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Understanding [Embedded - DSP \(Digital Signal Processors\)](#)

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

Applications of [Embedded - DSP \(Digital Signal Processors\)](#)

Details

Product Status	Obsolete
Type	Fixed Point
Interface	Host Interface, Serial Port
Clock Rate	80MHz
Non-Volatile Memory	External
On-Chip RAM	80kB
Voltage - I/O	1.8V, 2.5V, 3.3V
Voltage - Core	1.80V
Operating Temperature	0°C ~ 70°C (TA)
Mounting Type	Surface Mount
Package / Case	144-LFBGA, CSPBGA
Supplier Device Package	144-CSPBGA (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/analog-devices/adsp-2185nkcaz-320

GENERAL DESCRIPTION

The ADSP-218xN series consists of six single chip microcomputers optimized for digital signal processing applications. The high-level block diagram for the ADSP-218xN series members appears on the previous page. All series members are pin-compatible and are differentiated solely by the amount of on-chip SRAM. This feature, combined with ADSP-21xx code compatibility, provides a great deal of flexibility in the design decision. Specific family members are shown in [Table 1](#).

Table 1. ADSP-218xN DSP Microcomputer Family

Device	Program Memory (K words)	Data Memory (K words)
ADSP-2184N	4	4
ADSP-2185N	16	16
ADSP-2186N	8	8
ADSP-2187N	32	32
ADSP-2188N	48	56
ADSP-2189N	32	48

ADSP-218xN series members combine the ADSP-2100 family base architecture (three computational units, data address generators, and a program sequencer) with two serial ports, a 16-bit internal DMA port, a byte DMA port, a programmable timer, Flag I/O, extensive interrupt capabilities, and on-chip program and data memory.

ADSP-218xN series members integrate up to 256K bytes of on-chip memory configured as up to 48K words (24-bit) of program RAM, and up to 56K words (16-bit) of data RAM. Power-down circuitry is also provided to meet the low power needs of battery-operated portable equipment. The ADSP-218xN is available in a 100-lead LQFP package and 144-ball BGA.

Fabricated in a high-speed, low-power, 0.18 μm CMOS process, ADSP-218xN series members operate with a 12.5 ns instruction cycle time. Every instruction can execute in a single processor cycle.

The ADSP-218xN's flexible architecture and comprehensive instruction set allow the processor to perform multiple operations in parallel. In one processor cycle, ADSP-218xN series members can:

- Generate the next program address
- Fetch the next instruction
- Perform one or two data moves
- Update one or two data address pointers
- Perform a computational operation

This takes place while the processor continues to:

- Receive and transmit data through the two serial ports
- Receive and/or transmit data through the internal DMA port

- Receive and/or transmit data through the byte DMA port
- Decrement timer

ARCHITECTURE OVERVIEW

The ADSP-218xN series instruction set provides flexible data moves and multifunction (one or two data moves with a computation) instructions. Every instruction can be executed in a single processor cycle. The ADSP-218xN assembly language uses an algebraic syntax for ease of coding and readability. A comprehensive set of development tools supports program development.

The functional block diagram is an overall block diagram of the ADSP-218xN series. The processor contains three independent computational units: the ALU, the multiplier/accumulator (MAC), and the shifter. The computational units process 16-bit data directly and have provisions to support multiprecision computations. The ALU performs a standard set of arithmetic and logic operations; division primitives are also supported. The MAC performs single-cycle multiply, multiply/add, and multiply/subtract operations with 40 bits of accumulation. The shifter performs logical and arithmetic shifts, normalization, denormalization, and derive exponent operations.

The shifter can be used to efficiently implement numeric format control, including multiword and block floating-point representations.

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

A powerful program sequencer and two dedicated data address generators ensure efficient delivery of operands to these computational units. The sequencer supports conditional jumps, subroutine calls, and returns in a single cycle. With internal loop counters and loop stacks, ADSP-218xN series members execute looped code with zero overhead; no explicit jump instructions are required to maintain loops.

Two data address generators (DAGs) provide addresses for simultaneous dual operand fetches (from data memory and program memory). Each DAG maintains and updates four address pointers. Whenever the pointer is used to access data (indirect addressing), it is post-modified by the value of one of four possible modify registers. A length value may be associated with each pointer to implement automatic modulo addressing for circular buffers.

Five internal buses provide efficient data transfer:

- Program Memory Address (PMA) Bus
- Program Memory Data (PMD) Bus
- Data Memory Address (DMA) Bus
- Data Memory Data (DMD) Bus
- Result (R) Bus

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The two address buses (PMA and DMA) share a single external address bus, allowing memory to be expanded off-chip, and the two data buses (PMD and DMD) share a single external data bus. Byte memory space and I/O memory space also share the external buses.

Program memory can store both instructions and data, permitting ADSP-218xN series members to fetch two operands in a single cycle, one from program memory and one from data memory. ADSP-218xN series members can fetch an operand from program memory and the next instruction in the same cycle.

In lieu of the address and data bus for external memory connection, ADSP-218xN series members may be configured for 16-bit Internal DMA port (IDMA port) connection to external systems. The IDMA port is made up of 16 data/address pins and five control pins. The IDMA port provides transparent, direct access to the DSP's on-chip program and data RAM.

An interface to low-cost byte-wide memory is provided by the Byte DMA port (BDMA port). The BDMA port is bidirectional and can directly address up to four megabytes of external RAM or ROM for off-chip storage of program overlays or data tables.

The byte memory and I/O memory space interface supports slow memories and I/O memory-mapped peripherals with programmable wait state generation. External devices can gain control of external buses with bus request/grant signals (\overline{BR} , \overline{BGH} , and \overline{BG}). One execution mode (Go Mode) allows the ADSP-218xN to continue running from on-chip memory. Normal execution mode requires the processor to halt while buses are granted.

ADSP-218xN series members can respond to eleven interrupts. There can be up to six external interrupts (one edge-sensitive, two level-sensitive, and three configurable) and seven internal interrupts generated by the timer, the serial ports (SPORT), the BDMA port, and the power-down circuitry. There is also a master RESET signal. The two serial ports provide a complete synchronous serial interface with optional companding in hardware and a wide variety of framed or frameless data transmit and receive modes of operation.

Each port can generate an internal programmable serial clock or accept an external serial clock.

ADSP-218xN series members provide up to 13 general-purpose flag pins. The data input and output pins on SPORT1 can be alternatively configured as an input flag and an output flag. In addition, eight flags are programmable as inputs or outputs, and three flags are always outputs.

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

Serial Ports

ADSP-218xN series members incorporate two complete synchronous serial ports (SPORT0 and SPORT1) for serial communications and multiprocessor communication.

Following is a brief list of the capabilities of the ADSP-218xN SPORTs. For additional information on Serial Ports, refer to the *ADSP-218x DSP Hardware Reference*.

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

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Table 3. Interrupt Priority and Interrupt Vector Addresses

Source Of Interrupt	Interrupt Vector Address (Hex)
Reset (or Power-Up with PUCR = 1)	0x0000 (Highest Priority)
Power-Down (Nonmaskable)	0x002C
$\overline{\text{IRQ2}}$	0x0004
$\overline{\text{IRQLT}}$	0x0008
$\overline{\text{IRQL0}}$	0x000C
SPORT0 Transmit	0x0010
SPORT0 Receive	0x0014
$\overline{\text{IRQE}}$	0x0018
BDMA Interrupt	0x001C
SPORT1 Transmit or $\overline{\text{IRQ1}}$	0x0020
SPORT1 Receive or $\overline{\text{IRQ0}}$	0x0024
Timer	0x0028 (Lowest Priority)

Interrupt routines can either be nested with higher priority interrupts taking precedence or processed sequentially. Interrupts can be masked or unmasked with the IMASK register. Individual interrupt requests are logically ANDed with the bits in IMASK; the highest priority unmasked interrupt is then selected. The power-down interrupt is nonmaskable.

