idle cycle for synchronous accesses, and external acknowledge controls to support interfacing to pipelined or slow devices, host processors, and other memory-mapped peripherals with variable access, hold, and disable time requirements.

Host Interface

The ADSP-TS101S provides an easy and configurable interface between its external bus and host processors through the external port. To accommodate a variety of host processors, the host interface supports pipelined or slow protocols for accesses of the host as slave. Each protocol has programmable transmission parameters, such as idle cycles, pipe depth, and internal wait cycles.

The host interface supports burst transactions initiated by a host processor. After the host issues the starting address of the burst and asserts the $\overline{\text{BRST}}$ signal, the DSP increments the address internally while the host continues to assert $\overline{\text{BRST}}$.

The host interface provides a deadlock recovery mechanism that enables a host to recover from deadlock situations involving the DSP. The $\overline{\text{BOFF}}$ signal provides the deadlock recovery mechanism. When the host asserts $\overline{\text{BOFF}}$, the DSP backs off the current transaction and asserts $\overline{\text{HBG}}$ and relinquishes the external bus.

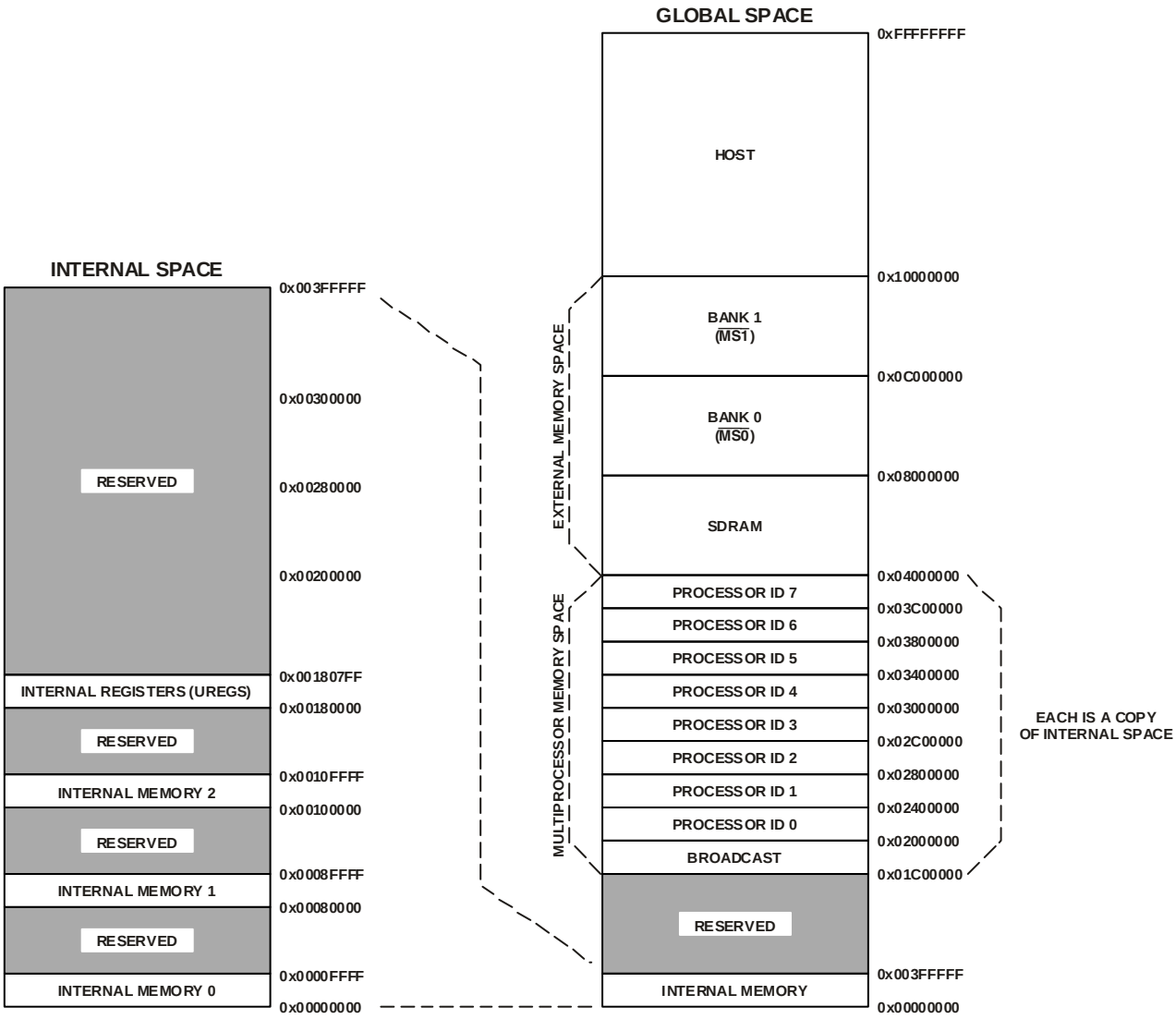


Figure 2. ADSP-TS101S memory map

The host can directly read or write the internal memory of the ADSP-TS101S, and it can access most of the DSP registers, including DMA control (TCB) registers. Vector interrupts support efficient execution of host commands.

Multiprocessor Interface

The ADSP-TS101S offers powerful features tailored to multiprocessing DSP systems through the external port and link ports. This multiprocessing capability provides highest bandwidth for interprocessor communication, including:

- Up to eight DSPs on a common bus
- On-chip arbitration for glueless multiprocessing
- Link ports for point to point communication

The external port and link ports provide integrated, glueless multiprocessing support.

The external port supports a unified address space (see Figure 2) that enables direct interprocessor accesses of each ADSP-TS101S's internal memory and registers. The DSP's on-chip distributed bus arbitration logic provides simple, glueless connection for systems containing up to eight ADSP-TS101Ss and a host processor. Bus arbitration has a rotating priority. Bus lock supports indivisible read-modify-write sequences for semaphores. A bus fairness feature prevents one DSP from holding the external bus too long.

The DSP's four link ports provide a second path for interprocessor communications with throughput of 1G bytes per second. The cluster bus provides 800M bytes per second throughput—with a total of 1.8G bytes per second interprocessor bandwidth.

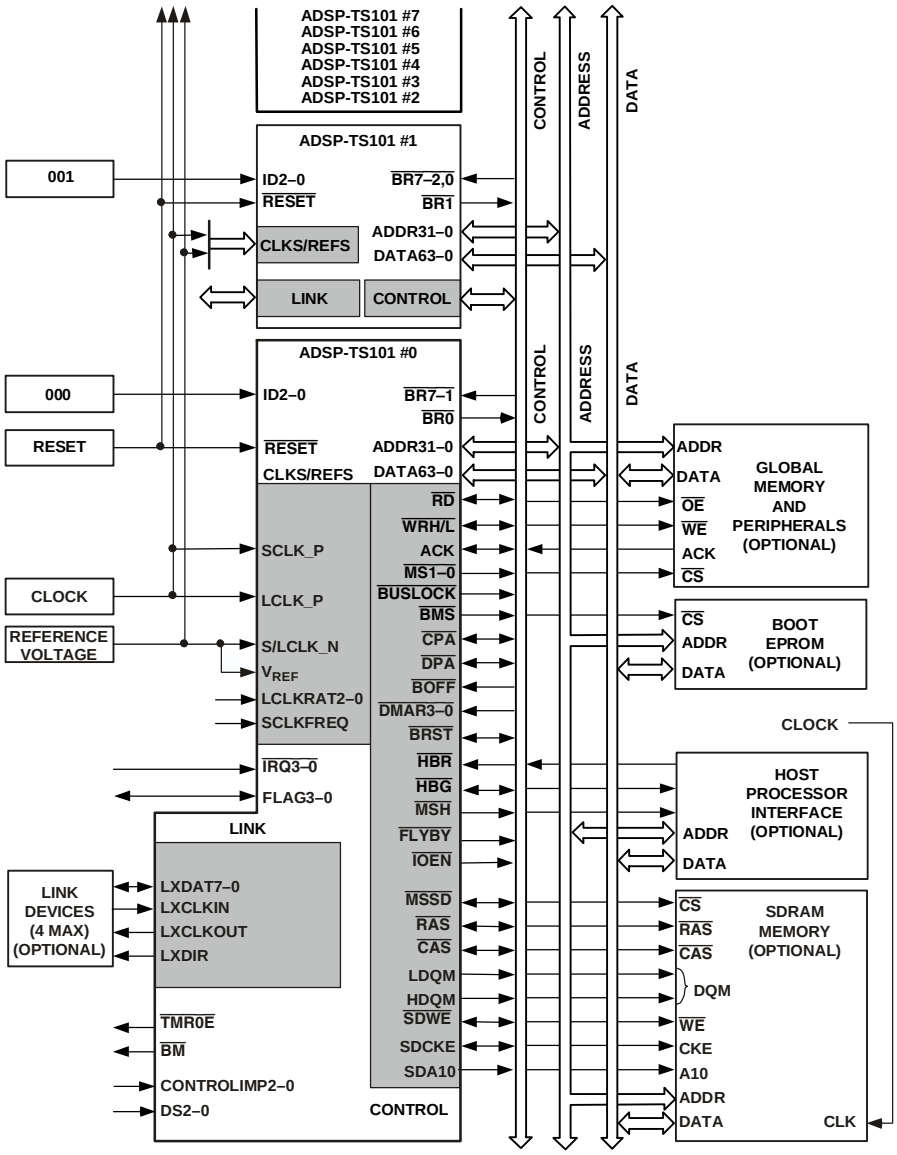


Figure 3. ADSP-TS101S Shared Memory Multiprocessing System

SDRAM Controller

The SDRAM controller controls the ADSP-TS101S's transfers of data to and from synchronous DRAM (SDRAM) at a throughput of 32 or 64 bits per SCLK cycle using the external port and SDRAM control pins.

The SDRAM interface provides a glueless interface with standard SDRAMs—16M bit, 64M bit, 128M bit, and 256M bit. The DSP supports directly a maximum of 64M words × 32 bit of SDRAM. The SDRAM interface is mapped in external memory in the DSP's unified memory map.

EPROM Interface

The ADSP-TS101S can be configured to boot from external 8-bit EPROM at reset through the external port. An automatic process (which follows reset) loads a program from the EPROM into internal memory. This process uses sixteen wait cycles for each read access. During booting, the $\overline{BMS}$ pin functions as the EPROM chip select signal. The EPROM boot procedure uses DMA channel 0, which packs the bytes into 32-bit instructions. Applications can also access the EPROM (write flash memories) during normal operation through DMA.

The EPROM or Flash Memory interface is not mapped in the DSP's unified memory map. It is a byte address space limited to a maximum of 16M bytes (twenty-four address bits). The EPROM or Flash Memory interface can be used after boot via a DMA.

DMA Controller

The ADSP-TS101S's on-chip DMA controller, with 14 DMA channels, provides zero-overhead data transfers without processor intervention. The DMA controller operates independently and invisibly to the DSP's core, enabling DMA operations to occur while the DSP's core continues to execute program instructions.

The DMA controller performs DMA transfers between internal memory and external memory and memory-mapped peripherals, the internal memory of other DSPs on a common bus, a host processor, or link port I/O; between external memory and external peripherals or link port I/O; and between an external bus master and internal memory or link port I/O. The DMA controller performs the following DMA operations:

- External port block transfers. Four dedicated bidirectional DMA channels transfer blocks of data between the DSP's internal memory and any external memory or memory-mapped peripheral on the external bus. These transfers support master mode and handshake mode protocols.
- Link port transfers. Eight dedicated DMA channels (four transmit and four receive) transfer quad-word data only between link ports and between a link port and internal or external memory. These transfers only use handshake mode protocol. DMA priority rotates between the four receive channels.
- AutoDMA transfers. Two dedicated unidirectional DMA channels transfer data received from an external bus master to internal memory or to link port I/O. These transfers only use slave mode protocol, and an external bus master must initiate the transfer.

The DMA controller provides these additional features:

- Flyby transfers. Flyby operations only occur through the external port (DMA channel 0) and do not involve the DSP's core. The DMA controller acts as a conduit to transfer data from one external device to another through external memory. During a transaction, the DSP relinquishes the external data bus; outputs addresses, memory selects ($\overline{MS1–0}$) and the $\overline{FLYBY}$, $\overline{IOEN}$, and $\overline{RD}/\overline{WR}$ strobes; and responds to ACK.
- DMA chaining. DMA chaining operations enable applications to automatically link one DMA transfer sequence to another for continuous transmission. The sequences can occur over different DMA channels and have different transmission attributes.
- Two-dimensional transfers. The DMA controller can access and transfer two-dimensional memory arrays on any DMA transmit or receive channel. These transfers are implemented with index, count, and modify registers for both the X and Y dimensions.

Link Ports

The DSP's four link ports provide additional eight-bit bidirectional I/O capability. With the ability to operate at a double data rate—latching data on both the rising and falling edges of the clock—running at 125 MHz, each link port can support up to 250M bytes per second, for a combined maximum throughput of 1G bytes per second.

The link ports provide an optional communications channel that is useful in multiprocessor systems for implementing point-to-point interprocessor communications. Applications can also use the link ports for booting.

Each link port has its own double-buffered input and output registers. The DSP's core can write directly to a link port's transmit register and read from a receive register, or the DMA controller can perform DMA transfers through eight (four transmit and four receive) dedicated link port DMA channels.

Each link port has three signals that control its operation. LxCLKOUT and LxCLKIN implement clock/acknowledge handshaking. LxDIR indicates the direction of transfer and is used only when buffering the LxDAT signals. An example application would be using differential low-swing buffers for long twisted-pair wires. LxDAT provides the 8-bit data bus input/output.

Applications can program separate error detection mechanisms for transmit and receive operations (applications can use the checksum mechanism to implement consecutive link port transfers), the size of data packets, and the speed at which bytes are transmitted.

Under certain conditions, the link port receiver can initiate a token switch to reverse the direction of transfer; the transmitter becomes the receiver and vice versa.

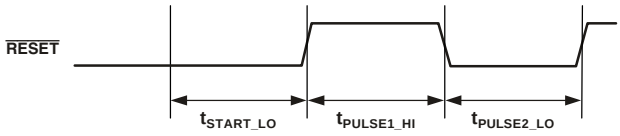
Timer and General-Purpose I/O

The ADSP-TS101S has a timer pin ($\overline{TMR0E}$) that generates output when a programmed timer counter has expired and four programmable general-purpose I/O pins (FLAG3–0) that can function as either single-bit input or output. As outputs, these pins can signal peripheral devices; as inputs, they can provide the test for conditional branching.

Reset and Booting

The ADSP-TS101S has three levels of reset:

- Power-up reset—After power-up of the system, and strap options are stable, the $\overline{\text{RESET}}$ pin must be asserted (low) for a minimum of 1 ms followed by a deasserted (high) pulse of a minimum of 50 SCLK cycles and a maximum of 100 SCLK cycles and asserted (low) for a minimum of 100 SCLK cycles. $\overline{\text{TRST}}$ must also be asserted (low) during power-up to ensure proper operation of the device. See Figure 4.
- Normal reset—For any resets following the power-up reset sequence, the $\overline{\text{RESET}}$ pin must be asserted for at least 100 SCLK cycles.
- Core reset—When setting the SQRST bit in SQCTL, the core is reset, but not the external port or I/O.



NOTES:

t_{START_LO} = 1ms MINIMUM AFTER POWER SUPPLIES ARE STABLE
t_{PULSE1_HI} = 50×SCLK MINIMUM TO 100×SCLK MAXIMUM
t_{PULSE2_LO} = 100×SCLK MINIMUM

Figure 4. Power-up Reset Waveform

After reset, the ADSP-TS101S has four boot options for beginning operation:

- Boot from EPROM. The DSP defaults to EPROM booting when the $\overline{\text{BMS}}$ pin strap option is set low. For more information, see Strap Pin Function Descriptions on page 19.
- Boot by an external master (host or another ADSP-TS101S). Any master on the cluster bus can boot the ADSP-TS101S through writes to its internal memory or through auto DMA.
- Boot by link port. All four receive link DMA channels are initialized after reset to transfer a 256-word block to internal memory address 0 to 255, and to issue an interrupt at the end of the block (similar to EP DMA). The corresponding DMA interrupts are set to address zero (0).
- No boot—Start running from an external memory. Using the 'no boot' option, the ADSP-TS101S must start running from an external memory, caused by asserting one of the $\overline{\text{IRQ3–0}}$ interrupt signals.

The ADSP-TS101S core always exits from reset in the idle state and waits for an interrupt. Some of the interrupts in the interrupt vector table are initialized and enabled after reset.

Low-Power Operation

The ADSP-TS101S can enter a low-power sleep mode, in which its core does not execute instructions, reducing power consumption to a minimum. The ADSP-TS101S exits sleep mode when it senses a falling edge on any of its $\overline{\text{IRQ3–0}}$ interrupt inputs. The interrupt, if enabled, causes the ADSP-TS101S to execute the corresponding interrupt service routine. This feature is useful for systems that require a low-power standby mode.

