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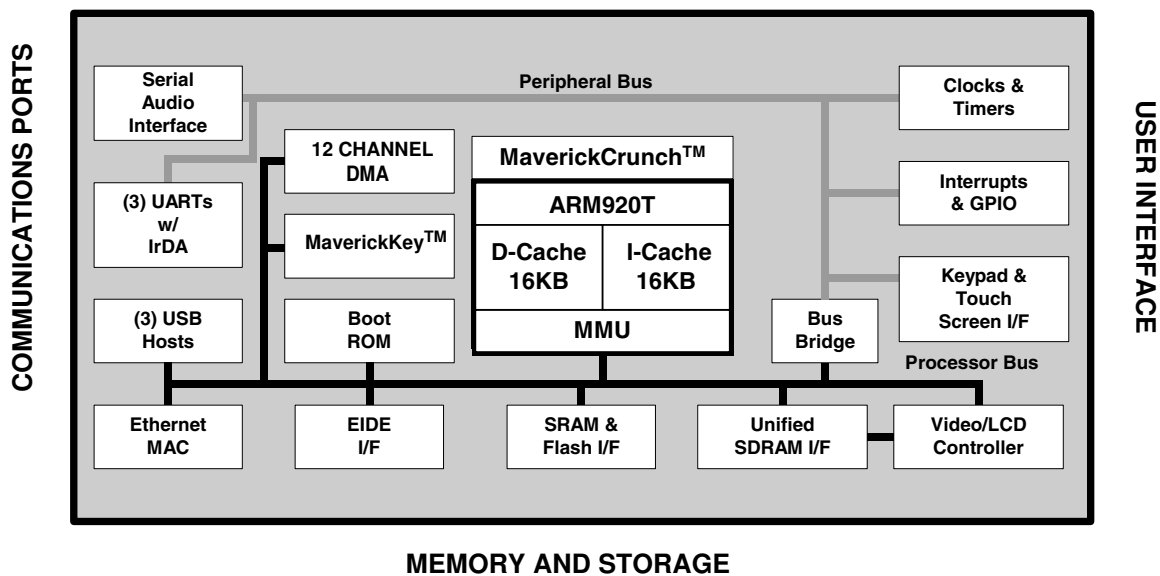


**FEATURES**

- 200-MHz ARM920T Processor
  - 16-kbyte Instruction Cache
  - 16-kbyte Data Cache
- Linux®, Microsoft® Windows® CE-enabled MMU
- 100-MHz System Bus
- MaverickCrunch™ Math Engine
  - Floating Point, Integer, and Signal Processing Instructions
  - Optimized for digital music compression and decompression algorithms.
  - Hardware interlocks allow in-line coding.
- MaverickKey™ IDs
  - 32-bit unique ID can be used for DRM-compliant, 128-bit random ID.
- Integrated Peripheral Interfaces
  - 32-bit SDRAM Interface (up to 4 banks)
  - 32/16-bit SRAM / FLASH / ROM
  - Serial EEPROM Interface
  - EIDE (up to 2 devices)
  - 1/10/100 Mbps Ethernet MAC
  - Three UARTs
  - Three-port USB 2.0 Full-speed Host (OHCI) (12 Mbits per second)
  - LCD and Raster Interface
  - Touchscreen Interface with ADC

**Universal Platform  
System-on-chip Processor**

- IrDA Interface
- 8 x 8 Keypad Scanner
- One Serial Peripheral Interface (SPI) Port
- 6-channel or 2-channel Serial Audio Interface (I<sup>2</sup>S)
- 2-channel, Low-cost Serial Audio Interface (AC'97)
- 2 High-resolution PWMs (16 bits each)
- Internal Peripherals
  - 12 Direct Memory Access (DMA) Channels
  - Real-time Clock with Software Trim
  - Dual PLL controls all clock domains.
  - Watchdog Timer
  - Two General-purpose 16-bit Timers
  - One General-purpose 32-bit Timer
  - One 40-bit Debug Timer
  - Interrupt Controller
  - Boot ROM
- Package
  - 352 pin PBGA



## OVERVIEW

The EP9312 is an ARM920T-based system-on-a-chip design with a large peripheral set targeted to a variety of applications:

- Thin client computers for business and home
- Internet radio
- Internet access devices
- Industrial computers
- Specialized terminals
- Point of sale terminals
- Test and measurement equipment

The ARM920T microprocessor core with separate 16-kbyte, 64-way set-associative instruction and data caches is augmented by the MaverickCrunch™ co-processor enabling high-speed floating point calculations.

MaverickKey™ unique hardware programmed IDs are a solution to the growing concern over secure web content and commerce. With Internet security playing an important role in the delivery of digital media such as books or music, traditional software methods are quickly

becoming unreliable. The MaverickKey unique IDs provide OEMs with a method of utilizing specific hardware IDs such as those assigned for SDMI (Secure Digital Music Initiative) or any other authentication mechanism.

A high-performance 1/10/100 Mbps Ethernet media access Controller (EMAC) is included along with external interfaces to SPI, I<sup>2</sup>S audio, Raster/LCD, IDE storage peripherals, keypad, and touchscreen. A three-port USB 2.0 Full-speed Host (OHCI) (12 Mbits per second) and three UARTs are included as well.