ADSP-218xN series members mask all interrupts for one instruction cycle following the execution of an instruction that modifies the IMASK register. This does not affect serial port autobuffering or DMA transfers.

The interrupt control register, ICNTL, controls interrupt nesting and defines the $\overline{\text{IRQ0}}$, $\overline{\text{IRQ1}}$, and $\overline{\text{IRQ2}}$ external interrupts to be either edge- or level-sensitive. The $\overline{\text{IRQE}}$ pin is an external edge-sensitive interrupt and can be forced and cleared. The $\overline{\text{IRQL0}}$ and $\overline{\text{IRQL1}}$ pins are external level sensitive interrupts.

The IFC register is a write-only register used to force and clear interrupts. On-chip stacks preserve the processor status and are automatically maintained during interrupt handling. The stacks are 12 levels deep to allow interrupt, loop, and subroutine nesting. The following instructions allow global enable or disable servicing of the interrupts (including power-down), regardless of the state of IMASK:

```
ENA INTS;
DIS INTS;
```

Disabling the interrupts does not affect serial port autobuffering or DMA. When the processor is reset, interrupt servicing is enabled.

LOW-POWER OPERATION

ADSP-218xN series members have three low-power modes that significantly reduce the power dissipation when the device operates under standby conditions. These modes are:

- Power-Down
- Idle
- Slow Idle

The CLKOUT pin may also be disabled to reduce external power dissipation.

Power-Down

ADSP-218xN series members have a low-power feature that lets the processor enter a very low-power dormant state through hardware or software control. Following is a brief list of power-down features. Refer to the *ADSP-218x DSP Hardware Reference*, “System Interface” chapter, for detailed information about the power-down feature.

- Quick recovery from power-down. The processor begins executing instructions in as few as 200 CLKIN cycles.
- Support for an externally generated TTL or CMOS processor clock. The external clock can continue running during power-down without affecting the lowest power rating and 200 CLKIN cycle recovery.
- Support for crystal operation includes disabling the oscillator to save power (the processor automatically waits approximately 4096 CLKIN cycles for the crystal oscillator to start or stabilize), and letting the oscillator run to allow 200 CLKIN cycle start-up.
- Power-down is initiated by either the power-down pin ($\overline{\text{PWD}}$) or the software power-down force bit. Interrupt support allows an unlimited number of instructions to be executed before optionally powering down. The power-down interrupt also can be used as a nonmaskable, edge-sensitive interrupt.
- Context clear/save control allows the processor to continue where it left off or start with a clean context when leaving the power-down state.
- The $\overline{\text{RESET}}$ pin also can be used to terminate power-down.
- Power-down acknowledge pin (PWDACK) indicates when the processor has entered power-down.

Idle

When the ADSP-218xN is in the Idle Mode, the processor waits indefinitely in a low-power state until an interrupt occurs. When an unmasked interrupt occurs, it is serviced; execution then continues with the instruction following the IDLE instruction. In Idle mode IDMA, BDMA, and autobuffer cycle steals still occur.

Slow Idle

The IDLE instruction is enhanced on ADSP-218xN series members to let the processor’s internal clock signal be slowed, further reducing power consumption. The reduced clock frequency, a programmable fraction of the normal clock rate, is specified by a selectable divisor given in the IDLE instruction.

The format of the instruction is:

```
IDLE (n);
```

where n = 16, 32, 64, or 128. This instruction keeps the processor fully functional, but operating at the slower clock rate. While it is in this state, the processor’s other internal clock signals,

such as SCLK, CLKOUT, and timer clock, are reduced by the same ratio. The default form of the instruction, when no clock divisor is given, is the standard IDLE instruction.

When the IDLE (n) instruction is used, it effectively slows down the processor's internal clock and thus its response time to incoming interrupts. The one-cycle response time of the standard idle state is increased by n, the clock divisor. When an enabled interrupt is received, ADSP-218xN series members remain in the idle state for up to a maximum of n processor cycles (n = 16, 32, 64, or 128) before resuming normal operation.

When the IDLE (n) instruction is used in systems that have an externally generated serial clock (SCLK), the serial clock rate may be faster than the processor's reduced internal clock rate. Under these conditions, interrupts must not be generated at a

faster rate than can be serviced, due to the additional time the processor takes to come out of the idle state (a maximum of n processor cycles).

SYSTEM INTERFACE

Figure 2 shows typical basic system configurations with the ADSP-218xN series, two serial devices, a byte-wide EPROM, and optional external program and data overlay memories (mode-selectable). Programmable wait state generation allows the processor to connect easily to slow peripheral devices. ADSP-218xN series members also provide four external interrupts and two serial ports or six external interrupts and one serial port. Host Memory Mode allows access to the full external data bus, but limits addressing to a single address bit (A0). Through the use of external hardware, additional system peripherals can be added in this mode to generate and latch address signals.

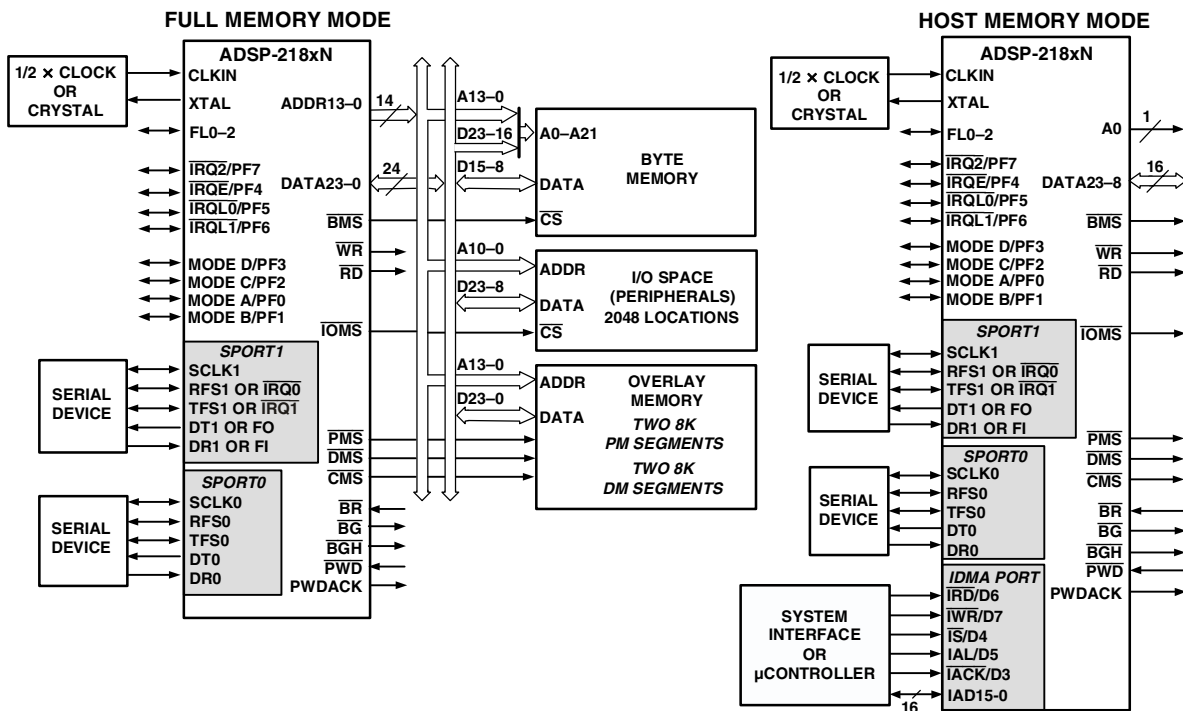


Figure 2. Basic System Interface

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Clock Signals

ADSP-218xN series members can be clocked by either a crystal or a TTL-compatible clock signal.

The CLKIN input cannot be halted, changed during operation, nor operated below the specified frequency during normal operation. The only exception is while the processor is in the power-down state. For additional information, refer to the *ADSP-218x DSP Hardware Reference*, for detailed information on this power-down feature.