Clock Domains

The ADSP-TS101S has two clock inputs that drive its two major clock domains:

- SCLK (system clock). Provides clock input for the external bus interface and defines the AC specification reference for the external bus signals. The external bus interface runs at 1× the SCLK frequency. A DLL locks internal SCLK to SCLK input. The maximum SCLK frequency is one half the internal DSP clock (CCLK) frequency. SCLK must be connected to the same clock source as LCLK.
- LCLK (local clock). Provides clock input to the internal clock driver, CCLK, which is internal clock for the core, internal buses, memory, and link ports. The instruction execution rate is equal to CCLK. A PLL from LCLK generates CCLK which is phase-locked. The LCLKRAT pins define the clock multiplication of LCLK to CCLK (see Table 4 on page 13). The link port clock is generated from CCLK via a software programmable divisor.

  $\overline{\text{RESET}}$ must be asserted until LCLK is stable and within specification for at least 1 ms. This applies to power-up as well as any dynamic modification of LCLK after power-up. Dynamic modification may include LCLK going out of specification as long as $\overline{\text{RESET}}$ is asserted.

Connecting SCLK and LCLK to the same clock source is a requirement for the device. Using an integer clock multiplication value provides predictable cycle-by-cycle operation, a requirement of fault-tolerant systems and some multiprocessing systems.

Power Supplies

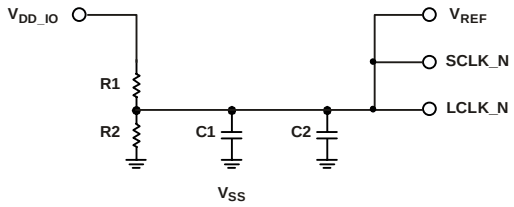
The ADSP-TS101S has separate power supply connections for internal logic (V_{DD}), analog circuits (V_{DD_A}), and I/O buffer (V_{DD_IO}) power supply. The internal (V_{DD}) and analog (V_{DD_A}) supplies must meet the 1.2 V requirement. The I/O buffer (V_{DD_IO}) supply must meet the 3.3 V requirement.

Note that the analog (V_{DD_A}) supply powers the clock generator PLLs. To produce a stable clock, systems must provide a clean power supply to power input V_{DD_A}. Designs must pay critical attention to bypassing the V_{DD_A} supply.

The ideal power on sequence for the DSP is to provide power up of all supplies simultaneously. If there is going to be some delay between power up of the supplies, provide V_{DD} (and V_{DD_A}) first, then V_{DD_IO}.

Filtering Reference Voltage and Clocks

Figure 5 shows a possible circuit for filtering V_{REF}, SCLK_N, and LCLK_N. This circuit provides the reference voltage for the switching voltage, system clock, and local clock references.



R1: 2 kΩ SERIES RESISTOR
R2: 1.67 KΩ SERIES RESISTOR
C1: 1µF CAPACITOR (SMD)
C2: 1 nF CAPACITOR (HF SMD) PLACED CLOSE TO DSP'S PINS

Figure 5. V_{REF}, SCLK_N, & LCLK_N filtering scheme

Development Tools

The ADSP-TS101S is supported with a complete set of software and hardware development tools, including Analog Devices' emulators and VisualDSP++[2] development environment. The same emulator hardware that supports other TigerSHARC DSPs also fully emulates the ADSP-TS101S.

The VisualDSP++ project management environment lets programmers develop and debug an application. This environment includes an easy-to-use assembler (which is based on an algebraic syntax), an archiver (librarian/library builder), a linker, a loader, a cycle-accurate instruction-level simulator, a C/C++ compiler, and a C/C++ run-time library that includes DSP and mathematical functions. Two key points for these tools are:

- Compiled TigerSHARC C/C++ code efficiency—the compiler has been developed for efficient translation of C/C++ code to TigerSHARC assembly. The DSP has architectural features that improve the efficiency of compiled C/C++ code.
- TigerSHARC family code compatibility—The assembler has legacy features to ease the conversion of existing previous TigerSHARC applications to the ADSP-TS101S.

Debugging both C/C++ and assembly programs with the VisualDSP++ debugger, programmers can:

- View mixed C/C++ and assembly code (interleaved source and object information)
- Insert break points
- Set conditional breakpoints on registers, memory, and stacks
- Trace instruction execution
- Perform linear or statistical profiling of program execution
- Fill, dump, and graphically plot the contents of memory
- Debug source-level code
- Create custom debugger windows

The VisualDSP++ IDE lets programmers define and manage DSP software development. Its dialog boxes and property pages let programmers configure and manage all of the TigerSHARC development tools, including the syntax highlighting in the VisualDSP++ editor. This capability lets programmers:

- Control how the development tools process inputs and generate outputs.
- Maintain a one-to-one correspondence with the tool's command line switches.

Analog Devices' DSP emulators use the IEEE 1149.1 JTAG test access port of the ADSP-TS101S processor to monitor and control the target board processor during emulation. The emulator provides full-speed emulation, allowing inspection and modification of memory, registers, and processor stacks. Nonintrusive in-circuit emulation is assured by the use of the processor's JTAG interface—the emulator does not affect target system loading or timing.

In addition to the software and hardware development tools available from Analog Devices, third parties provide a wide range of tools supporting the TigerSHARC processor family. Hardware tools include TigerSHARC PC plug-in cards. Third Party software tools include DSP libraries, real-time operating systems, and block diagram design tools.

Designing an Emulator-Compatible DSP Board (Target)

The White Mountain DSP (Product Line of Analog Devices, Inc.) family of emulators are tools that every DSP developer needs to test and debug hardware and software systems. Analog Devices has supplied an IEEE 1149.1 JTAG Test Access Port (TAP) on each JTAG DSP. The emulator uses the TAP to access the internal features of the DSP, allowing the developer to load code, set breakpoints, observe variables, observe memory, and examine registers. The DSP must be halted to send data and commands, but once an operation has been completed by the emulator, the DSP system is set running at full speed with no impact on system timing.

To use these emulators, the target's design must include the interface between an Analog Devices' JTAG DSP and the emulation header on a custom DSP target board.

Target Board Header

The emulator interface to an Analog Devices' JTAG DSP is a 14-pin header, as shown in Figure 6. The customer must supply this header on the target board in order to communicate with the emulator. The interface consists of a standard dual row 0.025" square post header, set on 0.1" × 0.1" spacing, with a minimum post length of 0.235". Pin 3 is the key position used to prevent the pod from being inserted backwards. This pin must be clipped on the target board.

[2]VisualDSP++ is a registered trademark of Analog Devices, Inc.

Also, the clearance (length, width, and height) around the header must be considered. Leave a clearance of at least 0.15" and 0.10" around the length and width of the header, and reserve a height clearance to attach and detach the pod connector.

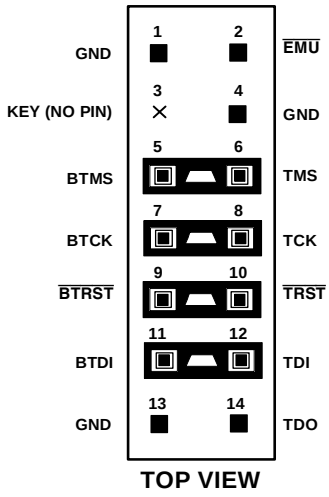


Figure 6. JTAG Target Board Connector for JTAG Equipped Analog Devices DSP (Jumpers in Place)

As can be seen in Figure 6, there are two sets of signals on the header. There are the standard JTAG signals TMS, TCK, TDI, TDO, $\overline{\text{TRST}}$, and $\overline{\text{EMU}}$ used for emulation purposes (via an emulator). There are also secondary JTAG signals BTMS, BTCK, BTDI, and $\overline{\text{BTRST}}$ that are optionally used for board-level (boundary scan) testing.

When the emulator is not connected to this header, place jumpers across BTMS, BTCK, $\overline{\text{BTRST}}$, and BTDI as shown in Figure 7. This holds the JTAG signals in the correct state to allow the DSP to run free. Remove all the jumpers when connecting the emulator to the JTAG header.

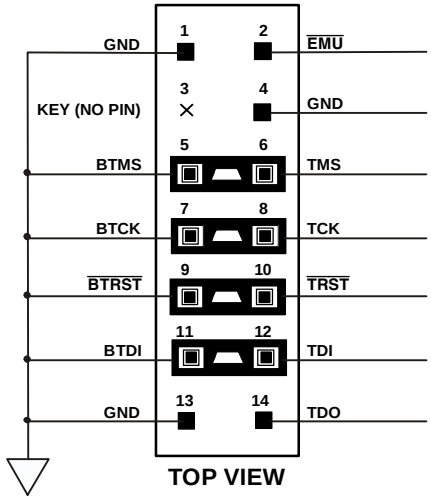


Figure 7. JTAG Target Board Connector with No Local Boundary Scan

JTAG Emulator Pod Connector

Figure 8 details the dimensions of the JTAG pod connector at the 14-pin target end. Figure 9 displays the keep-out area for a target board header. The keep-out area allows the pod connector to properly seat onto the target board header. This board area should contain no components (chips, resistors, capacitors, etc.). The dimensions are referenced to the center of the 0.25" square post pin.

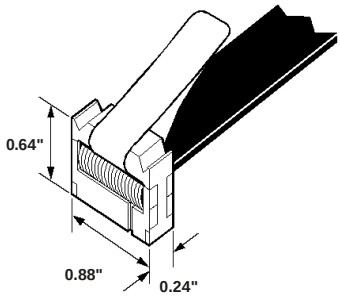


Figure 8. JTAG Pod Connector Dimensions

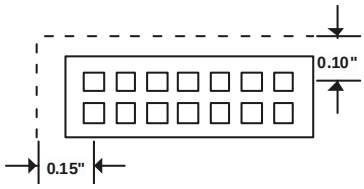


Figure 9. JTAG Pod Connector Keep-Out Area

Design-for-Emulation Circuit Information

For details on target board design issues including: single processor connections, multiprocessor scan chains, signal buffering, signal termination, and emulator pod logic, see the *EE-68: Analog Devices JTAG Emulation Technical Reference* on the Analog Devices website—use site search on "EE-68" (www.analog.com). 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-TS101S's architecture and functionality. For detailed information on the ADSP-TS101S's core architecture and instruction set, see the *TigerSHARC DSP Hardware Specification* and the *TigerSHARC DSP Instruction Set Specification*. For detailed information on the development tools for this processor, see the *VisualDSP++ User's Guide and Reference for the ADSP-TS101S TigerSHARC DSP*.

PIN FUNCTION DESCRIPTIONS

While most of the ADSP-TS101S's input pins are normally synchronous—tied to a specific clock—a few are asynchronous. For these asynchronous signals, an on-chip synchronization circuit prevents metastability problems. The AC specification for asynchronous signals is used only when having predictable cycle-by-cycle behavior is required.

The output pins can be three-stated during normal operation. The DSP three-states all outputs during reset, allowing these pins to get to their internal pullup or pulldown state. Some output pins (control signals) have a pullup or pulldown that maintain a known value during transitions between different drivers.

Table 3. Pin Definitions—Clocks and Reset

Signal	Type	Description
LCLK_N	I	Local Clock Reference. Connect this pin to V_{REF} as shown in Figure 5.
LCLK_P	I	Local Clock Input. DSP clock input. The instruction cycle rate = n × LCLK, where n is user-programmable to 2, 2.5, 3, 3.5, 4, 5, or 6. For more information, see Clock Domains on page 9.
LCLKRAT2–0[1]	I (pd)	LCLK Ratio. The DSP's core clock (instruction cycle rate) = n × LCLK, where n is user-programmable to 2, 2.5, 3, 3.5, 4, 5, or 6 as shown in Table 4. These pins must have a constant value while the DSP is powered.
SCLK_N	I	System Clock Reference. Connect this pin to V_{REF} as shown in Figure 5.
SCLK_P	I	System Clock Input. The DSP's system input clock for cluster bus. This pin must be connected to the same clock source as LCLK_P. For more information, see Clock Domains on page 9.
SCLKFREQ[2]	I (pu)	SCLK Frequency. Indicates the SCLK frequency range to the SCLK deskew PLL. When SCLKFREQ = 0, SCLK =< 50 MHz. When SCLKFREQ = 1, SCLK => 50 MHz (default). This pin must have a constant value while the DSP is powered.
$\overline{\text{RESET}}$	I/A	Reset. Sets the DSP to a known state and causes program to be in idle state. $\overline{\text{RESET}}$ must be asserted a specified time according to the type of reset operation. For details, see Reset and Booting on page 9.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

[1]The internal 100 kΩ internal pulldown may not be sufficient depending on system noise and/or leakage. A stronger pulldown may be necessary.
[2]The internal 100 kΩ internal pullup may not be sufficient depending on system noise and/or leakage. A stronger pullup may be necessary.

Table 4. LCLK Ratio

LCLKRAT2–0	Ratio
000 (default)	2
001	2.5
010	3
011	3.5
100	4
101	5
110	6
111	Reserved

Table 5. Pin Definitions—External Port

Signal	Type	Description
ADDR31–0[1]	I/O/T	Address Bus. The DSP issues addresses for accessing memory and peripherals on these pins. In a multiprocessor system, the bus master drives addresses for accessing internal memory or I/O processor registers of other ADSP-TS101Ss. The DSP inputs addresses when a host or another DSP accesses its internal memory or I/O processor registers.
DATA63–0[1]	I/O/T	External Data Bus. The DSP drives and receives data and instructions on these pins. Pull-up resistors on unused DATA pins are unnecessary.
$\overline{\text{RD}}$[2]	I/O/T (pu)	Memory Read. $\overline{\text{RD}}$ is asserted whenever the DSP reads from any slave in the system, excluding SDRAM. When the DSP is a slave, $\overline{\text{RD}}$ is an input and indicates read transactions that access its internal memory or universal registers. In a multiprocessor system, the bus master drives $\overline{\text{RD}}$. $\overline{\text{RD}}$ changes concurrently with ADDR pins.
$\overline{\text{WRL}}$[2]	I/O/T (pu)	Write Low. $\overline{\text{WRL}}$ is asserted in two cases: When the ADSP-TS101S writes to an even address word of external memory or to another external bus agent; and when the ADSP-TS101S writes to a 32-bit zone (host, memory or DSP programmed to 32-bit bus). An external master (host or DSP) asserts $\overline{\text{WRL}}$ for writing to a DSP's low word of internal memory. In a multiprocessor system, the bus master drives $\overline{\text{WRL}}$. $\overline{\text{WRL}}$ changes concurrently with ADDR pins. When the DSP is a slave, $\overline{\text{WRL}}$ is an input and indicates write transactions that access its internal memory or universal registers.
$\overline{\text{WRH}}$[2]	I/O/T (pu)	Write High. $\overline{\text{WRH}}$ is asserted when the ADSP-TS101S writes a long word (64 bits) or writes to an odd address word of external memory or to another external bus agent on a 64-bit data bus. An external master (host or another DSP) must assert $\overline{\text{WRH}}$ for writing to a DSP's high word of 64-bit data bus. In a multiprocessing system, the bus master drives $\overline{\text{WRH}}$. $\overline{\text{WRH}}$ changes concurrently with ADDR pins. When the DSP is a slave, $\overline{\text{WRH}}$ is an input and indicates write transactions that access its internal memory or universal registers.
ACK	I/O/T	Acknowledge. External slave devices can de-assert ACK to add wait states to external memory accesses. ACK is used by I/O devices, memory controllers and other peripherals on the data phase. The DSP can de-assert ACK to add wait states to read accesses of its internal memory. The ADSP-TS101S does not drive ACK during slave writes. Therefore, an external (approximately 10 kΩ) pullup is required.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

Table 5. Pin Definitions—External Port (continued)