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

ADSP-218xN series members use an input clock with a frequency equal to half the instruction rate; a 40 MHz input clock yields a 12.5 ns processor cycle (which is equivalent to 80 MHz). Normally, instructions are executed in a single processor cycle. All device timing is relative to the internal instruction clock rate, which is indicated by the CLKOUT signal when enabled.

Because ADSP-218xN series members include an on-chip oscillator circuit, an external crystal may be used. The crystal should be connected across the CLKIN and XTAL pins, with two capacitors connected as shown in Figure 3. Capacitor values are dependent on crystal type and should be specified by the crystal manufacturer. A parallel-resonant, fundamental frequency, microprocessor-grade crystal should be used. To provide an adequate feedback path around the internal amplifier circuit, place a resistor in parallel with the circuit, as shown in Figure 3.

A clock output (CLKOUT) signal is generated by the processor at the processor's cycle rate. This can be enabled and disabled by the CLKODIS bit in the SPORT0 Autobuffer Control Register.

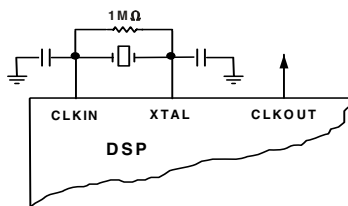


Figure 3. External Crystal Connections

RESET

The $\overline{\text{RESET}}$ signal initiates a master reset of the ADSP-218xN. The $\overline{\text{RESET}}$ signal must be asserted during the power-up sequence to assure proper initialization. $\overline{\text{RESET}}$ during initial power-up must be held long enough to allow the internal clock to stabilize. If $\overline{\text{RESET}}$ is activated any time after power-up, the clock continues to run and does not require stabilization time.

The power-up sequence is defined as the total time required for the crystal oscillator circuit to stabilize after a valid V_{DD} is applied to the processor, and for the internal phase-locked loop (PLL) to lock onto the specific crystal frequency. A minimum of

2000 CLKIN cycles ensures that the PLL has locked, but does not include the crystal oscillator start-up time. During this power-up sequence the $\overline{\text{RESET}}$ signal should be held low. On any subsequent resets, the $\overline{\text{RESET}}$ signal must meet the minimum pulse-width specification (t_{RSP}).

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

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

POWER SUPPLIES

ADSP-218xN series members have separate power supply connections for the internal (V_{DDINT}) and external (V_{DDEXT}) power supplies. The internal supply must meet the 1.8 V requirement. The external supply can be connected to a 1.8 V, 2.5 V, or 3.3 V supply. All external supply pins must be connected to the same supply. All input and I/O pins can tolerate input voltages up to 3.6 V, regardless of the external supply voltage. This feature provides maximum flexibility in mixing 1.8 V, 2.5 V, or 3.3 V components.

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IOWAIT0–3 as shown in Figure 10, which in combination with the wait state mode bit, specify up to 15 wait states to be automatically generated for each of four regions. The wait states act on address ranges, as shown in Table 6.

Note: In Full Memory Mode, all 2048 locations of I/O space are directly addressable. In Host Memory Mode, only address pin A0 is available; therefore, additional logic is required externally to achieve complete addressability of the 2048 I/O space locations.

Table 6. Wait States

Address Range	Wait State Register
0x000–0x1FF	IOWAIT0 and Wait State Mode Select Bit
0x200–0x3FF	IOWAIT1 and Wait State Mode Select Bit
0x400–0x5FF	IOWAIT2 and Wait State Mode Select Bit
0x600–0x7FF	IOWAIT3 and Wait State Mode Select Bit

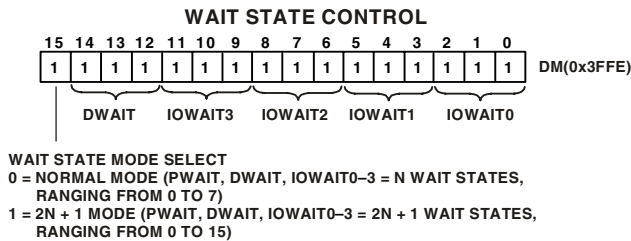


Figure 10. Wait State Control Register

Composite Memory Select

ADSP-218xN series members have a programmable memory select signal that is useful for generating memory select signals for memories mapped to more than one space. The $\overline{\text{CMS}}$ signal is generated to have the same timing as each of the individual memory select signals ($\overline{\text{PMS}}$, $\overline{\text{DMS}}$, $\overline{\text{BMS}}$, $\overline{\text{IOMS}}$) but can combine their functionality. Each bit in the CMSSSEL register, when set, causes the $\overline{\text{CMS}}$ signal to be asserted when the selected memory select is asserted. For example, to use a 32K word memory to act as both program and data memory, set the $\overline{\text{PMS}}$ and $\overline{\text{DMS}}$ bits in the CMSSSEL register and use the $\overline{\text{CMS}}$ pin to drive the chip select of the memory, and use either $\overline{\text{DMS}}$ or $\overline{\text{PMS}}$ as the additional address bit.

The $\overline{\text{CMS}}$ pin functions like the other memory select signals with the same timing and bus request logic. A 1 in the enable bit causes the assertion of the $\overline{\text{CMS}}$ signal at the same time as the selected memory select signal. All enable bits default to 1 at reset, except the $\overline{\text{BMS}}$ bit.

See Figure 11 and Figure 12 for illustration of the programmable flag and composite control register and the system control register.

Byte Memory Select

The ADSP-218xN's $\overline{\text{BMS}}$ disable feature combined with the $\overline{\text{CMS}}$ pin allows use of multiple memories in the byte memory space. For example, an EPROM could be attached to the $\overline{\text{BMS}}$

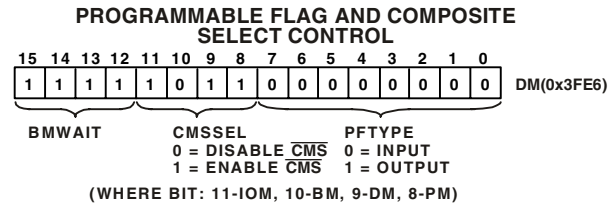


Figure 11. Programmable Flag and Composite Control Register

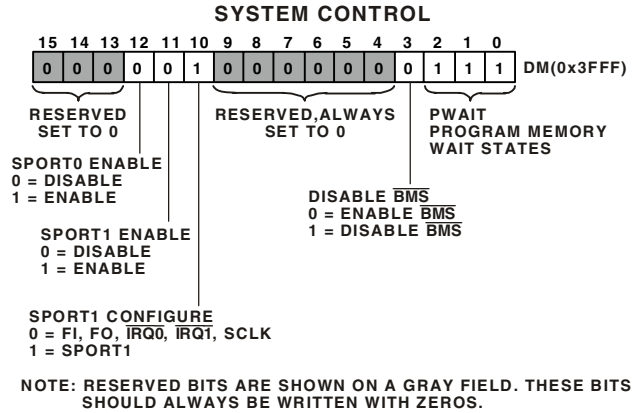


Figure 12. System Control Register

select, and a flash memory could be connected to $\overline{\text{CMS}}$. Because at reset $\overline{\text{BMS}}$ is enabled, the EPROM would be used for booting. After booting, software could disable $\overline{\text{BMS}}$ and set the $\overline{\text{CMS}}$ signal to respond to $\overline{\text{BMS}}$, enabling the flash memory.

Byte Memory

The byte memory space is a bidirectional, 8-bit-wide, external memory space used to store programs and data. Byte memory is accessed using the BDMA feature. The byte memory space consists of 256 pages, each of which is 16K × 8 bits.

The byte memory space on the ADSP-218xN series supports read and write operations as well as four different data formats. The byte memory uses data bits 15–8 for data. The byte memory uses data bits 23–16 and address bits 13–0 to create a 22-bit address. This allows up to a 4 megabit × 8 (32 megabit) ROM or RAM to be used without glue logic. All byte memory accesses are timed by the BMWAIT register and the wait state mode bit.

Byte Memory DMA (BDMA, Full Memory Mode)

The byte memory DMA controller (Figure 13) allows loading and storing of program instructions and data using the byte memory space. The BDMA circuit is able to access the byte memory space while the processor is operating normally and steals only one DSP cycle per 8-, 16-, or 24-bit word transferred.

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The IDMA port has a 16-bit multiplexed address and data bus and supports 24-bit program memory. The IDMA port is completely asynchronous and can be written while the ADSP-218xN is operating at full speed.

The DSP memory address is latched and then automatically incremented after each IDMA transaction. An external device can therefore access a block of sequentially addressed memory by specifying only the starting address of the block. This increases throughput as the address does not have to be sent for each memory access.

IDMA port access occurs in two phases. The first is the IDMA Address Latch cycle. When the acknowledge is asserted, a 14-bit address and 1-bit destination type can be driven onto the bus by an external device. The address specifies an on-chip memory location, the destination type specifies whether it is a DM or PM access. The falling edge of the IDMA address latch signal (IAL) or the missing edge of the IDMA select signal (\overline{IS}) latches this value into the IDMAA register.

Once the address is stored, data can be read from, or written to, the ADSP-218xN's on-chip memory. Asserting the select line (\overline{IS}) and the appropriate read or write line (\overline{IRD} and \overline{IWR} respectively) signals the ADSP-218xN that a particular transaction is required. In either case, there is a one-processor-cycle delay for synchronization. The memory access consumes one additional processor cycle.

Once an access has occurred, the latched address is automatically incremented, and another access can occur.

Through the IDMAA register, the DSP can also specify the starting address and data format for DMA operation. Asserting the IDMA port select (\overline{IS}) and address latch enable (IAL) directs the ADSP-218xN to write the address onto the IAD14–0 bus into the IDMA Control Register (Figure 14). If Bit 15 is set to 0, IDMA latches the address. If Bit 15 is set to 1, IDMA latches into the OVLAY register. This register, also shown in Figure 14, is memory-mapped at address DM (0x3FE0). Note that the latched address (IDMAA) cannot be read back by the host.

When Bit 14 in 0x3FE7 is set to zero, short reads use the timing shown in Figure 36 on Page 38. When Bit 14 in 0x3FE7 is set to 1, timing in Figure 37 on Page 39 applies for short reads in short read only mode. Set IDDMOVLAY and IDPMOVLAY bits in the IDMA overlay register as indicated in Table 8. Refer to the *ADSP-218x DSP Hardware Reference* for additional details.

Note: In full memory mode all locations of 4M-byte memory space are directly addressable. In host memory mode, only address pin A0 is available, requiring additional external logic to provide address information for the byte.

Bootstrap Loading (Booting)

ADSP-218xN series members have two mechanisms to allow automatic loading of the internal program memory after reset. The method for booting is controlled by the Mode A, B, and C configuration bits.

When the mode pins specify BDMA booting, the ADSP-218xN initiates a BDMA boot sequence when reset is released.

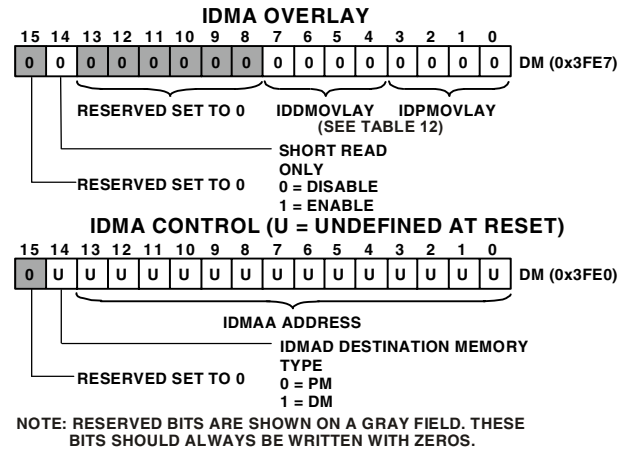


Figure 14. IDMA OVLAY/Control Registers

The BDMA interface is set up during reset to the following defaults when BDMA booting is specified: the BDIR, BMPAGE, BIAD, and BEAD registers are set to 0, the BTYPE register is set to 0 to specify program memory 24-bit words, and the BWCOUNT register is set to 32. This causes 32 words of on-chip program memory to be loaded from byte memory. These 32 words are used to set up the BDMA to load in the remaining program code. The BCR bit is also set to 1, which causes program execution to be held off until all 32 words are loaded into on-chip program memory. Execution then begins at address 0.

The ADSP-2100 Family development software (Revision 5.02 and later) fully supports the BDMA booting feature and can generate byte memory space-compatible boot code.

The IDLE instruction can also be used to allow the processor to hold off execution while booting continues through the BDMA interface. For BDMA accesses while in Host Mode, the addresses to boot memory must be constructed externally to the ADSP-218xN. The only memory address bit provided by the processor is A0.

IDMA Port Booting

ADSP-218xN series members can also boot programs through its internal DMA port. If Mode C = 1, Mode B = 0, and Mode A = 1, the ADSP-218xN boots from the IDMA port. IDMA feature can load as much on-chip memory as desired. Program execution is held off until the host writes to on-chip program memory location 0.

BUS REQUEST AND BUS GRANT

ADSP-218xN series members can relinquish control of the data and address buses to an external device. When the external device requires access to memory, it asserts the Bus Request

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- Fill and dump memory
- Source level debugging

The VisualDSP++ IDE lets programmers define and manage DSP software development. The dialog boxes and property pages let programmers configure and manage all of the ADSP-218xN development tools, including the syntax highlighting in the VisualDSP++ editor. This capability controls how the development tools process inputs and generate outputs.

The ADSP-2189M EZ-KIT Lite[†] provides developers with a cost-effective method for initial evaluation of the powerful ADSP-218xN DSP family architecture. The ADSP-2189M EZ-KIT Lite includes a stand-alone ADSP-2189M DSP board supported by an evaluation suite of VisualDSP++. With this EZ-KIT Lite, users can learn about DSP hardware and software development and evaluate potential applications of the ADSP-218xN series. The ADSP-2189M EZ-KIT Lite provides an evaluation suite of the VisualDSP++ development environment with the C compiler, assembler, and linker. The size of the DSP executable that can be built using the EZ-KIT Lite tools is limited to 8K words.

The EZ-KIT Lite includes the following features:

- 75 MHz ADSP-2189M
- Full 16-Bit Stereo Audio I/O with AD73322 Codec
- RS-232 Interface
- EZ-ICE Connector for Emulator Control
- DSP Demonstration Programs
- Evaluation Suite of VisualDSP++

The ADSP-218x EZ-ICE[‡] Emulator provides an easier and more cost-effective method for engineers to develop and optimize DSP systems, shortening product development cycles for faster time-to-market. ADSP-218xN series members integrate on-chip emulation support with a 14-pin ICE-Port interface. This interface provides a simpler target board connection that requires fewer mechanical clearance considerations than other ADSP-2100 Family EZ-ICEs. ADSP-218xN series members need not be removed from the target system when using the EZ-ICE, nor are any adapters needed. Due to the small footprint of the EZ-ICE connector, emulation can be supported in final board designs. The EZ-ICE performs a full range of functions, including:

- In-target operation
- Up to 20 breakpoints
- Single-step or full-speed operation
- Registers and memory values can be examined and altered
- PC upload and download functions
- Instruction-level emulation of program booting and execution

- Complete assembly and disassembly of instructions
- C source-level debugging

Designing an EZ-ICE-Compatible System

ADSP-218xN series members have on-chip emulation support and an ICE-Port, a special set of pins that interface to the EZ-ICE. These features allow in-circuit emulation without replacing the target system processor by using only a 14-pin connection from the target system to the EZ-ICE. Target systems must have a 14-pin connector to accept the EZ-ICE's in-circuit probe, a 14-pin plug.