Signal	Type	Description
$\overline{BMS}$[2,3]	O/T (pu/pd)	Boot Memory Select. $\overline{BMS}$ is the chip select for boot EPROM or flash memory. During reset, the DSP uses $\overline{BMS}$ as a strap pin (EBOOT) for EPROM boot mode. When the DSP is configured to boot from EPROM, $\overline{BMS}$ is active during the boot sequence. Pulldown enabled during $\overline{RESET}$ (asserted); pullup enabled after $\overline{RESET}$ (deasserted). In a multiprocessor system, the DSP bus master drives $\overline{BMS}$.For details see Reset and Booting on page 9 and the EBOOT signal description in Table 14 on page 19.
$\overline{MS1–0}$[2]	O/T (pu)	Memory Select. $\overline{MS0}$ or $\overline{MS1}$ is asserted whenever the DSP accesses memory banks 0 or 1 respectively. $\overline{MS1–0}$ are decoded memory address pins that change concurrently with ADDR pins. When ADDR31:26 = 0b000010, $\overline{MS0}$ is asserted. When ADDR31:26 = 0b000011, $\overline{MS1}$ is asserted. In multiprocessor systems, the master DSP drives $\overline{MS1–0}$.
$\overline{MSH}$[2]	O/T (pu)	Memory Select Host. $\overline{MSH}$ is asserted whenever the DSP accesses the host address space (ADDR31:28 ≠ 0b0000). $\overline{MSH}$ is a decoded memory address pin that changes concurrently with ADDR pins. In a multiprocessor system, the bus master DSP drives $\overline{MSH}$.
$\overline{BR7–0}$	I/O	Multiprocessing Bus Request Pins. Used by the DSPs in a multiprocessor system to arbitrate for bus mastership. Each DSP drives its own $\overline{BRx}$ line (corresponding to the value of its ID2–0 inputs) and monitors all others. In systems with fewer than eight DSPs, set the unused $\overline{BRx}$ pins high.
ID2–0[3]	I (pd)	Multiprocessor ID. Indicates the DSP's ID, from which the DSP determines its order in a multiprocessor system. These pins also indicate to the DSP which bus request ($\overline{BR0}$–$\overline{BR7}$) to assert when requesting the bus: 000 = $\overline{BR0}$, 001 = $\overline{BR1}$, 010 = $\overline{BR2}$, 011 = $\overline{BR3}$, 100 = $\overline{BR4}$, 101 = $\overline{BR5}$, 110 = $\overline{BR6}$, or 111 = $\overline{BR7}$. ID2–0 must have a constant value during system operation and can change during reset only.
$\overline{BM}$[3]	O (pd)	Bus Master. The current bus master DSP asserts $\overline{BM}$. For debugging only. At reset this is a strap pin. For more information, see Table 14 on page 19.
$\overline{BOFF}$	I	Back Off. A deadlock situation can occur when the host and a DSP try to read from each other's bus at the same time. When deadlock occurs, the host can assert $\overline{BOFF}$ to force the DSP to relinquish the bus before completing its outstanding transaction.
$\overline{BUSLOCK}$[2]	O/T (pu)	Bus Lock Indication. Provides an indication that the current bus master has locked the bus.
$\overline{BRST}$[2]	I/O/T (pu)	Burst. The current bus master (DSP or host) asserts this pin to indicate that it is reading or writing data associated with consecutive addresses. A slave device can ignore addresses after the first one and increment an internal address counter after each transfer. For host-to-DSP burst accesses, the DSP increments the address automatically while $\overline{BRST}$ is asserted.
$\overline{HBR}$	I	Host Bus Request. A host must assert $\overline{HBR}$ to request control of the DSP's external bus. When $\overline{HBR}$ is asserted in a multiprocessing system, the bus master relinquishes the bus and asserts $\overline{HBG}$ once the outstanding transaction is finished.
$\overline{HBG}$[2]	I/O/T (pu)	Host Bus Grant. Acknowledges $\overline{HBR}$ and indicates that the host can take control of the external bus. When relinquishing the bus, the master DSP three-states the ADDR31–0, DATA63–0, $\overline{MSH}$, $\overline{MSSD}$, $\overline{MS1–0}$, $\overline{RD}$, $\overline{WRL}$, $\overline{WRH}$, $\overline{BMS}$, $\overline{BRST}$, $\overline{FLYBY}$, $\overline{IOEN}$, $\overline{RAS}$, $\overline{CAS}$, $\overline{SDWE}$, SDA10, SDCKE, LDQM and HDQM pins, and the DSP puts the SDRAM in self-refresh mode. The DSP asserts $\overline{HBG}$ until the host deasserts $\overline{HBR}$. In multiprocessor systems, the current bus master DSP drives $\overline{HBG}$, and all slave DSPs monitor it.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

Table 5. Pin Definitions—External Port (continued)

Signal	Type	Description
$\overline{\text{CPA}}$	I/O (o/d)	Core Priority Access. Asserted while the DSP's core accesses external memory. This pin enables a slave DSP to interrupt a master DSP's background DMA transfers and gain control of the external bus for core-initiated transactions. $\overline{\text{CPA}}$ is an open drain output, connected to all DSPs in the system. The $\overline{\text{CPA}}$ pin has an internal 500 Ω pullup resistor, which is only enabled on the DSP with ID=0. If not required in the system, leave $\overline{\text{CPA}}$ unconnected (external pullups will be required for ID1–ID7).
$\overline{\text{DPA}}$	I/O (o/d)	DMA Priority Access. Asserted while a high-priority DSP DMA channel accesses external memory. This pin enables a high-priority DMA channel on a slave DSP to interrupt transfers of a normal-priority DMA channel on a master DSP and gain control of the external bus for DMA-initiated transactions. $\overline{\text{DPA}}$ is an open drain output, connected to all DSPs in the system. The $\overline{\text{DPA}}$ pin has an internal 500 Ω pullup resistor, which is only enabled on the DSP with ID=0. If not required in the system, leave $\overline{\text{DPA}}$ unconnected (external pullups will be required for ID1–ID7).
$\overline{\text{DMAR3–0}}$	I/A	DMA Request Pins. Enable external I/O devices to request DMA services from the DSP. In response to $\overline{\text{DMARx}}$, the DSP performs DMA transfers according to the DMA channel's initialization. The DSP ignores DMA requests from uninitialized channels.
$\overline{\text{FLYBY}}$[2]	O/T (pu)	Flyby Mode. When a DSP DMA channel is initiated in $\overline{\text{FLYBY}}$ mode, it generates flyby transactions on the external bus. During flyby transactions, the DSP asserts $\overline{\text{FLYBY}}$, which signals the source or destination I/O device to latch the next data or strobe the current data, respectively, and to prepare for the next data on the next cycle.
$\overline{\text{IOEN}}$[2]	O/T (pu)	I/O Device Output Enable. Enables the output buffers of an external I/O device for fly-by transactions between the device and external memory. Active on fly-by transactions.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

[1]The address and data buses may float for several cycles during bus mastership transitions between a TigerSHARC and a host. Floating in this case means that these inputs are not driven by any source and that DC-biased terminations are not present. It is not necessary to add pullups as there are no reliability issues and the worst-case power consumption for these floating inputs is negligible. Unconnected address pins may require pullups or pulldowns to avoid erroneous slave accesses, depending on the system. Unconnected data pins may be left floating.
[2]The internal 100 kΩ internal pullup may not be sufficient depending on system noise and/or leakage. A stronger pullup may be necessary.
[3]The internal 100 kΩ internal pulldown may not be sufficient depending on system noise and/or leakage. A stronger pulldown may be necessary.

Table 6. Pin Definitions—SDRAM Controller

Signal	Type	Description
$\overline{\text{MSSD}}$[1]	I/O/T (pu)	Memory Select SDRAM. $\overline{\text{MSSD}}$ is asserted whenever the DSP accesses SDRAM memory space. $\overline{\text{MSSD}}$ is a decoded memory address pin that is asserted whenever the DSP issues an SDRAM command cycle (access to ADDR31:26 = 0b000001). In a multiprocessor system, the master DSP drives $\overline{\text{MSSD}}$.
$\overline{\text{RAS}}$[1]	I/O/T (pu)	Row Address Select. When sampled low, $\overline{\text{RAS}}$ indicates that a row address is valid in a read or write of SDRAM. In other SDRAM accesses, it defines the type of operation to execute according to SDRAM specification.
$\overline{\text{CAS}}$[1]	I/O/T (pu)	Column Address Select. When sampled low, $\overline{\text{CAS}}$ indicates that a column address is valid in a read or write of SDRAM. In other SDRAM accesses, it defines the type of operation to execute according to the SDRAM specification.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

Table 6. Pin Definitions—SDRAM Controller (continued)

Signal	Type	Description
LDQM[1]	O/T (pu)	Low Word SDRAM Data Mask. When sampled high, three-states the SDRAM DQ buffers. LDQM is valid on SDRAM transactions when $\overline{CAS}$ is asserted, and inactive on read transactions. On write transactions, LDQM is active when accessing an odd address word on a 64-bit memory bus to disable the write of the low word.
HDQM[1]	O/T (pu)	High Word SDRAM Data Mask. When sampled high, three-states the SDRAM DQ buffers. HDQM is valid on SDRAM transactions when $\overline{CAS}$ is asserted, and inactive on read transactions. On write transactions, HDQM is active when accessing an even address in word accesses or when memory is configured for a 32-bit bus to disable the write of the high word.
SDA10[1]	O/T (pu)	SDRAM Address bit 10 pin. Separate A10 signals enable SDRAM refresh operation while the DSP executes non-SDRAM transactions.
SDCKE[1,2]	I/O/T (pu/pd)	SDRAM Clock Enable. Activates the SDRAM clock for SDRAM self-refresh or suspend modes. A slave DSP in a multiprocessor system does not have the pullup or pulldown. A master DSP (or ID=0 in a single processor system) has a 100 kΩ pullup before granting the bus to the host, except when the SDRAM is put in self refresh mode. In self refresh mode, the master has a 100 kΩ pulldown before granting the bus to the host.
$\overline{SDWE}$[1]	I/O/T (pu)	SDRAM Write Enable. When sampled low while $\overline{CAS}$ is active, $\overline{SDWE}$ indicates an SDRAM write access. When sampled high while $\overline{CAS}$ is active, $\overline{SDWE}$ indicates an SDRAM read access. In other SDRAM accesses, $\overline{SDWE}$ defines the type of operation to execute according to SDRAM specification.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

[1]The internal 100 kΩ internal pullup may not be sufficient depending on system noise and/or leakage. A stronger pullup may be necessary.
[2]The internal 100 kΩ internal pulldown may not be sufficient depending on system noise and/or leakage. A stronger pulldown may be necessary.

Table 7. Pin Definitions—JTAG Port

Signal	Type	Description
$\overline{EMU}$	O (o/d)	Emulation. Connected to the DSP's JTAG emulator target board connector only.
TCK	I	Test Clock (JTAG). Provides an asynchronous clock for JTAG scan.
TDI[1]	I (pu)	Test Data Input (JTAG). A serial data input of the scan path.
TDO	O/T	Test Data Output (JTAG). A serial data output of the scan path.
TMS[1]	I (pu)	Test Mode Select (JTAG). Used to control the test state machine.
$\overline{TRST}$[1]	I/A (pu)	Test Reset (JTAG). Resets the test state machine. $\overline{TRST}$ must be asserted or pulsed low after power up for proper device operation. For more information, see Reset and Booting on page 9.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

[1]The internal 100 kΩ internal pullup may not be sufficient depending on system noise and/or leakage. A stronger pullup may be necessary.

Table 8. Pin Definitions—Flags, Interrupts, and Timer

Signal	Type	Description
FLAG3–0[1]	I/O/A (pd)	FLAG pins. Bidirectional input/output pins can be used as program conditions. Each pin can be configured individually for input or for output. FLAG3–0 are inputs after power-up and reset.
$\overline{\text{IRQ3–0}}$[2]	I/A (pu)	Interrupt Request. When asserted, the DSP generates an interrupt. Each of the $\overline{\text{IRQ3–0}}$ pins can be independently set for edge-triggered or level-sensitive operation. After reset, these pins are disabled unless the $\overline{\text{IRQ3–0}}$ strap option and interrupt vectors are initialized for booting.
$\overline{\text{TMR0E}}$[1]	O (pd)	Timer 0 expires. This output pulses for four SCLK cycles whenever timer 0 expires. At reset this is a strap pin. For more information, see Table 14 on page 19.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

[1]The internal 100 kΩ internal pulldown may not be sufficient depending on system noise and/or leakage. A stronger pulldown may be necessary.
[2]The internal 100 kΩ internal pullup may not be sufficient depending on system noise and/or leakage. A stronger pullup may be necessary.

Table 9. Pin Definitions—Link Ports

Signal	Type	Description
L0DAT7–0[1]	I/O	Link0 Data 7–0
L1DAT7–0[1]	I/O	Link1 Data 7–0
L2DAT7–0[1]	I/O	Link2 Data 7–0
L3DAT7–0[1]	I/O	Link3 Data 7–0
L0CLKOUT	O	Link0 Clock/Acknowledge Output
L1CLKOUT	O	Link1 Clock/Acknowledge Output
L2CLKOUT	O	Link2 Clock/Acknowledge Output
L3CLKOUT	O	Link3 Clock/Acknowledge Output
L0CLKIN	I/A	Link0 Clock/Acknowledge Input
L1CLKIN	I/A	Link1 Clock/Acknowledge Input
L2CLKIN	I/A	Link2 Clock/Acknowledge Input
L3CLKIN	I/A	Link3 Clock/Acknowledge Input
L0DIR	O	Link0 Direction. (0 = input, 1 = output)
L1DIR	O	Link1 Direction. (0 = input, 1 = output)
L2DIR[2]	O (pd)	Link2 Direction. (0 = input, 1 = output) At reset this is a strap pin. For more information, see Table 14 on page 19.
L3DIR	O (pd)	Link3 Direction. (0 = input, 1 = output)

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

[1]The link port data pins, if connected or floated for extended periods (i.e., token slave with no token master), do not require pullups or pulldowns as there are no reliability issues and the worst-case power consumption for these floating inputs is negligible. Floating in this case means that these inputs are not driven by any source and that DC-biased terminations are not present.
[2]The internal 100 kΩ internal pulldown may not be sufficient depending on system noise and/or leakage. A stronger pulldown may be necessary.

Table 10. Pin definitions—Impedance and Drive Strength Control

Signal	Type	Description
CONTROLIMP2–1[1] CONTROLIMP0[2]	I (pu) I (pd)	Impedance Control. Every group of outputs has two controls: dig_ctrl 0 = Disabled (maximum drive strength) 1 = Enabled (use DSx drive strength selection) pulse 0 = Disabled (constant drive strength as selected by DSx pins) 1 = Enabled (2 ns pulse for max drive at the beginning of the transition; constant drive otherwise as selected by DSx pins) For ADC (Address/Data/Controls) and LINK (all link port outputs) signals, the CONTROLIMP2–0 pins control impedance as shown in Table 11.
DS2–0[1]	I (pu)	Digital Drive Strength Selection. Selected as shown in Table 12. For drive strength calculation, see Output Drive Currents on page 29.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

[1]The internal 100 kΩ internal pullup may not be sufficient depending on system noise and/or leakage. A stronger pullup may be necessary.
[2]The internal 100 kΩ internal pulldown may not be sufficient depending on system noise and/or leakage. A stronger pulldown may be necessary.

Table 11. Control Impedance Selection

	ADC		LINK	
CONTROLIMP2–0	dig_ctrl	pulse	dig_ctrl	pulse
000	0	X	0	X
001	0	X	0	X
010	0	X	1	0
011	0	X	1	1
100	1	0	0	X
101	1	1	0	X
110 (default)	1	0	1	0
111	1	1	1	1

Table 12. Drive Strength Selection

DS2–0	Drive Strength
000	11%
001	29%
010	37%
011	49%
100	62%
101	75%
110	88%
111 (default)	100%

Table 13. Pin Definitions—Power, Ground, and Reference

Signal	Type	Description
V_{DD}	P	V_{DD} pins for internal logic.
V_{DD_A}	P	V_{DD} pins for analog circuits. Pay critical attention to bypassing this supply.
V_{DD_IO}	P	V_{DD} pins for I/O buffers.
V_{REF}	I	Reference voltage defines the trip point for all input buffers, except $\overline{\text{RESET}}$, $\overline{\text{IRQ3–0}}$, $\overline{\text{DMAR3–0}}$, ID2–0, CONTROLIMP2–0, TCK, TDI, TMS, and $\overline{\text{TRST}}$. The value is 1.5 V ± 100 mV (which is the TTL trip point). V_{REF} can be connected to a power supply or set by a voltage divider circuit. The voltage divider should have an HF decoupling capacitor (1 nF HF SMD) connected to V_{SS}. Tie the decoupling capacitor between V_{REF} input and V_{SS}, as close to the DSP's pins as possible. For more information, see Filtering Reference Voltage and Clocks on page 10.
V_{SS}	G	Ground pins.
V_{SS_A}	G	Ground pins for analog circuits.

A = asynchronous; G = ground; I = input; O = output; o/d = open drain output; P = power supply;
pd = internal pulldown 100 kΩ; pu = internal pullup 100 kΩ; T = Three-State

STRAP PIN FUNCTION DESCRIPTIONS

Some pins have alternate functions at reset. Strap options set DSP operating modes. During reset, the DSP samples the strap option pins. Strap pins have a 100 kΩ pull-down for the default value. If a strap pin is not connected to an external pull-up or logic load, the DSP samples the default value during reset. If strap pins are connected to logic inputs, a stronger external pulldown may be required to ensure default value depending on leakage and/or low level input current of the logic load. To set a mode other than the default mode, connect the strap pin to a sufficiently stronger external pull-up. Table 14 lists and describes each of the DSP's strap pins.