Note: The EZ-ICE uses the same V_{DD} voltage as the V_{DD} voltage used for V_{DDEXT} . Because the input pins of the ADSP-218xN series members are tolerant to input voltages up to 3.6 V, regardless of the value of V_{DDEXT} , the voltage setting for the EZ-ICE must not exceed 3.3 V.

Issuing the chip reset command during emulation causes the DSP to perform a full chip reset, including a reset of its memory mode. Therefore, it is vital that the mode pins are set correctly PRIOR to issuing a chip reset command from the emulator user interface. If a passive method of maintaining mode information is being used (as discussed in [Setting Memory Mode on Page 5](#)), it does not matter that the mode information is latched by an emulator reset. However, if the $\overline{\text{RESET}}$ pin is being used as a method of setting the value of the mode pins, the effects of an emulator reset must be taken into consideration.

One method of ensuring that the values located on the mode pins are those desired is to construct a circuit like the one shown in [Figure 15](#). This circuit forces the value located on the Mode A pin to logic high, regardless of whether it is latched via the $\overline{\text{RESET}}$ or $\overline{\text{ERESET}}$ pin.

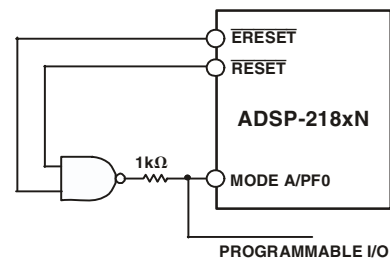


Figure 15. Mode A Pin/EZ-ICE Circuit

The ICE-Port interface consists of the following ADSP-218xN pins: $\overline{\text{EBR}}$, $\overline{\text{EINT}}$, EE , $\overline{\text{EBG}}$, ECLK , $\overline{\text{ERESET}}$, ELIN , EMS , and EOUT .

These ADSP-218xN pins must be connected only to the EZ-ICE connector in the target system. These pins have no function except during emulation, and do not require pull-up or pull-down resistors. The traces for these signals between the ADSP-218xN and the connector must be kept as short as possible, no longer than 3 inches.

The following pins are also used by the EZ-ICE: $\overline{\text{BR}}$, $\overline{\text{BG}}$, $\overline{\text{RESET}}$, and GND .

[†] EZ-KIT Lite is a registered trademark of Analog Devices, Inc.

[‡] EZ-ICE is a registered trademark of Analog Devices, Inc.

Table 9. Common-Mode Pins (Continued)

Pin Name	No. of Pins	I/O	Function
V _{DDINT}	4	I	Internal V _{DD} (1.8 V) Power (BGA)
V _{DDEXT}	7	I	External V _{DD} (1.8 V, 2.5 V, or 3.3 V) Power (BGA)
GND	20	I	Ground (BGA)
EZ-Port	9	I/O	For Emulation Use

¹ Interrupt/Flag pins retain both functions concurrently. If IMASK is set to enable the corresponding interrupts, the DSP will vector to the appropriate interrupt vector address when the pin is asserted, either by external devices or set as a programmable flag.

² SPORT configuration determined by the DSP System Control Register. Software configurable.

MEMORY INTERFACE PINS

ADSP-218xN series members can be used in one of two modes: Full Memory Mode, which allows BDMA operation with full external overlay memory and I/O capability, or Host Mode, which allows IDMA operation with limited external addressing capabilities.

The operating mode is determined by the state of the Mode C pin during $\overline{\text{RESET}}$ and cannot be changed while the processor is running. Table 10 and Table 11 list the active signals at specific pins of the DSP during either of the two operating modes (Full Memory or Host). A signal in one table shares a pin with a signal from the other table, with the active signal determined by the mode that is set. For the shared pins and their alternate signals (e.g., A4/IAD3), refer to the package pinouts in Table 27 on Page 41 and Table 28 on Page 43.

Table 10. Full Memory Mode Pins (Mode C = 0)

Pin Name	No. of Pins	I/O	Function
A13-0	14	O	Address Output Pins for Program, Data, Byte, and I/O Spaces
D23-0	24	I/O	Data I/O Pins for Program, Data, Byte, and I/O Spaces (8 MSBs are also used as Byte Memory Addresses.)

Table 11. Host Mode Pins (Mode C = 1)

Pin Name	No. of Pins	I/O	Function
IAD15-0	16	I/O	IDMA Port Address/Data Bus
A0	1	O	Address Pin for External I/O, Program, Data, or Byte Access ¹
D23-8	16	I/O	Data I/O Pins for Program, Data, Byte, and I/O Spaces
$\overline{\text{IWR}}$	1	I	IDMA Write Enable
$\overline{\text{IRD}}$	1	I	IDMA Read Enable
IAL	1	I	IDMA Address Latch Pin
$\overline{\text{IS}}$	1	I	IDMA Select
$\overline{\text{IACK}}$	1	O	IDMA Port Acknowledge Configurable in Mode D; Open Drain

¹ In Host Mode, external peripheral addresses can be decoded using the A0, $\overline{\text{CMS}}$, $\overline{\text{PMS}}$, $\overline{\text{DMS}}$, and $\overline{\text{IOMS}}$ signals.

TERMINATING UNUSED PINS

Table 12 shows the recommendations for terminating unused pins.

Table 12. Unused Pin Terminations

Pin Name ¹	I/O 3-State (Z) ²	Reset State	Hi-Z ³ Caused By	Unused Configuration
XTAL	O	O		Float
CLKOUT	O	O		Float ⁴
A13-1 or	O (Z)	Hi-Z	$\overline{\text{BR}}$, $\overline{\text{EBR}}$	Float
IAD12-0	I/O (Z)	Hi-Z	$\overline{\text{IS}}$	Float
A0	O (Z)	Hi-Z	$\overline{\text{BR}}$, $\overline{\text{EBR}}$	Float

Table 12. Unused Pin Terminations (Continued)

Pin Name ¹	I/O 3-State (Z) ²	Reset State	Hi-Z ³ Caused By	Unused Configuration
$\overline{\text{ERESET}}$	1	1		Float
$\overline{\text{EMS}}$	0	0		Float
$\overline{\text{EINT}}$	1	1		Float
ECLK	1	1		Float
ELIN	1	1		Float
ELOUT	0	0		Float

¹ CLKIN, $\overline{\text{RESET}}$, and PF3-0/Mode D-A are not included in this table because these pins must be used.

² All bidirectional pins have three-stated outputs. When the pin is configured as an output, the output is Hi-Z (high impedance) when inactive.

³ Hi-Z = High Impedance.

⁴ If the CLKOUT pin is not used, turn it OFF, using CLKODIS in SPORT0 autobuffer control register.

⁵ If the Interrupt/Programmable Flag pins are not used, there are two options: Option 1: When these pins are configured as INPUTS at reset and function as interrupts and input flag pins, pull the pins High (inactive). Option 2: Program the unused pins as OUTPUTS, set them to 1 prior to enabling interrupts, and let pins float.

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Clock Signals and Reset

Table 15. Clock Signals and Reset

Parameter	Min	Max	Unit
<i>Timing Requirements:</i>			
t_{CKI} CLKIN Period	25	40	ns
t_{CKIL} CLKIN Width Low	8		ns
t_{CKIH} CLKIN Width High	8		ns
<i>Switching Characteristics:</i>			
t_{CKL} CLKOUT Width Low	$0.5t_{CK} - 3$		ns
t_{CKH} CLKOUT Width High	$0.5t_{CK} - 3$		ns
t_{CKOH} CLKIN High to CLKOUT High	0	8	ns
<i>Control Signals Timing Requirements:</i>			
t_{RSP} $\overline{\text{RESET}}$ Width Low	$5t_{CK}^1$		ns
t_{MS} Mode Setup before $\overline{\text{RESET}}$ High	7		ns
t_{MH} Mode Hold after $\overline{\text{RESET}}$ High	5		ns

¹ Applies after power-up sequence is complete. Internal phase lock loop requires no more than 2000 CLKIN cycles, assuming stable CLKIN (not including crystal oscillator start-up time).

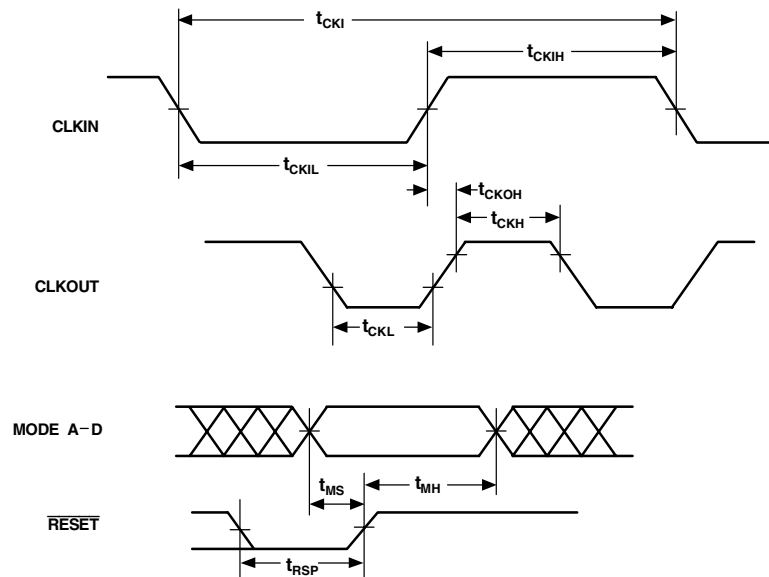


Figure 26. Clock Signals and Reset

Interrupts and Flags

Table 16. Interrupts and Flags

Parameter	Min	Max	Unit
<i>Timing Requirements:</i>			
t_{IFS} \overline{IRQx} , FI, or PFx Setup before CLKOUT Low ^{1, 2, 3, 4}	$0.25t_{CK} + 10$		ns
t_{IFH} \overline{IRQx} , FI, or PFx Hold after CLKOUT High ^{1, 2, 3, 4}	$0.25t_{CK}$		ns
<i>Switching Characteristics:</i>			
t_{FOH} Flag Output Hold after CLKOUT Low ⁵	$0.5t_{CK} - 5$		ns
t_{FOD} Flag Output Delay from CLKOUT Low ⁵		$0.5t_{CK} + 4$	ns

¹ If \overline{IRQx} and FI inputs meet t_{IFS} and t_{IFH} setup/hold requirements, they will be recognized during the current clock cycle; otherwise the signals will be recognized on the following cycle. (Refer to "Interrupt Controller Operation" in the *Program Control* chapter of the *ADSP-218x DSP Hardware Reference* for further information on interrupt servicing.)

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

³ $\overline{IRQx} = \overline{IRQ0}, \overline{IRQ1}, \overline{IRQ2}, \overline{IRQL0}, \overline{IRQL1}, \overline{IRQLE}$.

⁴ PFx = PF0, PF1, PF2, PF3, PF4, PF5, PF6, PF7.

⁵ Flag Outputs = PFx, FL0, FL1, FL2, FO.

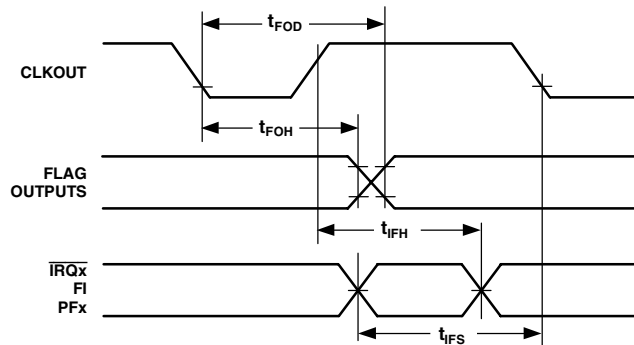


Figure 27. Interrupts and Flags

Memory Read

Table 18. Memory Read

Parameter	Min	Max	Unit
<i>Timing Requirements:</i>			
t_{RDD} \overline{RD} Low to Data Valid ¹		$0.5t_{CK} - 5 + w$	ns
t_{AA} A13-0, \overline{xMS} to Data Valid ²		$0.75t_{CK} - 6 + w$	ns
t_{RDH} Data Hold from \overline{RD} High	0		ns
<i>Switching Characteristics:</i>			
t_{RP} \overline{RD} Pulse Width	$0.5t_{CK} - 3 + w$		ns
t_{CRD} CLKOUT High to \overline{RD} Low	$0.25t_{CK} - 2$	$0.25t_{CK} + 4$	ns
t_{ASR} A13-0, \overline{xMS} Setup before \overline{RD} Low	$0.25t_{CK} - 3$		ns
t_{RDA} A13-0, \overline{xMS} Hold after \overline{RD} Deasserted	$0.25t_{CK} - 3$		ns
t_{RWR} \overline{RD} High to \overline{RD} or \overline{WR} Low	$0.5t_{CK} - 3$		ns

¹ w = wait states $3 t_{CK}$.

² $\overline{xMS} = \overline{PMS}, \overline{DMS}, \overline{CMS}, \overline{IOMS}, \overline{BMS}$.

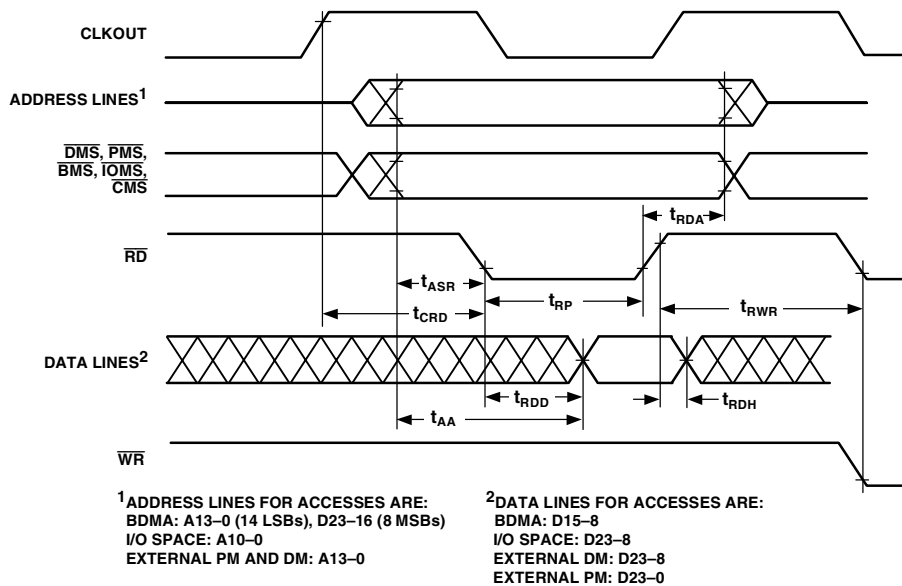


Figure 29. Memory Read

ADSP-218xN

IDMA Address Latch

Table 21. IDMA Address Latch

Parameter	Min	Max	Unit
<i>Timing Requirements:</i>			
t_{IALP} Duration of Address Latch ^{1, 2}	10		ns
t_{IASU} IAD15–0 Address Setup Before Address Latch End ²	5		ns
t_{IAH} IAD15–0 Address Hold After Address Latch End ²	3		ns
t_{IKA} \overline{IACK} Low before Start of Address Latch ^{2, 3}	0		ns
t_{IALS} Start of Write or Read After Address Latch End ^{2, 3}	3		ns
t_{IALD} Address Latch Start After Address Latch End ^{1, 2}	2		ns

¹ Start of Address Latch = \overline{IS} Low and IAL High.

² End of Address Latch = \overline{IS} High or IAL Low.

³ Start of Write or Read = \overline{IS} Low and \overline{IWR} Low or \overline{IRD} Low.