Table 14. Pin Definitions—I/O Strap Pins

Signal	On Pin...	Description
EBOOT	$\overline{\text{BMS}}$	EPROM boot. 0 = boot from EPROM immediately after reset (default) 1 = idle after reset and wait for an external device to boot DSP through the external port or a link port
IRQEN	$\overline{\text{BM}}$	Interrupt Enable. 0 = disable and set $\overline{\text{IRQ3–0}}$ interrupts to level-sensitive after reset (default) 1 = enable and set $\overline{\text{IRQ3–0}}$ interrupts to edge-sensitive immediately after reset
TM1	L2DIR	Test Mode 1. 0 = required setting during reset. 1 = reserved.
TM2	$\overline{\text{TMR0E}}$	Test Mode 2. 0 = required setting during reset. 1 = reserved.

ADSP-TS101S—SPECIFICATIONS

Note that component specifications are subject to change without notice.

RECOMMENDED OPERATING CONDITIONS

Parameter		Test Conditions	Min	Max	Unit
V_{DD}	Internal Supply Voltage		1.14	1.26	V
V_{DD_A}	Analog Supply Voltage		1.14	1.26	V
V_{DD_IO}	I/O Supply Voltage		3.15	3.45	V
T_{CASE}	Case Operating Temperature		–40	+85	°C
V_{IH}	High-Level Input Voltage[1]	@ V_{DD}, V_{DD_IO} = max	2	V_{DD_IO} + 0.5	V
V_{IL}	Low-Level Input Voltage[1]	@ V_{DD}, V_{DD_IO} = min	–0.5	0.8	V
V_{REF}	Voltage reference		1.4	1.6	V

[1]Applies to input and bidirectional pins.

ELECTRICAL CHARACTERISTICS

Parameter		Test Conditions	Min	Max	Unit
V_{OH}	High-Level Output Voltage[1]	@V_{DD_IO} = min, I_{OH} = –2 mA	2.4		V
V_{OL}	Low-Level Output Voltage[1]	@V_{DD_IO} = min, I_{OL} = 4 mA		0.4	V
I_{IH}	High-Level Input Current[2]	@V_{DD_IO} = max, V_{IN} = V_{DD_IO} max		10	µA
I_{IHP}	High-Level Input Current (pd)[3]	@V_{DD_IO} = max, V_{IN} = V_{DD_IO} max	TBD	TBD	µA
I_{IL}	Low-Level Input Current[4]	@V_{DD_IO} = max, V_{IN} = 0V		10	µA
I_{ILP}	Low-Level Input Current (pu)[5]	@V_{DD_IO} = max, V_{IN} = 0V	TBD	TBD	µA
I_{OZH}	Three-State Leakage Current High[6,10]	@V_{DD_IO} = max, V_{IN} = V_{DD_IO} max		10	µA
I_{OZHP}	Three-State Leakage Current High (pd)[7]	@V_{DD_IO} = max, V_{IN} = V_{DD_IO} max	TBD	TBD	µA
I_{OZL}	Three-State Leakage Current Low[8]	@V_{DD_IO} = max, V_{IN} = 0V		10	µA
I_{OZLP}	Three-State Leakage Current Low (pu)[9]	@V_{DD_IO} = max, V_{IN} = 0	TBD	TBD	µA
I_{OZLO}	Three-State Leakage Current Low (od)[10]	@V_{DD_IO} = max, V_{IN} = 0V	TBD	TBD	µA
C_{IN}	Input Capacitance[11,12]	@f_{IN} = 1MHz,T_{CASE} = 25C, V_{IN} = 2.5V	TBD	TBD	F

[1]Applies to output and bidirectional pins.
[2]Applies to input pins without internal pulldowns (pd).
[3]Applies to input pins with internal pulldowns (pd).
[4]Applies to input pins without internal pullups (pu).
[5]Applies to input pins with internal pullups (pu).
[6]Applies to three-stateable pins without internal pulldowns (pd).
[7]Applies to three-stateable pins with internal pulldowns (pd).
[8]Applies to three-stateable pins without internal pullups (pu).
[9]Applies to three-stateable pins with internal pullups (pu).
[10]Applies to open drain (od) pins with 500 Ω pullups (pu).
[11]Applies to all signals.
[12]Guaranteed but not tested.

ABSOLUTE MAXIMUM RATINGS

Internal (Core) Supply Voltage (V_{DD})[1] . . . –0.3 V to +1.40 V
Analog (PLL) Supply Voltage (V_{DD_A})[1] . . –0.3 V to +1.40 V
External (I/O) Supply Voltage (V_{DD_IO})[1] . . . –0.3 V to +4.6 V
Input Voltage[1] . . . . . –0.5 V to V_{DD_IO}+0.5 V
Output Voltage Swing[1] . . . . . –0.5 V to V_{DD_IO}+0.5 V
Storage Temperature Range[1] . . . . . –65°C to +150°C

[1] Stresses greater than those listed above 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.

ESD SENSITIVITY

CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADSP-TS101S features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high-energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

ADSP-TS101S TIMING SPECIFICATIONS

With the exception of Link port, $\overline{\text{DMAR3–0}}$, and $\overline{\text{IRQ3–0}}$ pins, all AC timing for the ADSP-TS101S is relative to a reference clock edge. Because input setup/hold, output valid/hold, and output enable/disable times are relative to a clock edge, the timing data for the ADSP-TS101S has few calculated (formula-based) values.For information on AC timing, see General AC Timing on page 22. For information on Link port transfer timing, see Link Port Data Transfer and Token Switch Timing on page 25.

General AC Timing

Timing is measured on signals when they cross the 1.5 V level as described in Figure 10 on page 24. 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.

The general AC timing data appears in Table 16 and Table 17.

The AC asynchronous timing data for the $\overline{\text{IRQ3–0}}$ and $\overline{\text{DMAR3–0}}$ pins appears in Table 15.

Table 15. AC Asynchronous Signal Specifications (all values in this table are in nanoseconds)

Name	Description	Pulsewidth Low (min)	Pulsewidth High (min)
$\overline{\text{IRQ3–0}}$[1]	Interrupt Request	t_{CCLK} + TBD ns	t_{CCLK} + TBD ns
$\overline{\text{DMAR3–0}}$[1]	DMA Request	t_{CCLK} + 3 ns	t_{CCLK} + 3 ns

[1]These input pins have Schmitt triggers and therefore do not need to be synchronized to a clock reference.

Table 16. Reference Clocks

Signal	Type	Description	Speed Grade (MHz)	Clock Cycle Min (ns)	Clock Cycle Max (ns)	Clock High Min (ns)	Clock Low Min (ns)	Skew to LCLK Max (ps)
CCLK[1]	–	Core Clock	250	4.0	12.5	–	–	–
LCLK_P[2,3]	I	Local Clock	250	CR×4.0	CR×12.5	{40% to 60% Duty Cycle}		–
SCLK_P[3,4]	I	System Clock, SCLKFREQ = 1	All	Greater of 10 CCLK×2	20	{40% to 60% Duty Cycle}		50
		System Clock, SCLKFREQ = 0	All	Greater of 20 or CCLK×2	50			
TCK	I	Test Clock (JTAG)	All	Greater of 30 or CCLK×4	–	12	12	–

[1]CCLK is the internal DSP clock or instruction cycle time. The period of this clock is equal to the Local Clock (LCLK_P) period divided by the Local Clock Ratio (LCLKRAT2–0). For information on available internal DSP clock rates, see the Ordering Guide on page 42.
[2]The Core clock Ratio (CR) is 2, 2.5, 3, 3.5, 4, 5, or 6 as set by the LCLKRAT2–0 pins. For more information, see Table 4 on page 13.
[3]For more information, see Clock Domains on page 9.
[4]For more information, see Table 3 on page 12.

Table 17. AC Signal Specifications (all values in this table are in nanoseconds)

Name	Description	Input Setup (min)	Input Hold (min)	Output Valid (max)	Output Hold (min)	Output Enable (max)[1]	Output Disable (max)[1]	Reference Clock
ADDR31–0	External Address Bus	1.5	0.5	4	1	1.5	4	SCLK
DATA63–0	External Data Bus	1.5	0.5	4	1	1.5	4	SCLK
$\overline{\text{MSH}}$	Memory Select HOST Line	—	—	4	1	1.5	4	SCLK
$\overline{\text{MSSD}}$	Memory Select SDRAM Line	1.5	0.5	4	1	1.5	4	SCLK

Table 17. AC Signal Specifications (all values in this table are in nanoseconds) (continued)

Name	Description	Input Setup (min)	Input Hold (min)	Output Valid (max)	Output Hold (min)	Output Enable (max)[1]	Output Disable (max)[1]	Reference Clock
$\overline{MS1–0}$	Memory Select for Static Blocks	—	—	4	1	1.5	4	SCLK
$\overline{RD}$	Memory Read	1.5	0.5	4	1	1.5	4	SCLK
$\overline{WRL}$	Write Low Word	1.5	0.5	4	1	1.5	4	SCLK
$\overline{WRH}$	Write High Word	1.5	0.5	4	1	1.5	4	SCLK
ACK	Acknowledge for Data	1.5	0.5	4	1	1.5	4	SCLK
SDCKE	SDRAM Clock Enable	1.5	0.5	4	1	1.5	4	SCLK
$\overline{RAS}$	Row Address Select	1.5	0.5	4	1	1.5	4	SCLK
$\overline{CAS}$	Column Address Select	1.5	0.5	4	1	1.5	4	SCLK
$\overline{SDWE}$	SDRAM Write Enable	1.5	0.5	4	1	1.5	4	SCLK
LDQM	Low Word SDRAM Data Mask	—	—	4	1	1.5	4	SCLK
HDQM	High Word SDRAM Data Mask	—	—	4	1	1.5	4	SCLK
SDA10	SDRAM ADDR10	—	—	4	1	1.5	4	SCLK
$\overline{HBR}$	Host Bus Request	1.5	0.5	—	—	—	—	SCLK
$\overline{HBG}$	Host Bus Grant	1.5	0.5	4	1	1.5	4	SCLK
$\overline{BOFF}$	Back Off Request	1.5	0.5	—	—	—	—	SCLK
$\overline{BUSLOCK}$	Bus Lock	—	—	4	1	1.5	4	SCLK
$\overline{BRST}$	Burst pin	1.5	0.5	4	1	1.5	4	SCLK
$\overline{BR7–0}$	Multiprocessing Bus Request pins	1.5	0.5	4	1	—	—	SCLK
$\overline{FLYBY}$	FLYBY pin	—	—	4	1	1.5	4	SCLK
$\overline{IOEN}$	FLYBY pin	—	—	4	1	1.5	4	SCLK
$\overline{CPA}$ [2,5]	Core Priority Access	1.5	0.5	TBD	TBD	1.5	4	SCLK
$\overline{DPA}$ [2,5]	DMA Priority Access	1.5	0.5	TBD	TBD	1.5	4	SCLK
$\overline{BMS}$[3]	Boot Memory Select	1.5	0.5	4	1	1.5	4	SCLK
FLAG3–0[4]	FLAG pins	1.5	0.5	4	1	1.5	4	SCLK
$\overline{TMR0E}$[3]	Timer 0 Expired	—	—	4	1	—	—	SCLK
$\overline{RESET}$[5,6]	Global Reset pin	1.5	0.5	—	—	—	—	SCLK
TMS[5]	Test Mode Select (JTAG)	1.5	0.5	—	—	—	—	TCK
TDI[5]	Test Data Input (JTAG)	1.5	0.5	—	—	—	—	TCK
TDO	Test Data Output (JTAG)	—	—	4	1	1.5	4	TCK
$\overline{TRST}$[5,6,8]	Test Reset (JTAG)	1.5	0.5	—	—	—	—	TCK
$\overline{BM}$[3]	Bus Master Debug aid only	—	—	4	1	—	—	SCLK
$\overline{EMU}$[7]	Emulation	—	—	4	1	1.5	4	TCK or LCLK
ID2–0[8]	Chip ID – must be constant	—	—	—	—	—	—	—
CONTROLIMP2–0[8]	Static pins – must be constant	—	—	—	—	—	—	—

Table 17. AC Signal Specifications (all values in this table are in nanoseconds) (continued)

Name	Description	Input Setup (min)	Input Hold (min)	Output Valid (max)	Output Hold (min)	Output Enable (max)[1]	Output Disable (max)[1]	Reference Clock
DS2–0[8]	Static pins – must be constant	—	—	—	—	—	—	—
LCLKRAT2–0[8]	Static pins – must be constant	—	—	—	—	—	—	—
SCLKFREQ[8]	Static pins – must be constant	—	—	—	—	—	—	—

[1]The external port protocols employ bus IDLE cycles for bus mastership transitions as well as slave address boundary crossings to avoid any potential bus contention. The apparent driver overlap, due to output disables being larger than output enables, is not actual.
[2]$\overline{CPA}$ and $\overline{DPA}$ pins are open drains and have 0.5 kΩ internal pullups.
[3]This pin is a strap option. During reset, an internal resistor pulls the pin low.
[4]These pins have an asynchronous minimum pulse width of t_{SCLK} + TBD ns.
[5]These input pins have Schmitt triggers and therefore do not need to be synchronized to a clock reference. These synchronous specifications only apply for recognition in the current clock reference cycle.
[6]For additional requirement details, see Reset and Booting on page 9.
[7]Reference clock depends on function.
[8]These pins may change only during reset; recommend connecting it to V_{DD}/V_{SS}.

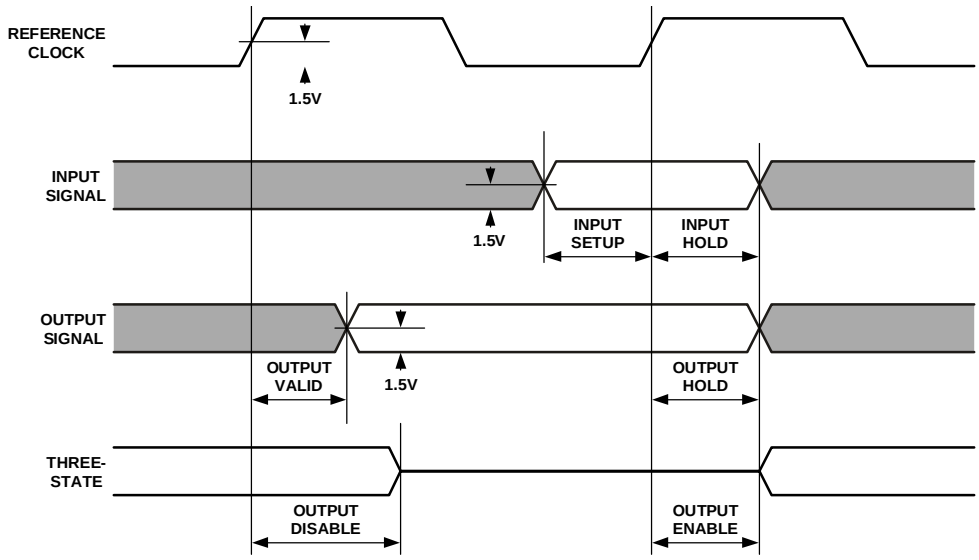


Figure 10. General AC parameters timing

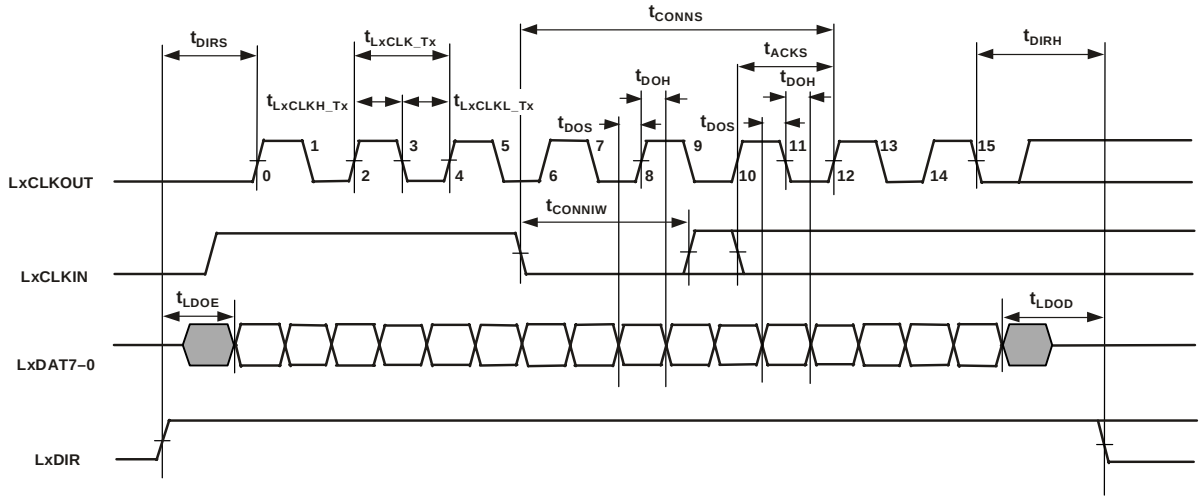
Link Port Data Transfer and Token Switch Timing

Table 18, Table 19, Table 20, and Table 21 with Figure 11, Figure 12, Figure 13, and Figure 14 provide the timing specifications for the link ports data transfer and token switch.