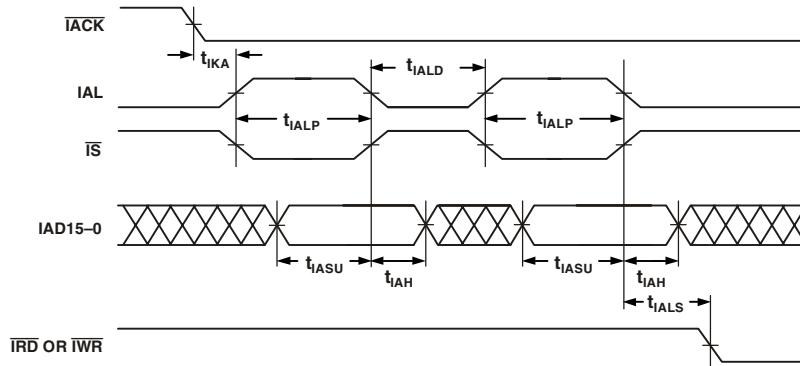


Figure 32. IDMA Address Latch

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IDMA Write, Long Write Cycle

Table 23. IDMA Write, Long Write Cycle

Parameter		Min	Max	Unit
<i>Timing Requirements:</i>				
t_{IKW}	$\overline{\text{IACK}}$ Low Before Start of Write ¹	0		ns
t_{IKSU}	IAD15-0 Data Setup Before End of Write ^{2, 3, 4}	$0.5t_{CK} + 5$		ns
t_{IKH}	IAD15-0 Data Hold After End of Write ^{2, 3, 4}	0		ns
<i>Switching Characteristics:</i>				
t_{IKLW}	Start of Write to $\overline{\text{IACK}}$ Low ⁴	$1.5t_{CK}$		ns
t_{IKHW}	Start of Write to $\overline{\text{IACK}}$ High		10	ns

¹ Start of Write = $\overline{\text{IS}}$ Low and $\overline{\text{IWR}}$ Low.

² If Write Pulse ends before $\overline{\text{IACK}}$ Low, use specifications t_{IDSU} , t_{IDH} .

³ If Write Pulse ends after $\overline{\text{IACK}}$ Low, use specifications t_{IKSU} , t_{IKH} .

⁴ This is the earliest time for $\overline{\text{IACK}}$ Low from Start of Write. For IDMA Write cycle relationships, please refer to the *ADSP-2100 Family User's Manual*.

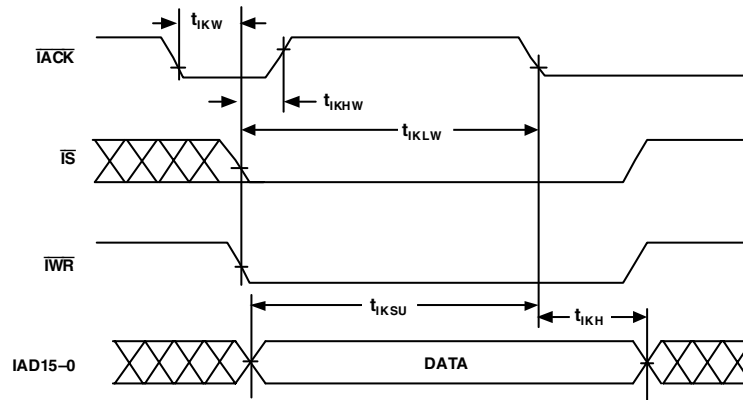


Figure 34. IDMA Write, Long Write Cycle

IDMA Read, Long Read Cycle

Table 24. IDMA Read, Long Read Cycle

Parameter	Min	Max	Unit
<i>Timing Requirements:</i>			
t_{IKR} \overline{IACK} Low Before Start of Read ¹	0		ns
t_{IRK} End of read After \overline{IACK} Low ²	2		ns
<i>Switching Characteristics:</i>			
t_{IKHR} \overline{IACK} High After Start of Read ¹		10	ns
t_{IKDS} IAD15-0 Data Setup Before \overline{IACK} Low	$0.5t_{CK} - 3$		ns
t_{IKDH} IAD15-0 Data Hold After End of Read ²	0		ns
t_{IKDD} IAD15-0 Data Disabled After End of Read ²		10	ns
t_{IRDE} IAD15-0 Previous Data Enabled After Start of Read	0		ns
t_{IRDV} IAD15-0 Previous Data Valid After Start of Read		11	ns
t_{IRDH1} IAD15-0 Previous Data Hold After Start of Read (DM/PM1) ³	$2t_{CK} - 5$		ns
t_{IRDH2} IAD15-0 Previous Data Hold After Start of Read (PM2) ⁴	$t_{CK} - 5$		ns

¹ Start of Read = \overline{IS} Low and \overline{IRD} Low.

² End of Read = \overline{IS} High or \overline{IRD} High.

³ DM read or first half of PM read.

⁴ Second half of PM read.

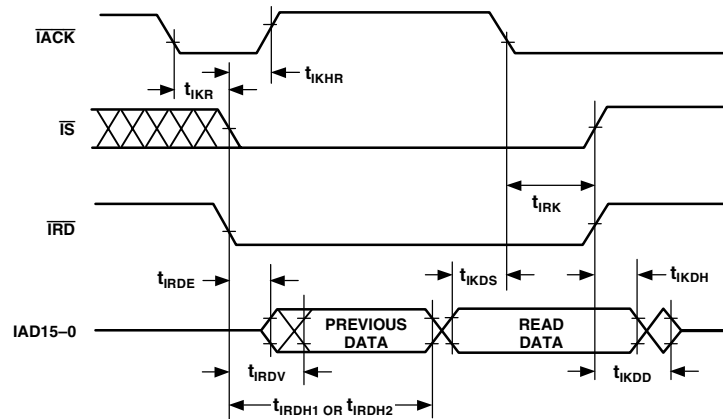


Figure 35. IDMA Read, Long Read Cycle

ADSP-218xN

IDMA Read, Short Read Cycle

Table 25. IDMA Read, Short Read Cycle

Parameter ^{1,2}		Min	Max	Unit
<i>Timing Requirements:</i>				
t_{IKR}	\overline{IACK} Low Before Start of Read ³	0		ns
t_{IRP1}	Duration of Read (DM/PM1) ⁴	10	$2t_{CK} - 5$	ns
t_{IRP2}	Duration of Read (PM2) ⁵	10	$t_{CK} - 5$	ns
<i>Switching Characteristics:</i>				
t_{IKHR}	\overline{IACK} High After Start of Read ³		10	ns
t_{IKDH}	IAD15-0 Data Hold After End of Read ⁶	0		ns
t_{IKDD}	IAD15-0 Data Disabled After End of Read ⁶		10	ns
t_{IRDE}	IAD15-0 Previous Data Enabled After Start of Read	0		ns
t_{IRDV}	IAD15-0 Previous Data Valid After Start of Read		10	ns

¹ Short Read Only must be disabled in the IDMA overlay memory mapped register. This mode is disabled by clearing (=0) Bit 14 of the IDMA overlay register, and is disabled by default upon reset.

² Consider using the Short Read Only mode, instead, because Short Read mode is not applicable at high clock frequencies.

³ Start of Read = \overline{IS} Low and \overline{IRD} Low.

⁴ DM Read or first half of PM Read.

⁵ Second half of PM Read.

⁶ End of Read = \overline{IS} High or \overline{IRD} High.