Table 18. Link Ports—Transmit

Parameter		Min	Max	Unit
Timing Requirements:				
t_{CONNS}	Connectivity Pulse Setup	$0.25 \times t_{LxCLK\_Tx}$		ns
t_{CONNIW}	Connectivity Pulse Input Width	t_{LxCLK_Tx}		ns
t_{ACKS}	Acknowledge Setup	$0.5 \times t_{LxCLK\_Tx}$		ns
Switching Characteristics:				
t_{LxCLK_Tx}[1]	Transmit Link Clock Period	$0.9 \times LR \times CCLK$	$1.1 \times LR \times CCLK$	ns
t_{LxCLKH_Tx}	Transmit Link Clock Width High	$0.4 \times t_{LxCLK\_Tx}$	$0.6 \times t_{LxCLK\_Tx}$	ns
t_{LxCLKL_Tx}	Transmit Link Clock Width Low	$0.4 \times t_{LxCLK\_Tx}$	$0.6 \times t_{LxCLK\_Tx}$	ns
t_{DIRS}	LxDIR Transmit Setup	$0.5 \times t_{LxCLK\_Tx}$	$2 \times t_{LxCLK\_Tx}$	ns
t_{DIRH}	LxDIR Transmit Hold	$0.5 \times t_{LxCLK\_Tx}$	$2 \times t_{LxCLK\_Tx}$	ns
t_{DOS}[2]	LxDAT7–0 Output Setup	$0.25 \times t_{LxCLK\_Tx} - 1$		ns
t_{DOH}[2]	LxDAT7–0 Output Hold	$0.25 \times t_{LxCLK\_Tx} - 1$		ns
t_{DOS}[3]	LxDAT7–0 Output Setup	$0.17 \times t_{LxCLK\_Tx} - 1$		ns
t_{DOH}[3]	LxDAT7–0 Output Hold	$0.17 \times t_{LxCLK\_Tx} - 1$		ns
t_{LDOE}	LxDAT7–0 Output Enable	CCLK		
t_{LDOD}[4]	LxDAT7–0 Output Disable	CCLK		

[1]The Link clock Ratio (LR) is 2, 3, 4, or 8 as set by the SPD bits in the LxCTL register.
[2]The formula for this parameter applies when LR is 2, 4, or 8.
[3]The formula for this parameter applies when LR is 3.
[4]This specification applies to the last data byte or the "Dummy" byte that follows the verification byte if enabled. For more information, see the *TigerSHARC DSP Hardware Specification*.



Note: LxCLKIN shows the connectivity pulse with each of the three possible transitions to "Acknowledge". After a connectivity pulse low minimum, LxCLKIN may [1] return high and remain high for "Acknowledge", [2] return high and subsequently go low (meeting t_{ACKS}) for "Not Acknowledge", or [3] remain low for "Not Acknowledge".

Figure 11. Link Ports—Transmit

Table 19. Link Ports—Receive

Parameter		Min	Max	Unit
Timing Requirements:				
t_{LxCLK_Rx}[1]	Receive Link Clock Period	0.9 × LR × CCLK	1.1 × LR × CCLK	ns
t_{LxCLKH_Rx}	Receive Link Clock Width High	0.4 × t_{LxCLK_Rx}	0.6 × t_{LxCLK_Rx}	ns
t_{LxCLKL_Rx}	Receive Link Clock Width Low	0.4 × t_{LxCLK_Rx}	0.6 × t_{LxCLK_Rx}	ns
t_{DIS}	LxDAT7–0 Input Setup	0.6		ns
t_{DIH}	LxDAT7–0 Input Hold	0.6		ns
Switching Characteristics:				
t_{CONNV}	Connectivity Pulse Valid	0	2.5 × t_{LxCLK_Rx}	ns
t_{CONNOW}	Connectivity Pulse Output Width	1.5 × t_{LxCLK_Rx}		ns

[1]The Link clock Ratio (LR) is 2, 3, 4, or 8 as set by the SPD bits in the LxCTL register.

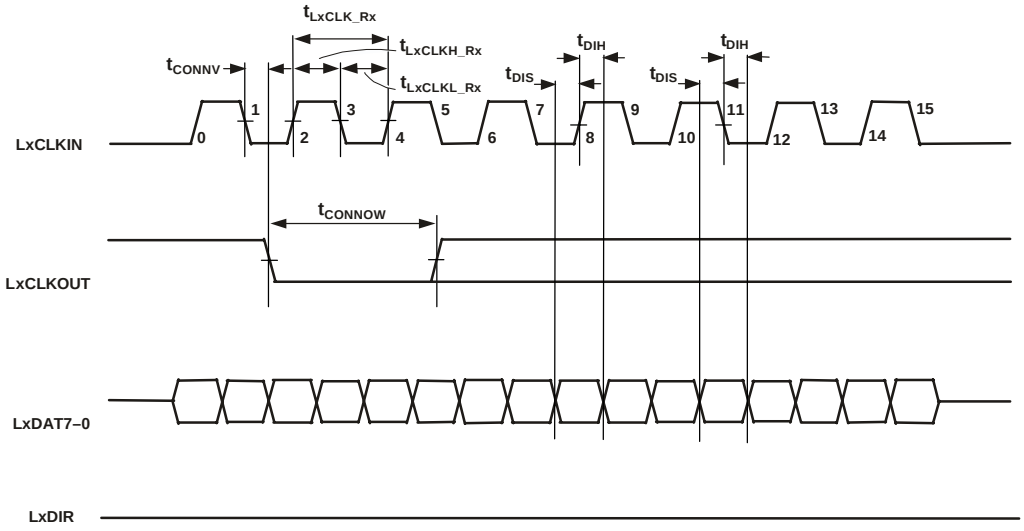
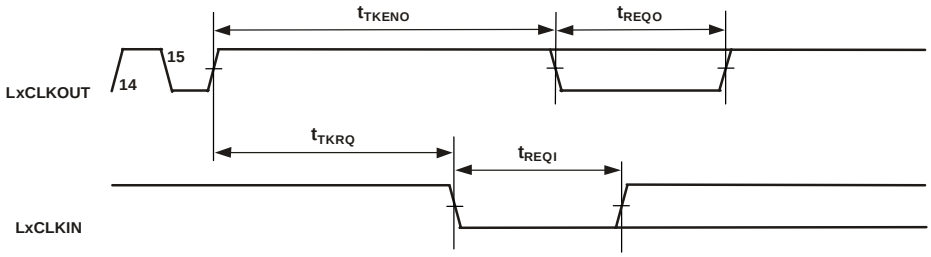


Figure 12. Link Ports—Receive

Table 20. Link Ports—Token Switch, Token Master

Parameter		Min	Max	Unit
Timing Requirements:				
t_{REQI}	Token Request Input Width	5.0 × t_{LxCLK_Rx}		ns
t_{TKRQ}	Token Request from Token Enable (for guaranteeing token switch during Token Enable)		3.0 × t_{LxCLK_Tx}	ns
Switching Characteristics:				
t_{TKENO}	Token Switch Enable Output	8.0 × t_{LxCLK_Tx}		ns
t_{REQO}	Token Request Output Width	6.0 × t_{LxCLK_Tx}		ns



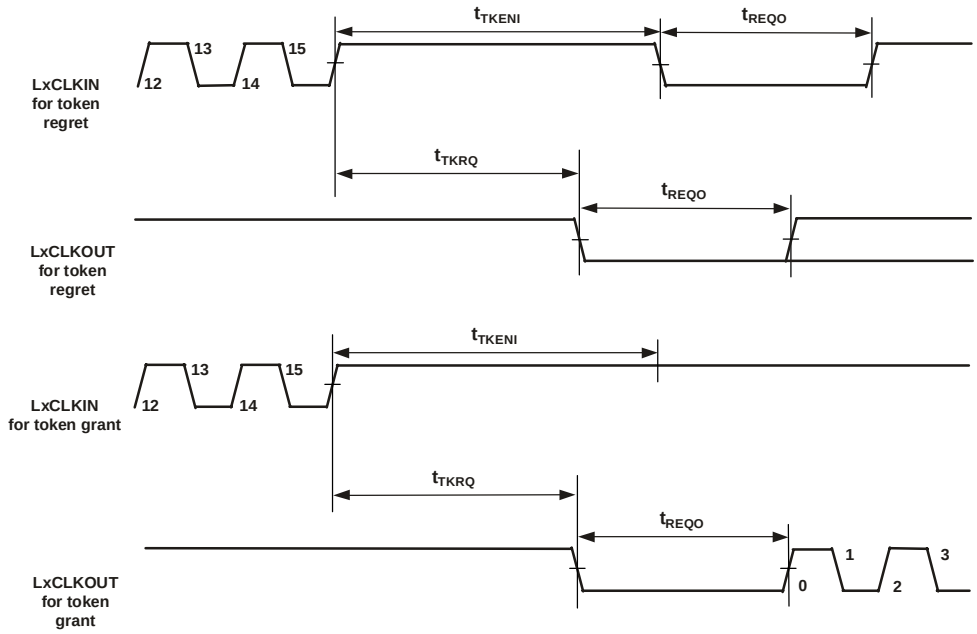
Note: LxCLKOUT shows both possible responses to the token request: [1] a "Token Grant" (LxCLKOUT remains high), and [2] a "Token Regret" (LxCLKOUT goes low).

Figure 13. Link Ports—Token Switch, Token Master

Table 21. Link Ports—Token Switch, Token Requester

Parameter		Min	Max	Unit
Timing Requirements:				
t_{TKENI}[1]	Token Switch Enable Input	8.0 × t_{LxCLK_Rx}		ns
Switching Characteristics:				
t_{REQO}	Token Request Output Width	6.0 × t_{LxCLK_Rx}		ns

[1] Required whenever there is a break in transmission.



Note: LxCLKOUT shows both possible responses to the token request: [1] a "Token Grant" (LxCLKOUT remains high), and [2] a "Token Regret" (LxCLKOUT goes low).

Figure 14. Link Ports—Token Switch, Token Requester

Output Drive Currents

Figure 15 is a place holder for typical I–V characteristics for the output drivers of the ADSP-TS101S. The curves in this diagram will represent the current drive capability of the output drivers as a function of output voltage.

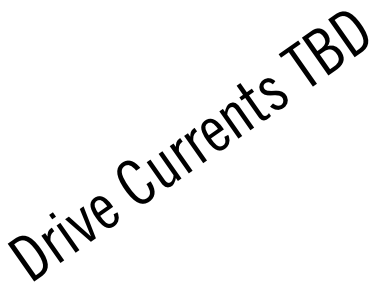


Figure 15. ADSP-TS101S Typical Drive Currents

Power Dissipation

Total power dissipation has two components, one due to internal circuitry and one due to the switching of external output drivers. These specifications apply to the internal power portion only (V_{DD}).

Internal Power Calculation

Internal power dissipation is dependent on the instruction execution sequence and the data operands involved. The ADSP-TS101S's power consumption for a specific application is calculated according to the following formula, where % is the amount of time the application spends in that state:

$$\begin{aligned}
&(\%\ Peak \times I_{DDINPEAK})\\
&(\%\ Maximum \times I_{DDINMAX})\\
&(\%\ Typical \times I_{DDINTYP})\\
&(\%\ Control \times I_{DDINCTRL})\\
&(\%\ DMA \times I_{DDINDMA})\\
&(\%\ Idle \times I_{DDINIDLE})\\
&+ (\%\ Idle\ Low\ Power \times I_{DDINIDLELP})\\
&\overline{\qquad\qquad\qquad\qquad\qquad\qquad}\\
&Total\ Current \langle I_{DDIN} \rangle\ for\ V_{DD}
\end{aligned}$$

The calculation in Figure 16 provides P_{INT}.

$$P_{INT} = I_{DDIN} \times V_{DD}$$

Figure 16. Internal Power P_{INT} Calculation

Table 22. Power Vectors

Parameter	Test Conditions	Max	Unit
$I_{DDINPEAK}$	TBD	TBD	mA
$I_{DDINMAX}$	TBD	TBD	mA
$I_{DDINTYP}$	TBD	TBD	mA
$I_{DDINCTRL}$	TBD	TBD	mA
$I_{DDINDMA}$	TBD	TBD	mA
$I_{DDINIDLE}$	TBD	TBD	mA
$I_{DDINIDLELP}$	TBD	TBD	mA

The following power vector definitions apply to the power consumption calculation and the power vector specifications in Table 22.

- $I_{DDINPEAK}$—V_{DD} supply current for peak activity
  Peak activity is a SIMD quad 16-bit fixed-point multiply, add, and subtract in parallel with two quad-word data fetches. The data fetched and operated on are worst case in terms of power consumption. This vector includes DMA activity as described below in the $I_{DDINDMA}$ definition. This represents worst-case processor operation and is not sustainable under normal application conditions.
- $I_{DDINMAX}$—V_{DD} supply current for maximum activity
  Maximum activity is a SIMD quad 16-bit fixed-point multiply and add in parallel with two quad-word data fetches. The data fetched and operated on are random. This vector includes DMA activity as described below in the $I_{DDINDMA}$ definition.
- $I_{DDINTYP}$—V_{DD} supply current for typical activity
  Typical activity is a SIMD quad 16-bit fixed-point compute operation in parallel with two quad-word data fetches. The data fetched and operated on are random. This vector includes DMA activity as described below in the $I_{DDINDMA}$ definition.
- $I_{DDINCTRL}$—V_{DD} supply current for control activity
  Control activity is continuous decision making and predicted branches. The branch prediction is deliberately set to be incorrect 50% of the time for equal distribution. This vector includes DMA activity as described below in the $I_{DDINDMA}$ definition.
- $I_{DDINDMA}$—V_{DD} supply current for DMA activity
  DMA activity is a single external port DMA from external to internal memory, quad-word transfers of 32 words total. The DMA is chained to itself and does not use interrupts. After setup, the core is not involved, executing the IDLE instruction only.

- $I_{DDINIDLE}$—V_{DD} supply current for idle activity

  Idle activity is the core executing the IDLE instruction only with no DMA or interrupts.

- $I_{DDINIDLELP}$—V_{DD} supply current for idle low power activity

  Idle Low Power activity is the core executing the IDLE(LP) instruction only with no DMA or interrupts.

External Power Calculation

The external power on V_{DD_IO} is consumed by the switching of output pins and is system dependent. For each unique group of pins, the magnitude of power consumed depends on:

- The number of output pins that switch during each cycle, *O*
- Their load capacitance, *C*
- Their voltage swing, V_{DD_IO}
- The maximum frequency at which they can switch, *f*

and is calculated by the formula in Figure 17.

$$P_{EXT} = O \times C \times V_{DD\_IO}^{2} \times f$$

Figure 17. External Power P_{EXT} Calculation

The load capacitance should include the input capacitance of each connected device as well as the DPS's own input capacitance (C_{IN}) For additional accuracy trace capacitance should be included if possible. The switching frequency includes driving the load high and then back low. Address and data pins can drive high and low at a maximum rate of ½ SCLK.

For example, estimate P_{EXT} for the external port pins with the following assumptions:

- System consists of one ADSP-TS101S with one bank of external memory (64-bit).
- Two 1M × 32 SDRAM chips are used, each with a load of 5 pF per pin (trace capacitance neglected for this example).
- Continuous burst of quad-word (128-bit) writes occur every cycle at a rate of SCLK, with 50% of the data pins switching (represents random data).
- Address increments sequentially on transaction boundary (every quad-word). For sequential addressing, the number of address bits switching approaches 2-bits.
- Control switches for refresh and page boundaries.
- SCLK = 100Mhz (bus cycle time).

The P_{EXT} equation is calculated for each class of pins that can drive as shown in Table 23.

Table 23. External Power P_{EXT} Calculation

Pin Type	# of Pins	% Switching	× C	× $V_{DD\_IO}^2$	× f	= P_{EXT}
Data	64	50	× (5 pF + C_{IN})	× 10.9 V^2	× 50 MHz	= TBD W
Address	32	6.25	× (10 pF + C_{IN})	× 10.9 V^2	× 25 MHz	= TBD W
Control	8	50	× (10 pF + C_{IN})	× 10.9 V^2	× 250 KHz	= TBD W
						P_{EXT} = TBD W

Test Conditions

The test conditions for timing parameters appearing in ADSP-TS101S—Specifications on page 20 include output disable time, output enable time, and capacitive loading. The timing specifications for the DSP apply for the voltage reference levels in Figure 18.

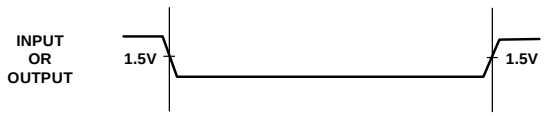


Figure 18. Voltage reference levels for AC measurements (except output enable/disable)

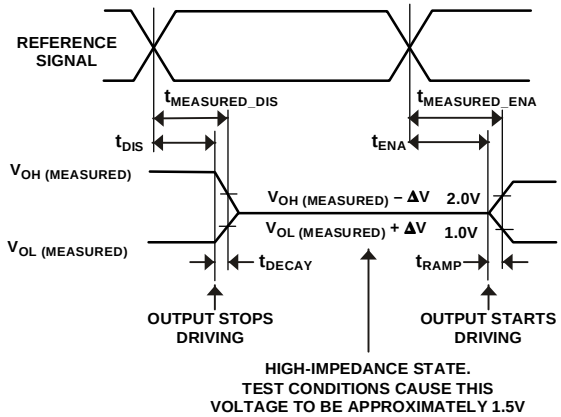


Figure 19. Output Enable/Disable

Output Disable Time

Output pins are considered to be disabled when they stop driving, go into a high impedance state, and start to decay from their output high or low voltage. The time for the voltage on the bus to decay by ΔV is dependent on the capacitive load, C_L and the load current, I_L. This decay time can be approximated by the following equation:

$$t_{DECAY} = (C_L \Delta V)/I_L$$

The output disable time t_{DIS} is the difference between $t_{MEASURED\_DIS}$ and t_{DECAY} as shown in Figure 19. The time $t_{MEASURED\_DIS}$ is the interval from when the reference signal switches to when the output voltage decays ΔV from the measured output high or output low voltage. t_{DECAY} is calculated with test loads C_L and I_L, and with ΔV equal to 0.5 V.

Output Enable Time

Output pins are considered to be enabled when they have made a transition from a high impedance state to when they start driving. The time for the voltage on the bus to ramp by ΔV is dependent on the capacitive load, C_L, and the drive current, I_D. This ramp time can be approximated by the following equation:

$$t_{RAMP} = (C_L \Delta V)/I_D$$

The output enable time t_{ENA} is the difference between $t_{MEASURED\_ENA}$ and t_{RAMP} as shown in Figure 19. The time $t_{MEASURED\_ENA}$ is the interval from when the reference signal switches to when the output voltage ramps ΔV from the measured three-stated output level. t_{RAMP} is calculated with test load C_L, drive current I_D, and with ΔV equal to 0.5 V.

Capacitive Loading

Output valid and holds are based on standard capacitive loads: TBD on all pins (see Figure 20). The delay and hold specifications given should be derated by a factor of TBD ns/TBD pF for loads other than the nominal value of TBD pF. Figure 21 and Figure 22 show how output rise time varies with capacitance. Figure 23 graphically shows how output valid and holds vary with load capacitance. (Note that this graph or derating does not apply to output disable delays; see Output Disable Time on page 31.) The graphs of Figure 21, Figure 22, and Figure 23 may not be linear outside the ranges shown.

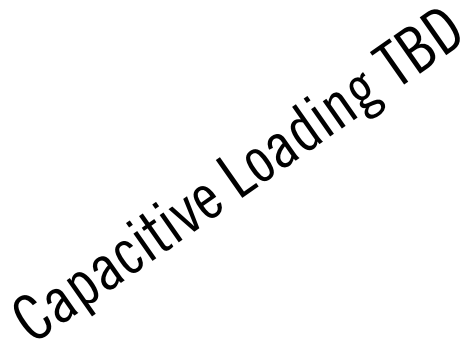


Figure 20. Equivalent Device Loading for AC Measurements (Includes All Fixtures)

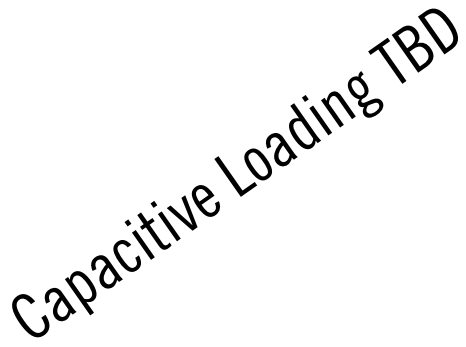


Figure 21. Typical Output Rise Time (10%–90%, V_{DD_IO} = Max) vs. Load Capacitance (at Default Drive Strength and Default Impedance Control)

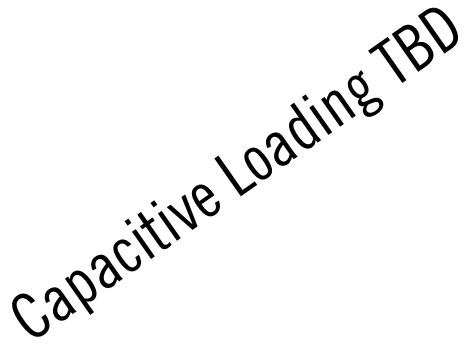


Figure 22. Typical Output Rise Time (10%–90%, V_{DD_IO} = Min) vs. Load Capacitance (at Default Drive Strength and Default Impedance Control)

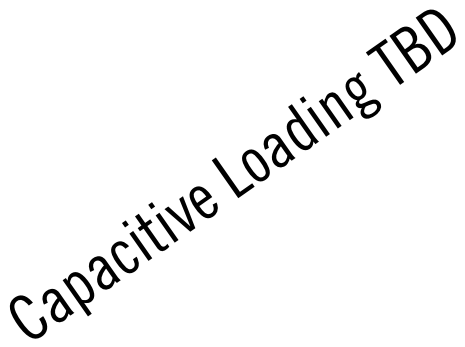


Figure 23. Typical Output Delay or Hold vs. Load Capacitance (at Max Case Temperature and at Default Drive Strength and Default Impedance Control)

Environmental Conditions

The ADSP-TS101S is rated for performance over the extended commercial temperature range, T_{CASE} = –40°C to 85°C.

Thermal Characteristics

The ADSP-TS101S is packaged in a 19 mm × 19 mm and 27 mm × 27 mm Plastic Ball Grid Array (PBGA). The ADSP-TS101S is specified for a case temperature (T_{CASE}). To ensure that the T_{CASE} data sheet specification is not exceeded, a heatsink and/or an air flow source may be used.

$T_{CASE} = T_{AMB} + (PD \times \theta_{CA})$

T_{CASE} = Case temperature (measured on top surface of package).

PD = Power dissipation in W = $P_{INT} + P_{EXT}$

This value depends on the specific application; methods for calculating P_{INT} and P_{EXT} are shown under Power Dissipation on page 29).

θ_{CA} = Value from Table 24 and Table 25.

Table 24. 19 mm × 19 mm θ_{CA} Values[1]

Airflow (Linear Ft./Min.)	0	200	400
θ_{CA} (°C/W)	10.0	7.4	6.3

[1]Where: θ_{JC} = 6.7°C/W and θ_{JB} = 5.8°C/W.

Table 25. 27 mm × 27 mm θ_{CA} Values[1]

Airflow (Linear Ft./Min.)	0	200	400
θ_{CA} (°C/W)	10.8	8.6	7.7

[1]Where: θ_{JC} = 3.2°C/W and θ_{JB} = 5.9°C/W.

484-BALL PBGA PIN CONFIGURATIONS

Table 26. 484-Ball (19 mm × 19 mm) PBGA Pin Assignments

Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name
A1	V_{SS}	B1	DATA21	C1	DATA23	D1	DATA24	E1	DATA25
A2	DATA14	B2	DATA18	C2	DATA17	D2	DATA19	E2	DATA22
A3	DATA11	B3	DATA12	C3	DATA15	D3	DATA16	E3	DATA20
A4	DATA8	B4	DATA13	C4	DATA9	D4	V_{DD_IO}	E4	V_{DD_IO}
A5	DATA4	B5	DATA7	C5	DATA10	D5	V_{DD}	E5	V_{DD}
A6	DATA1	B6	DATA5	C6	DATA6	D6	V_{DD}	E6	V_{DD}
A7	L0DIR	B7	DATA2	C7	DATA3	D7	V_{DD_IO}	E7	V_{DD_IO}
A8	L0CLKIN	B8	NC	C8	DATA0	D8	V_{DD_IO}	E8	V_{DD}
A9	L0DAT6	B9	L0DAT7	C9	L0CLKOUT	D9	V_{DD_IO}	E9	V_{DD}
A10	L0DAT3	B10	L0DAT4	C10	L0DAT5	D10	V_{DD_IO}	E10	V_{DD}
A11	L0DAT1	B11	L0DAT0	C11	L0DAT2	D11	V_{DD_IO}	E11	V_{DD_IO}
A12	V_{SS}	B12	V_{SS}	C12	LCLK_P	D12	V_{DD_IO}	E12	V_{DD}
A13	LCLK_N	B13	V_{DD_A}	C13	V_{SS}	D13	V_{DD_IO}	E13	V_{DD_IO}
A14	V_{SS_A}	B14	V_{SS_A}	C14	V_{DD_A}	D14	V_{DD_IO}	E14	V_{DD}
A15	SCLK_N	B15	V_{SS}	C15	DS0	D15	V_{DD_IO}	E15	V_{DD_IO}
A16	SCLK_P	B16	DS1	C16	DS2	D16	V_{DD}	E16	V_{DD}
A17	CONTROLIMP2	B17	CONTROLIMP0	C17	V_{REF}	D17	V_{DD_IO}	E17	V_{DD_IO}
A18	CONTROLIMP1	B18	$\overline{\text{DMAR2}}$	C18	TRST	D18	V_{DD}	E18	V_{DD_IO}
A19	$\overline{\text{RESET}}$	B19	$\overline{\text{DMAR0}}$	C19	$\overline{\text{DMAR3}}$	D19	V_{DD_IO}	E19	V_{DD_IO}
A20	$\overline{\text{DMAR1}}$	B20	TMS	C20	TCK	D20	TDO	E20	$\overline{\text{BM}}$
A21	$\overline{\text{EMU}}$	B21	TDI	C21	$\overline{\text{IRQ3}}$	D21	$\overline{\text{IRQ2}}$	E21	$\overline{\text{BMS}}$
A22	V_{SS}	B22	$\overline{\text{IRQ1}}$	C22	$\overline{\text{IRQ0}}$	D22	LCLKRAT1	E22	LCLKRAT2
F1	DATA29	G1	L3DAT1	H1	L3DAT2	J1	L3DAT5	K1	L3CLKOUT
F2	DATA30	G2	DATA28	H2	L3DAT0	J2	L3DAT3	K2	L3DAT7
F3	DATA26	G3	DATA27	H3	DATA31	J3	L3DAT4	K3	L3DAT6
F4	V_{DD_IO}	G4	V_{DD}	H4	V_{DD}	J4	V_{DD_IO}	K4	V_{DD_IO}
F5	V_{DD_IO}	G5	V_{DD}	H5	V_{DD}	J5	V_{DD_IO}	K5	V_{DD_IO}
F6	V_{SS}	G6	V_{SS}	H6	V_{SS}	J6	V_{SS}	K6	V_{SS}
F7	V_{SS}	G7	V_{SS}	H7	V_{SS}	J7	V_{SS}	K7	V_{SS}
F8	V_{SS}	G8	V_{SS}	H8	V_{SS}	J8	V_{SS}	K8	V_{SS}
F9	V_{SS}	G9	V_{SS}	H9	V_{SS}	J9	V_{SS}	K9	V_{SS}
F10	V_{SS}	G10	V_{SS}	H10	V_{SS}	J10	V_{SS}	K10	V_{SS}
F11	V_{SS}	G11	V_{SS}	H11	V_{SS}	J11	V_{SS}	K11	V_{SS}
F12	V_{SS}	G12	V_{SS}	H12	V_{SS}	J12	V_{SS}	K12	V_{SS}
F13	V_{SS}	G13	V_{SS}	H13	V_{SS}	J13	V_{SS}	K13	V_{SS}
F14	V_{SS}	G14	V_{SS}	H14	V_{SS}	J14	V_{SS}	K14	V_{SS}
F15	V_{SS}	G15	V_{SS}	H15	V_{SS}	J15	V_{SS}	K15	V_{SS}
F16	V_{SS}	G16	V_{SS}	H16	V_{SS}	J16	V_{SS}	K16	V_{SS}
F17	V_{DD}	G17	V_{SS}	H17	V_{SS}	J17	V_{SS}	K17	V_{SS}
F18	V_{DD_IO}	G18	V_{DD}	H18	V_{DD_IO}	J18	V_{DD}	K18	V_{DD}
F19	V_{DD_IO}	G19	V_{DD_IO}	H19	V_{DD_IO}	J19	V_{DD_IO}	K19	V_{DD_IO}
F20	LCLKRAT0	G20	FLAG3	H20	FLAG1	J20	ID0	K20	$\overline{\text{IOEN}}$
F21	SCLKFREQ	G21	$\overline{\text{BUSLOCK}}$	H21	FLAG2	J21	ID2	K21	$\overline{\text{FLYBY}}$
F22	$\overline{\text{TMR0E}}$	G22	FLAG0	H22	ID1	J22	$\overline{\text{MSH}}$	K22	$\overline{\text{WRL}}$

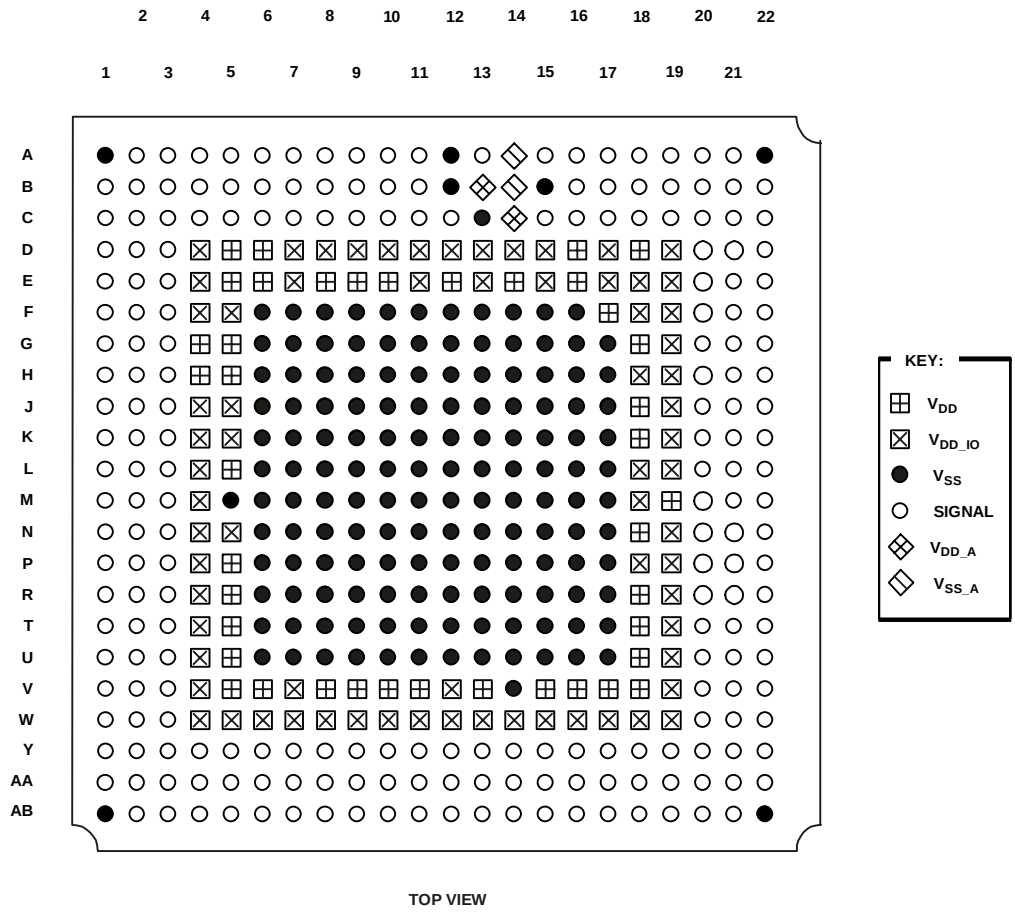
Table 26. 484-Ball (19 mm × 19 mm) PBGA Pin Assignments (continued)

Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name
L1	L3CLKIN	M1	L1DAT0	N1	L1DAT3	P1	L1DAT4	R1	L1DAT6
L2	NC	M2	L1DAT2	N2	L1DAT5	P2	L1CLKOUT	R2	DATA32
L3	L3DIR	M3	L1DAT1	N3	L1DAT7	P3	L1CLKIN	R3	DATA33
L4	V_{DD_IO}	M4	V_{DD_IO}	N4	V_{DD_IO}	P4	V_{DD_IO}	R4	V_{DD_IO}
L5	V_{DD}	M5	V_{SS}	N5	V_{DD_IO}	P5	V_{DD}	R5	V_{DD}
L6	V_{SS}	M6	V_{SS}	N6	V_{SS}	P6	V_{SS}	R6	V_{SS}
L7	V_{SS}	M7	V_{SS}	N7	V_{SS}	P7	V_{SS}	R7	V_{SS}
L8	V_{SS}	M8	V_{SS}	N8	V_{SS}	P8	V_{SS}	R8	V_{SS}
L9	V_{SS}	M9	V_{SS}	N9	V_{SS}	P9	V_{SS}	R9	V_{SS}
L10	V_{SS}	M10	V_{SS}	N10	V_{SS}	P10	V_{SS}	R10	V_{SS}
L11	V_{SS}	M11	V_{SS}	N11	V_{SS}	P11	V_{SS}	R11	V_{SS}
L12	V_{SS}	M12	V_{SS}	N12	V_{SS}	P12	V_{SS}	R12	V_{SS}
L13	V_{SS}	M13	V_{SS}	N13	V_{SS}	P13	V_{SS}	R13	V_{SS}
L14	V_{SS}	M14	V_{SS}	N14	V_{SS}	P14	V_{SS}	R14	V_{SS}
L15	V_{SS}	M15	V_{SS}	N15	V_{SS}	P15	V_{SS}	R15	V_{SS}
L16	V_{SS}	M16	V_{SS}	N16	V_{SS}	P16	V_{SS}	R16	V_{SS}
L17	V_{SS}	M17	V_{SS}	N17	V_{SS}	P17	V_{SS}	R17	V_{SS}
L18	V_{DD_IO}	M18	V_{DD_IO}	N18	V_{DD}	P18	V_{DD_IO}	R18	V_{DD}
L19	V_{DD_IO}	M19	V_{DD}	N19	V_{DD_IO}	P19	V_{DD_IO}	R19	V_{DD_IO}
L20	$\overline{BRST}$	M20	HDQM	N20	$\overline{SDWE}$	P20	ADDR31	R20	ADDR28
L21	$\overline{WRH}$	M21	$\overline{MS0}$	N21	$\overline{MSSD}$	P21	$\overline{RAS}$	R21	ADDR29
L22	$\overline{RD}$	M22	$\overline{MS1}$	N22	LDQM	P22	SDCKE	R22	$\overline{CAS}$
T1	L1DIR	U1	NC	V1	DATA34	W1	DATA40	Y1	DATA42
T2	DATA36	U2	DATA38	V2	DATA41	W2	DATA43	Y2	DATA45
T3	DATA37	U3	DATA39	V3	DATA35	W3	DATA46	Y3	L2DAT5
T4	V_{DD_IO}	U4	V_{DD_IO}	V4	V_{DD_IO}	W4	V_{DD_IO}	Y4	DATA48
T5	V_{DD}	U5	V_{DD}	V5	V_{DD}	W5	V_{DD_IO}	Y5	DATA52
T6	V_{SS}	U6	V_{SS}	V6	V_{DD}	W6	V_{DD_IO}	Y6	DATA58
T7	V_{SS}	U7	V_{SS}	V7	V_{DD_IO}	W7	V_{DD_IO}	Y7	DATA60
T8	V_{SS}	U8	V_{SS}	V8	V_{DD}	W8	V_{DD_IO}	Y8	DATA63
T9	V_{SS}	U9	V_{SS}	V9	V_{DD}	W9	V_{DD_IO}	Y9	L2DAT4
T10	V_{SS}	U10	V_{SS}	V10	V_{DD}	W10	V_{DD_IO}	Y10	L2CLKOUT
T11	V_{SS}	U11	V_{SS}	V11	V_{DD}	W11	V_{DD_IO}	Y11	NC
T12	V_{SS}	U12	V_{SS}	V12	V_{DD_IO}	W12	V_{DD_IO}	Y12	$\overline{BR4}$
T13	V_{SS}	U13	V_{SS}	V13	V_{DD}	W13	V_{DD_IO}	Y13	ACK
T14	V_{SS}	U14	V_{SS}	V14	V_{SS}	W14	V_{DD_IO}	Y14	$\overline{CPA}$
T15	V_{SS}	U15	V_{SS}	V15	V_{DD}	W15	V_{DD_IO}	Y15	ADDR0
T16	V_{SS}	U16	V_{SS}	V16	V_{DD}	W16	V_{DD_IO}	Y16	$\overline{BR7}$
T17	V_{SS}	U17	V_{SS}	V17	V_{DD}	W17	V_{DD_IO}	Y17	$\overline{HBG}$
T18	V_{DD}	U18	V_{DD}	V18	V_{DD}	W18	V_{DD_IO}	Y18	ADDR1
T19	V_{DD_IO}	U19	V_{DD_IO}	V19	V_{DD_IO}	W19	V_{DD_IO}	Y19	ADDR11
T20	ADDR23	U20	ADDR30	V20	ADDR14	W20	ADDR12	Y20	ADDR21
T21	ADDR25	U21	ADDR22	V21	ADDR19	W21	ADDR17	Y21	ADDR18
T22	ADDR27	U22	ADDR26	V22	ADDR24	W22	ADDR20	Y22	ADDR16

Table 26. 484-Ball (19 mm × 19 mm) PBGA Pin Assignments (continued)

Pin#	Signal Name	Pin#	Signal Name
AA1	DATA44	AB1	V_{SS}
AA2	DATA50	AB2	DATA53
AA3	DATA47	AB3	DATA55
AA4	DATA49	AB4	DATA56
AA5	DATA51	AB5	DATA59
AA6	DATA54	AB6	DATA62
AA7	DATA57	AB7	L2DAT1
AA8	DATA61	AB8	L2DAT2
AA9	L2DAT0	AB9	L2DAT6
AA10	L2DAT3	AB10	L2CLKIN
AA11	L2DAT7	AB11	L2DIR
AA12	$\overline{BR}$2	AB12	$\overline{BR}$0
AA13	$\overline{BR}$6	AB13	$\overline{BR}$1
AA14	$\overline{HBR}$	AB14	$\overline{BR}$3
AA15	$\overline{DPA}$	AB15	$\overline{BR}$5
AA16	ADDR2	AB16	BOFF
AA17	ADDR5	AB17	ADDR3
AA18	ADDR8	AB18	ADDR4
AA19	SDA10	AB19	ADDR6
AA20	ADDR10	AB20	ADDR7
AA21	ADDR13	AB21	ADDR9
AA22	ADDR15	AB22	V_{SS}

484-BALL METRIC PBGA PIN CONFIGURATIONS (TOP VIEW, SUMMARY)



TOP VIEW

625-BALL PBGA PIN CONFIGURATIONS

Table 27. 625-Ball (27 mm × 27 mm) PBGA Pin Assignments

Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name
A1	V_{SS}	B1	V_{SS}	C1	V_{SS}	D1	V_{SS}	E1	DATA23
A2	DATA17	B2	V_{SS}	C2	DATA20	D2	V_{SS}	E2	DATA22
A3	DATA14	B3	DATA16	C3	DATA21	D3	DATA19	E3	V_{SS}
A4	DATA11	B4	DATA13	C4	DATA18	D4	V_{DD_IO}	E4	V_{DD_IO}
A5	DATA9	B5	DATA12	C5	DATA15	D5	V_{DD_IO}	E5	V_{DD_IO}
A6	DATA7	B6	DATA10	C6	DATA8	D6	V_{DD_IO}	E6	V_{DD}
A7	DATA4	B7	DATA5	C7	DATA6	D7	V_{DD_IO}	E7	V_{DD}
A8	DATA1	B8	DATA2	C8	DATA3	D8	V_{DD_IO}	E8	V_{DD_IO}
A9	L0DIR	B9	NC	C9	DATA0	D9	V_{DD_IO}	E9	V_{DD_IO}
A10	L0DAT7	B10	L0CLKOUT	C10	L0CLKIN	D10	V_{DD_IO}	E10	V_{DD}
A11	L0DAT4	B11	L0DAT5	C11	L0DAT6	D11	V_{DD_IO}	E11	V_{DD}
A12	L0DAT1	B12	L0DAT2	C12	L0DAT3	D12	V_{DD_IO}	E12	V_{DD_IO}
A13	LCLK_N	B13	V_{SS}	C13	L0DAT0	D13	V_{DD_IO}	E13	V_{DD_IO}
A14	LCLK_P	B14	V_{SS}	C14	V_{SS_A}	D14	V_{DD_IO}	E14	V_{DD}
A15	V_{DD_A}	B15	V_{SS_A}	C15	V_{DD_A}	D15	V_{DD_IO}	E15	V_{DD}
A16	SCLK_N	B16	SCLK_P	C16	V_{SS}	D16	V_{DD_IO}	E16	V_{DD_IO}
A17	V_{REF}	B17	V_{SS}	C17	DS0	D17	V_{DD_IO}	E17	V_{DD_IO}
A18	DS1	B18	DS2	C18	CONTROLIMP0	D18	V_{DD_IO}	E18	V_{DD}
A19	CONTROLIMP2	B19	CONTROLIMP1	C19	$\overline{DMAR1}$	D19	V_{DD_IO}	E19	V_{DD}
A20	$\overline{RESET}$	B20	$\overline{DMAR3}$	C20	TDI	D20	V_{DD_IO}	E20	V_{DD_IO}
A21	$\overline{DMAR2}$	B21	$\overline{DMAR0}$	C21	$\overline{IRQ2}$	D21	V_{DD_IO}	E21	V_{DD_IO}
A22	$\overline{EMU}$	B22	$\overline{IRQ3}$	C22	LCLKRAT0	D22	V_{DD_IO}	E22	V_{DD_IO}
A23	$\overline{TRST}$	B23	TCK	C23	LCLKRAT1	D23	$\overline{BMS}$	E23	V_{SS}
A24	TMS	B24	$\overline{IRQ1}$	C24	$\overline{IRQ0}$	D24	V_{SS}	E24	SCLKFREQ
A25	V_{SS}	B25	TDO	C25	V_{SS}	D25	V_{SS}	E25	LCLKRAT2
F1	DATA26	G1	DATA29	H1	L3DAT0	J1	L3DAT3	K1	L3DAT6
F2	DATA25	G2	DATA28	H2	DATA31	J2	L3DAT2	K2	L3DAT5
F3	DATA24	G3	DATA27	H3	DATA30	J3	L3DAT1	K3	L3DAT4
F4	V_{DD_IO}	G4	V_{DD_IO}	H4	V_{DD_IO}	J4	V_{DD_IO}	K4	V_{DD_IO}
F5	V_{DD_IO}	G5	V_{DD}	H5	V_{DD}	J5	V_{DD_IO}	K5	V_{DD_IO}
F6	V_{DD}	G6	V_{DD}	H6	V_{DD}	J6	V_{DD}	K6	V_{DD}
F7	V_{DD}	G7	V_{SS}	H7	V_{SS}	J7	V_{SS}	K7	V_{SS}
F8	V_{DD}	G8	V_{SS}	H8	V_{SS}	J8	V_{SS}	K8	V_{SS}
F9	V_{DD}	G9	V_{SS}	H9	V_{SS}	J9	V_{SS}	K9	V_{SS}
F10	V_{DD}	G10	V_{SS}	H10	V_{SS}	J10	V_{SS}	K10	V_{SS}
F11	V_{DD}	G11	V_{SS}	H11	V_{SS}	J11	V_{SS}	K11	V_{SS}
F12	V_{DD}	G12	V_{SS}	H12	V_{SS}	J12	V_{SS}	K12	V_{SS}
F13	V_{DD}	G13	V_{SS}	H13	V_{SS}	J13	V_{SS}	K13	V_{SS}
F14	V_{DD}	G14	V_{SS}	H14	V_{SS}	J14	V_{SS}	K14	V_{SS}
F15	V_{DD}	G15	V_{SS}	H15	V_{SS}	J15	V_{SS}	K15	V_{SS}
F16	V_{DD}	G16	V_{SS}	H16	V_{SS}	J16	V_{SS}	K16	V_{SS}
F17	V_{DD}	G17	V_{SS}	H17	V_{SS}	J17	V_{SS}	K17	V_{SS}
F18	V_{DD}	G18	V_{SS}	H18	V_{SS}	J18	V_{SS}	K18	V_{SS}
F19	V_{DD}	G19	V_{SS}	H19	V_{SS}	J19	V_{SS}	K19	V_{SS}
F20	V_{DD}	G20	V_{DD}	H20	V_{DD}	J20	V_{DD}	K20	V_{DD}
F21	V_{DD}	G21	V_{DD}	H21	V_{DD_IO}	J21	V_{DD_IO}	K21	V_{DD}
F22	V_{DD_IO}	G22	V_{DD_IO}	H22	V_{DD_IO}	J22	V_{DD_IO}	K22	V_{DD_IO}
F23	$\overline{BM}$	G23	FLAG3	H23	FLAG0	J23	ID0	K23	NC
F24	$\overline{BUSLOCK}$	G24	FLAG2	H24	ID2	J24	NC	K24	NC
F25	$\overline{TMR0E}$	G25	FLAG1	H25	ID1	J25	NC	K25	NC

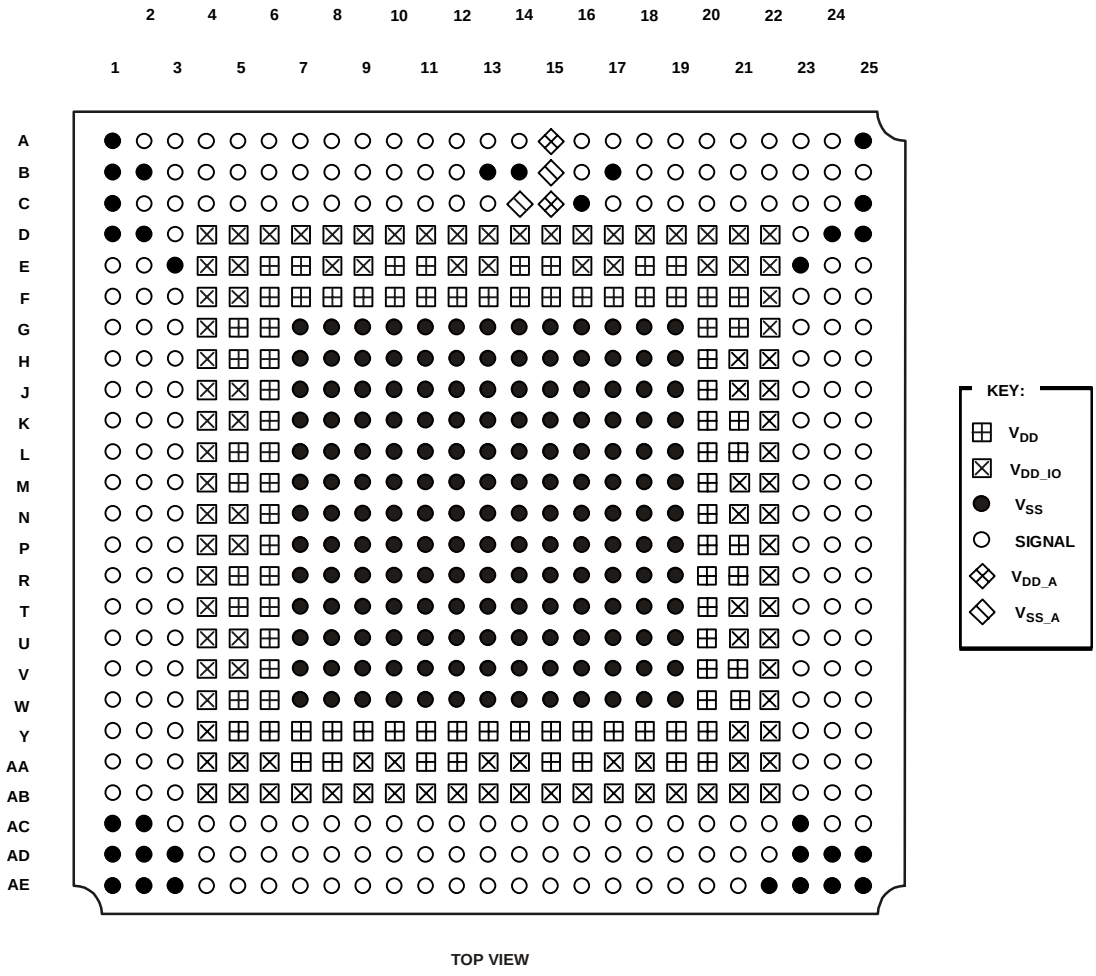
Table 27. 625-Ball (27 mm × 27 mm) PBGA Pin Assignments (continued)

Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name
L1	L3CLKIN	M1	L1DAT0	N1	L1DAT2	P1	L1DAT5	R1	L1CLKOUT
L2	L3CLKOUT	M2	NC	N2	NC	P2	L1DAT4	R2	L1DAT7
L3	L3DAT7	M3	L3DIR	N3	L1DAT1	P3	L1DAT3	R3	L1DAT6
L4	V_{DD_IO}	M4	V_{DD_IO}	N4	V_{DD_IO}	P4	V_{DD_IO}	R4	V_{DD_IO}
L5	V_{DD}	M5	V_{DD}	N5	V_{DD_IO}	P5	V_{DD_IO}	R5	V_{DD}
L6	V_{DD}	M6	V_{DD}	N6	V_{DD}	P6	V_{DD}	R6	V_{DD}
L7	V_{SS}	M7	V_{SS}	N7	V_{SS}	P7	V_{SS}	R7	V_{SS}
L8	V_{SS}	M8	V_{SS}	N8	V_{SS}	P8	V_{SS}	R8	V_{SS}
L9	V_{SS}	M9	V_{SS}	N9	V_{SS}	P9	V_{SS}	R9	V_{SS}
L10	V_{SS}	M10	V_{SS}	N10	V_{SS}	P10	V_{SS}	R10	V_{SS}
L11	V_{SS}	M11	V_{SS}	N11	V_{SS}	P11	V_{SS}	R11	V_{SS}
L12	V_{SS}	M12	V_{SS}	N12	V_{SS}	P12	V_{SS}	R12	V_{SS}
L13	V_{SS}	M13	V_{SS}	N13	V_{SS}	P13	V_{SS}	R13	V_{SS}
L14	V_{SS}	M14	V_{SS}	N14	V_{SS}	P14	V_{SS}	R14	V_{SS}
L15	V_{SS}	M15	V_{SS}	N15	V_{SS}	P15	V_{SS}	R15	V_{SS}
L16	V_{SS}	M16	V_{SS}	N16	V_{SS}	P16	V_{SS}	R16	V_{SS}
L17	V_{SS}	M17	V_{SS}	N17	V_{SS}	P17	V_{SS}	R17	V_{SS}
L18	V_{SS}	M18	V_{SS}	N18	V_{SS}	P18	V_{SS}	R18	V_{SS}
L19	V_{SS}	M19	V_{SS}	N19	V_{SS}	P19	V_{SS}	R19	V_{SS}
L20	V_{DD}	M20	V_{DD}	N20	V_{DD}	P20	V_{DD}	R20	V_{DD}
L21	V_{DD}	M21	V_{DD_IO}	N21	V_{DD_IO}	P21	V_{DD}	R21	V_{DD}
L22	V_{DD_IO}	M22	V_{DD_IO}	N22	V_{DD_IO}	P22	V_{DD_IO}	R22	V_{DD_IO}
L23	NC	M23	$\overline{\text{IOEN}}$	N23	$\overline{\text{WRH}}$	P23	$\overline{\text{MS}}1$	R23	LDQM
L24	NC	M24	$\overline{\text{MSH}}$	N24	$\overline{\text{WRL}}$	P24	$\overline{\text{MS}}0$	R24	NC
L25	$\overline{\text{FLYBY}}$	M25	$\overline{\text{BRST}}$	N25	$\overline{\text{RD}}$	P25	HDQM	R25	$\overline{\text{MSSD}}$
T1	NC	U1	DATA34	V1	DATA37	W1	DATA40	Y1	DATA43
T2	L1DIR	U2	DATA33	V2	DATA36	W2	DATA39	Y2	DATA42
T3	L1CLKIN	U3	DATA32	V3	DATA35	W3	DATA38	Y3	DATA41
T4	V_{DD_IO}	U4	V_{DD_IO}	V4	V_{DD_IO}	W4	V_{DD_IO}	Y4	V_{DD_IO}
T5	V_{DD}	U5	V_{DD_IO}	V5	V_{DD_IO}	W5	V_{DD}	Y5	V_{DD}
T6	V_{DD}	U6	V_{DD}	V6	V_{DD}	W6	V_{DD}	Y6	V_{DD}
T7	V_{SS}	U7	V_{SS}	V7	V_{SS}	W7	V_{SS}	Y7	V_{DD}
T8	V_{SS}	U8	V_{SS}	V8	V_{SS}	W8	V_{SS}	Y8	V_{DD}
T9	V_{SS}	U9	V_{SS}	V9	V_{SS}	W9	V_{SS}	Y9	V_{DD}
T10	V_{SS}	U10	V_{SS}	V10	V_{SS}	W10	V_{SS}	Y10	V_{DD}
T11	V_{SS}	U11	V_{SS}	V11	V_{SS}	W11	V_{SS}	Y11	V_{DD}
T12	V_{SS}	U12	V_{SS}	V12	V_{SS}	W12	V_{SS}	Y12	V_{DD}
T13	V_{SS}	U13	V_{SS}	V13	V_{SS}	W13	V_{SS}	Y13	V_{DD}
T14	V_{SS}	U14	V_{SS}	V14	V_{SS}	W14	V_{SS}	Y14	V_{DD}
T15	V_{SS}	U15	V_{SS}	V15	V_{SS}	W15	V_{SS}	Y15	V_{DD}
T16	V_{SS}	U16	V_{SS}	V16	V_{SS}	W16	V_{SS}	Y16	V_{DD}
T17	V_{SS}	U17	V_{SS}	V17	V_{SS}	W17	V_{SS}	Y17	V_{DD}
T18	V_{SS}	U18	V_{SS}	V18	V_{SS}	W18	V_{SS}	Y18	V_{DD}
T19	V_{SS}	U19	V_{SS}	V19	V_{SS}	W19	V_{SS}	Y19	V_{DD}
T20	V_{DD}	U20	V_{DD}	V20	V_{DD}	W20	V_{DD}	Y20	V_{DD}
T21	V_{DD_IO}	U21	V_{DD_IO}	V21	V_{DD}	W21	V_{DD}	Y21	V_{DD_IO}
T22	V_{DD_IO}	U22	V_{DD_IO}	V22	V_{DD_IO}	W22	V_{DD_IO}	Y22	V_{DD_IO}
T23	SDCKE	U23	$\overline{\text{CAS}}$	V23	ADDR31	W23	ADDR28	Y23	ADDR26
T24	NC	U24	NC	V24	ADDR30	W24	NC	Y24	ADDR25
T25	$\overline{\text{SDWE}}$	U25	$\overline{\text{RAS}}$	V25	ADDR29	W25	ADDR27	Y25	ADDR24

Table 27. 625-Ball (27 mm × 27 mm) PBGA Pin Assignments (continued)

Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name	Pin#	Signal Name
AA1	DATA46	AB1	DATA49	AC1	V_{SS}	AD1	V_{SS}	AE1	V_{SS}
AA2	DATA45	AB2	DATA48	AC2	V_{SS}	AD2	V_{SS}	AE2	V_{SS}
AA3	DATA44	AB3	DATA47	AC3	DATA50	AD3	V_{SS}	AE3	V_{SS}
AA4	V_{DD_IO}	AB4	V_{DD_IO}	AC4	DATA51	AD4	DATA52	AE4	DATA53
AA5	V_{DD_IO}	AB5	V_{DD_IO}	AC5	DATA54	AD5	DATA55	AE5	DATA56
AA6	V_{DD_IO}	AB6	V_{DD_IO}	AC6	DATA57	AD6	DATA58	AE6	DATA59
AA7	V_{DD}	AB7	V_{DD_IO}	AC7	DATA60	AD7	DATA61	AE7	DATA62
AA8	V_{DD}	AB8	V_{DD_IO}	AC8	DATA63	AD8	L2DAT0	AE8	L2DAT1
AA9	V_{DD_IO}	AB9	V_{DD_IO}	AC9	L2DAT2	AD9	L2DAT3	AE9	L2DAT4
AA10	V_{DD_IO}	AB10	V_{DD_IO}	AC10	L2DAT5	AD10	L2DAT6	AE10	L2DAT7
AA11	V_{DD}	AB11	V_{DD_IO}	AC11	L2CLKOUT	AD11	L2CLKIN	AE11	L2DIR
AA12	V_{DD}	AB12	V_{DD_IO}	AC12	NC	AD12	$\overline{BR}0$	AE12	$\overline{BR}1$
AA13	V_{DD_IO}	AB13	V_{DD_IO}	AC13	$\overline{BR}2$	AD13	$\overline{BR}3$	AE13	$\overline{BR}4$
AA14	V_{DD_IO}	AB14	V_{DD_IO}	AC14	$\overline{BR}5$	AD14	$\overline{BR}6$	AE14	$\overline{BR}7$
AA15	V_{DD}	AB15	V_{DD_IO}	AC15	ACK	AD15	$\overline{HBR}$	AE15	BOFF
AA16	V_{DD}	AB16	V_{DD_IO}	AC16	$\overline{HBG}$	AD16	$\overline{CPA}$	AE16	$\overline{DPA}$
AA17	V_{DD_IO}	AB17	V_{DD_IO}	AC17	ADDR0	AD17	ADDR1	AE17	ADDR2
AA18	V_{DD_IO}	AB18	V_{DD_IO}	AC18	ADDR3	AD18	ADDR4	AE18	ADDR5
AA19	V_{DD}	AB19	V_{DD_IO}	AC19	ADDR6	AD19	ADDR7	AE19	ADDR8
AA20	V_{DD}	AB20	V_{DD_IO}	AC20	ADDR9	AD20	SDA10	AE20	ADDR10
AA21	V_{DD_IO}	AB21	V_{DD_IO}	AC21	ADDR11	AD21	ADDR12	AE21	ADDR13
AA22	V_{DD_IO}	AB22	V_{DD_IO}	AC22	ADDR14	AD22	ADDR15	AE22	V_{SS}
AA23	ADDR23	AB23	ADDR20	AC23	V_{SS}	AD23	V_{SS}	AE23	V_{SS}
AA24	ADDR22	AB24	ADDR19	AC24	ADDR17	AD24	V_{SS}	AE24	V_{SS}
AA25	ADDR21	AB25	ADDR18	AC25	ADDR16	AD25	V_{SS}	AE25	V_{SS}

625-BALL METRIC PBGA PIN CONFIGURATIONS (TOP VIEW, SUMMARY)

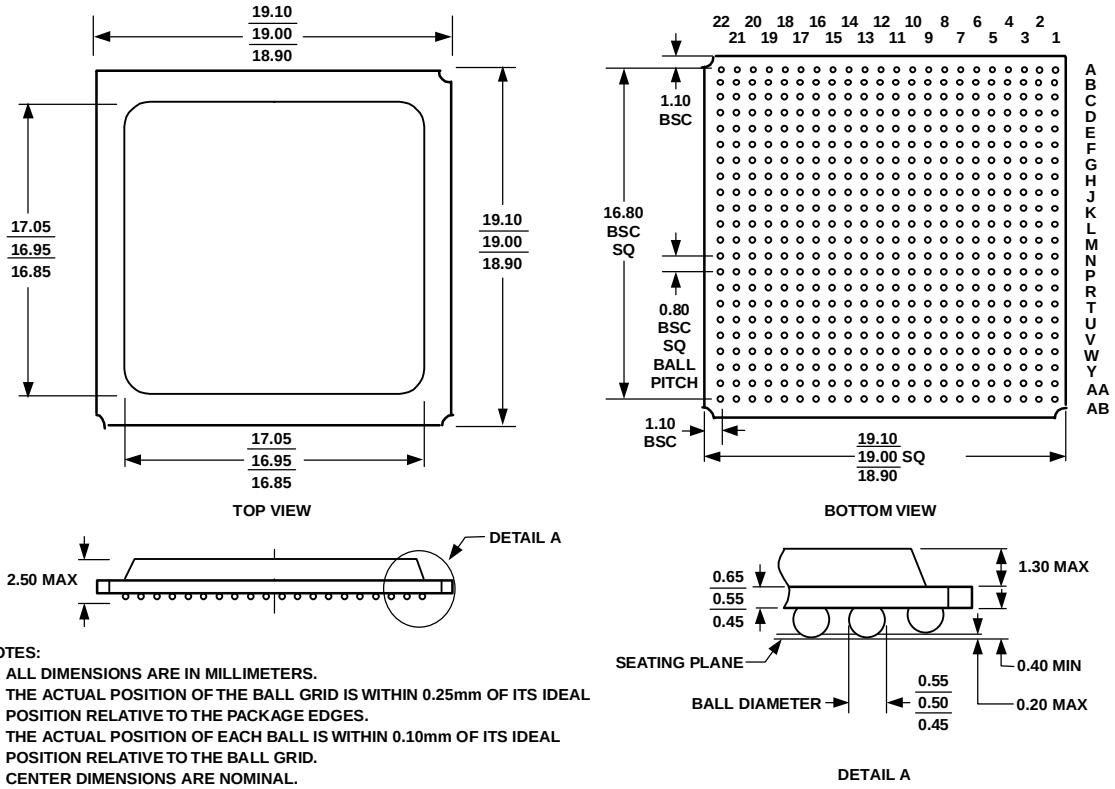


TOP VIEW

OUTLINE DIMENSIONS

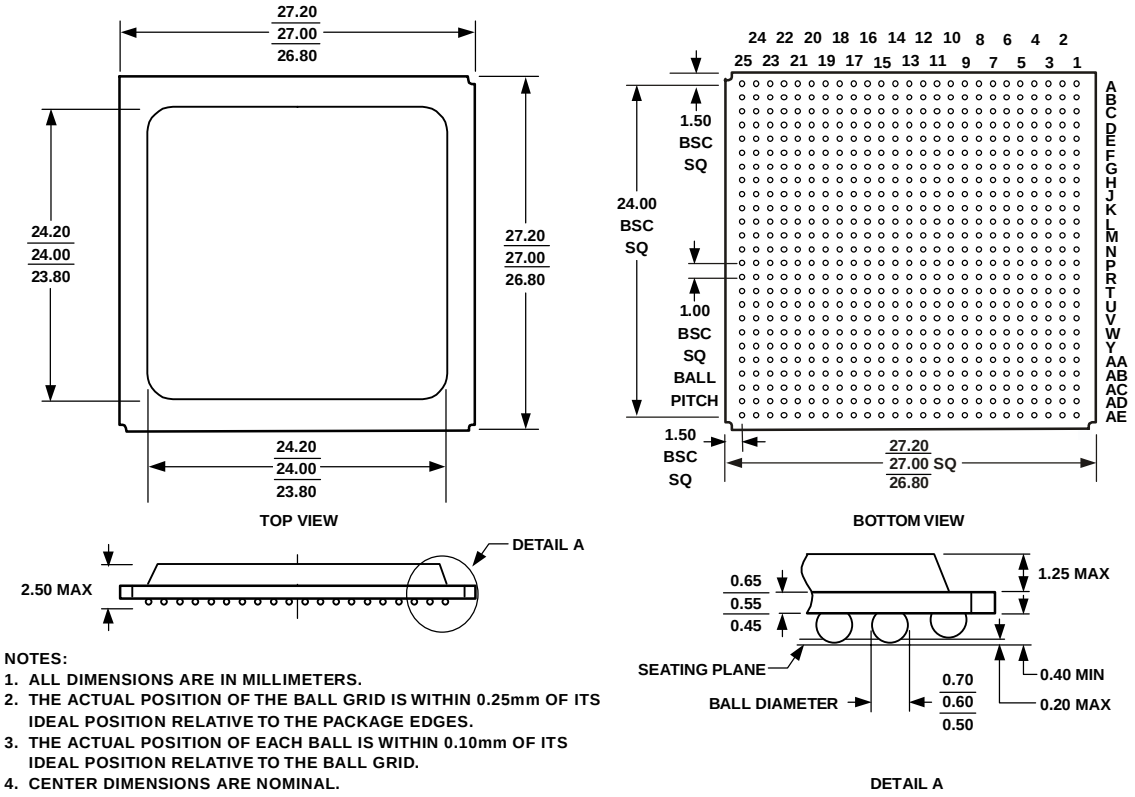
The ADSP-TS101S comes in a 19 mm × 19 mm, 484-ball Metric PBGA package with 22 rows of balls (B-484) and comes in a 27 mm × 27 mm, 625-ball Metric PBGA package with 25 rows of balls (B-625).

484-BALL METRIC PBGA (B-484)



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. THE ACTUAL POSITION OF THE BALL GRID IS WITHIN 0.25mm OF ITS IDEAL POSITION RELATIVE TO THE PACKAGE EDGES.
3. THE ACTUAL POSITION OF EACH BALL IS WITHIN 0.10mm OF ITS IDEAL POSITION RELATIVE TO THE BALL GRID.
4. CENTER DIMENSIONS ARE NOMINAL.

625-BALL METRIC PBGA (B-625)



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. THE ACTUAL POSITION OF THE BALL GRID IS WITHIN 0.25mm OF ITS IDEAL POSITION RELATIVE TO THE PACKAGE EDGES.
3. THE ACTUAL POSITION OF EACH BALL IS WITHIN 0.10mm OF ITS IDEAL POSITION RELATIVE TO THE BALL GRID.
4. CENTER DIMENSIONS ARE NOMINAL.

ORDERING GUIDE

Part Number[1, 2]	Case Temperature Range	Instruction Rate[3]	On-chip SRAM	Operating Voltage	Package
ADSP-TS101SKB1250X	–40°C to 85°C	250 MHz	6Mbit	1.2 V_{DD} 3.3 V_{DD_IO}	(B-625)[4]
ADSP-TS101SKB2250X	–40°C to 85°C	250 MHz	6Mbit	1.2 V_{DD} 3.3 V_{DD_IO}	(B-484)[5]

[1] S indicates 1.2/3.3 V supplies. K indicates –40°C to 85°C temperature. 250 indicates instruction rate.
[2] B = Plastic Ball Grid Array (PBGA) package.
[3] The instruction rate runs at the internal DSP clock (CCLK) rate.
[4] The B-625 package measures 27mm × 27mm.
[5] The B-484 package measures 19mm × 19mm.