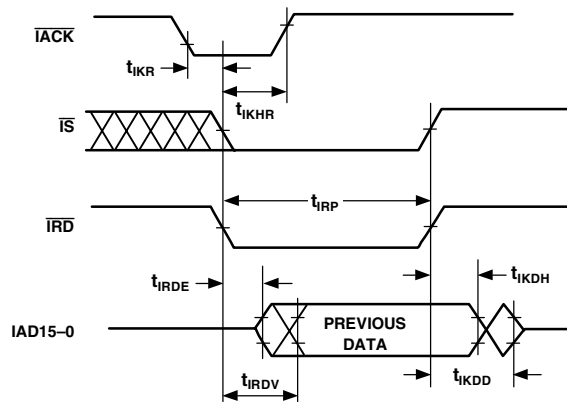


Figure 36. IDMA Read, Short Read Cycle

ADSP-218xN

LQFP PACKAGE PINOUT

The LQFP package pinout is shown [Figure 38](#) and in [Table 27](#). Pin names in bold text in the table replace the plain-text-named functions when Mode C = 1. A + sign separates two functions when either function can be active for either major I/O mode. Signals enclosed in brackets [] are state bits latched from the

value of the pin at the deassertion of $\overline{\text{RESET}}$. The multiplexed pins DT1/FO, TFS1/ $\overline{\text{IRQ1}}$, RFS1/ $\overline{\text{IRQ0}}$, and DR1/FI, are mode selectable by setting Bit 10 (SPORT1 configure) of the System Control Register. If Bit 10 = 1, these pins have serial port functionality. If Bit 10 = 0, these pins are the external interrupt and flag pins. This bit is set to 1 by default, upon reset.

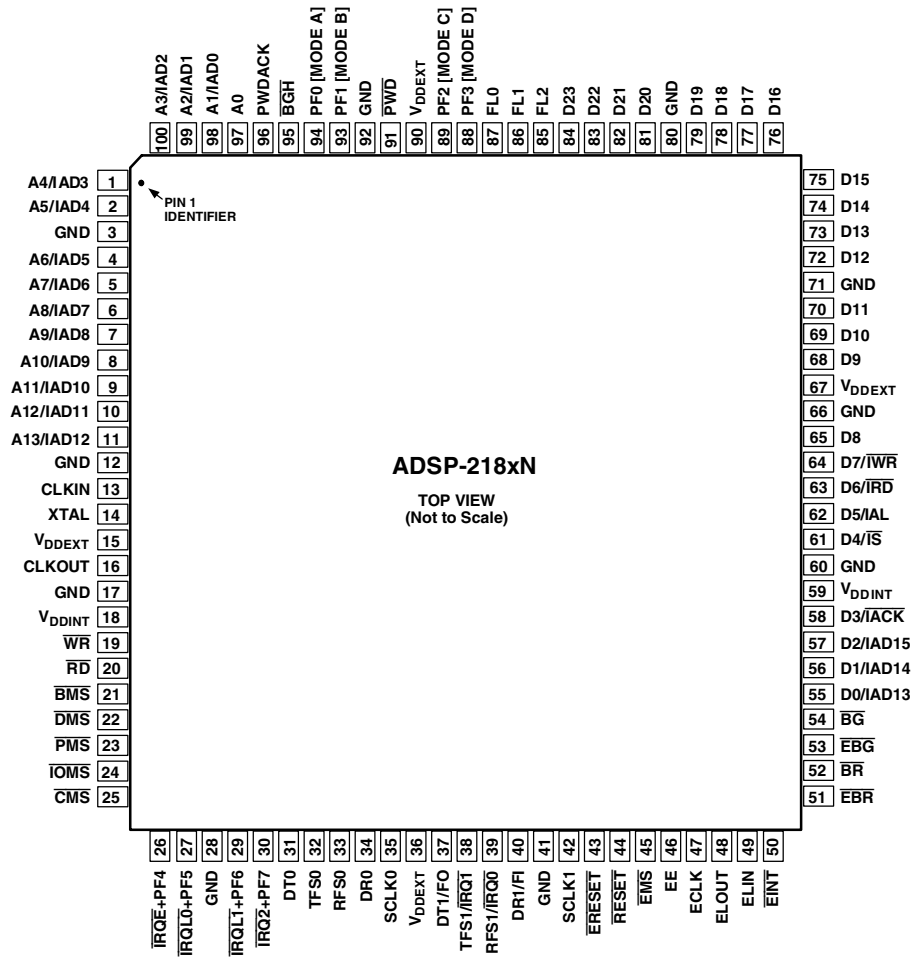


Figure 38. 100-Lead LQFP Pin Configuration

Table 28. BGA Package Pinout

Ball No.	Pin Name
A01	A2/ IAD1
A02	A1/ IAD0
A03	GND
A04	A0
A05	NC
A06	GND
A07	NC
A08	NC
A09	NC
A10	D22
A11	GND
A12	GND
B01	A4/ IAD3
B02	A3/ IAD2
B03	GND
B04	NC
B05	NC
B06	GND
B07	V _{DDEXT}
B08	D23
B09	D20
B10	D18
B11	D17
B12	D16
C01	PWDACK
C02	A6/ IAD5
C03	\overline{RD}
C04	A5/ IAD4
C05	A7/ IAD6
C06	\overline{PWD}
C07	V _{DDEXT}
C08	D21
C09	D19
C10	D15
C11	NC
C12	D14
D01	NC
D02	\overline{WR}
D03	NC
D04	\overline{BGH}
D05	A9/ IAD8
D06	PF1 [MODE B]
D07	PF2 [MODE C]
D08	NC
D09	D13
D10	D12
D11	NC
D12	GND
E01	V _{DDEXT}

**Table 28. BGA Package Pinout
(Continued)**

Ball No.	Pin Name
E02	V _{DDEXT}
E03	A8/ IAD7
E04	FL0
E05	PF0 [MODE A]
E06	FL2
E07	PF3 [MODE D]
E08	GND
E09	GND
E10	V _{DDEXT}
E11	GND
E12	D10
F01	A13/ IAD12
F02	NC
F03	A12/ IAD11
F04	A11/ IAD10
F05	FL1
F06	NC
F07	NC
F08	D7/ \overline{IWR}
F09	D11
F10	D8
F11	NC
F12	D9
G01	XTAL
G02	NC
G03	GND
G04	A10/ IAD9
G05	NC
G06	NC
G07	NC
G08	D6/ \overline{IRD}
G09	D5/ IAL
G10	NC
G11	NC
G12	D4/ \overline{IS}
H01	CLKIN
H02	GND
H03	GND
H04	GND
H05	V _{DDINT}
H06	DT0
H07	TFS0
H08	D2/ IAD15
H09	D3/ IACK
H10	GND
H11	NC
H12	GND
J01	CLKOUT
J02	V _{DDINT}

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Table 28. BGA Package Pinout
(Continued)

Ball No.	Pin Name
J03	NC
J04	V _{DDEXT}
J05	V _{DDEXT}
J06	SCLK0
J07	D0/ IAD13
J08	RFS1/ $\overline{\text{IRQ0}}$
J09	$\overline{\text{BG}}$
J10	D1/ IAD14
J11	V _{DDINT}
J12	V _{DDINT}
K01	NC
K02	NC
K03	NC
K04	$\overline{\text{BMS}}$
K05	$\overline{\text{DMS}}$
K06	RFS0
K07	TFS1/ $\overline{\text{IRQ1}}$
K08	SCLK1
K09	$\overline{\text{ERESET}}$
K10	$\overline{\text{EBR}}$
K11	$\overline{\text{BR}}$
K12	$\overline{\text{EBG}}$
L01	$\overline{\text{IRQE}}$ + PF4
L02	NC
L03	$\overline{\text{IRQL1}}$ + PF6
L04	$\overline{\text{IOMS}}$
L05	GND
L06	$\overline{\text{PMS}}$
L07	DR0
L08	GND
L09	$\overline{\text{RESET}}$
L10	ELIN
L11	ELOUT
L12	$\overline{\text{EINT}}$
M01	$\overline{\text{IRQL0}}$ + PF5
M02	$\overline{\text{IRQL2}}$ + PF7
M03	NC
M04	$\overline{\text{CMS}}$
M05	GND
M06	DT1/FO
M07	DR1/FI
M08	GND
M09	NC
M10	$\overline{\text{EMS}}$
M11	EE
M12	ECLK