The EP9312 is a high-performance, low-power, RISC-based, single-chip computer built around an ARM920T microprocessor core with a maximum operating clock rate of 200 MHz (184 MHz for industrial conditions). The ARM core operates from a 1.8 V supply, while the I/O operates at 3.3 V with power usage between 100 mW and 750 mW (dependent on speed).

Table A. Change History

Revision	Date	Changes
1	March 2001	Initial Release.
2	June 2001	Upgrade to revision B silicon.
3	August 2001	Upgrade to revision C silicon.
4	May 2003	Upgrade to revision D silicon.
5	December 2003	Update timing data.
6	July 2004	Update AC data. Add ADC data.
7	February 2005	Update with most-current characterization data.

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## Processor Core - ARM920T

The ARM920T is a Harvard architecture processor with separate 16-kbyte instruction and data caches with an 8-word line length but a unified memory. The processor utilizes a five-stage pipeline consisting of fetch, decode, execute, memory, and write stages. Key features include:

- ARM (32-bit) and Thumb (16-bit compressed) Instruction Sets
- 32-bit Advanced Microcontroller Bus Architecture (AMBA)
- 16-kbyte Instruction Cache with lockdown
- 16-kbyte Data Cache (programmable write-through or write-back) with Lockdown
- MMU for Linux<sup>®</sup>, Microsoft<sup>®</sup> Windows<sup>®</sup> CE, and other operating systems
- Translation Look Aside Buffers with 64 Data and 64 Instruction Entries
- Programmable Page Sizes of 1 Mbyte, 64 kbyte, 4 kbyte, and 1 kbyte
- Independent lockdown of TLB Entries

## MaverickCrunch<sup>™</sup> Math Engine

The MaverickCrunch Engine is a mixed-mode coprocessor designed primarily to accelerate the math processing required to rapidly encode digital audio formats. It accelerates single- and double-precision integer and floating point operations plus an integer multiply-accumulate (MAC) instruction that is considerably faster than the ARM920T's native MAC instruction. The ARM920T coprocessor interface is utilized thereby sharing its memory interface and instruction stream. Hardware forwarding and interlock allows the ARM to handle looping and addressing while MaverickCrunch handles computation. Features include:

- IEEE-754 single and double-precision floating point
- 32 / 64-bit integer
- Add / multiply / compare
- Integer MAC 32-bit input with 72-bit accumulate
- Integer Shifts
- Floating point to/from integer conversion
- Sixteen 64-bit register files
- Four 72-bit accumulators

## MaverickKey<sup>™</sup> Unique ID

MaverickKey unique hardware programmed IDs are a solution to the growing concern over secure web content and commerce. With Internet security playing an important role in the delivery of digital media such as books or music, traditional software methods are quickly becoming unreliable. The MaverickKey unique IDs

provide OEMs with a method of utilizing specific hardware IDs such as those assigned for SDMI (Secure Digital Music Initiative) or any other authentication mechanism.

Both a specific 32-bit ID as well as a 128-bit random ID are programmed into the EP9312 through the use of laser probing technology. These IDs can then be used to match secure copyrighted content with the ID of the target device the EP9312 is powering, and then deliver the copyrighted information over a secure connection. In addition, secure transactions can benefit by also matching device IDs to server IDs. MaverickKey IDs provide a level of hardware security required for today's Internet appliances.

## General Purpose Memory Interface (SDRAM, SRAM, ROM, FLASH)

The EP9312 features a unified memory address model where all memory devices are accessed over a common address/data bus. A separate internal port is dedicated to the read-only Raster/LCD refresh engine, while the rest of the memory accesses are performed via the Processor bus. The SRAM memory controller supports 8, 16 and 32-bit devices and accommodates an internal boot ROM concurrently with 32-bit SDRAM memory.

- 1 to 4 banks of 32-bit, 66- or 100-MHz SDRAM
- One internal port dedicated to the Raster/LCD Refresh Engine (Read Only)
- Address and data bus shared between SDRAM, SRAM, ROM, and FLASH memory
- NOR FLASH memory supported

Table B. General Purpose Memory Interface Pin Assignments

Pin Mnemonic	Pin Description
SDCLK	SDRAM Clock
SDCLKEN	SDRAM Clock Enable
SDCSn[3:0]	SDRAM Chip Selects 3-0
RASn	SDRAM RAS
CASn	SDRAM CAS
SDWEn	SDRAM Write Enable
CSn[7:6] and CSn[3:0]	Chip Selects 7, 6, 3, 2, 1, 0
AD[25:0]	Address Bus 25-0
DA[31:0]	Data Bus 31-0
DQMn[3:0]	SDRAM Output Enables / Data Masks
WRn	SRAM Write Strobe
RDn	SRAM Read / OE Strobe
WAITn	SRAM Wait Input

## IDE Interface

The IDE Interface provides an industry-standard connection to two AT Advanced Packet Interface (ATAPI) compliant devices. The IDE port will attach to a master and a slave device. The internal DMA controller performs all data transfers using the Multiword DMA and Ultra DMA modes. The interface supports the following operating modes:

- PIO Modes 0 thru 4
- Ultra DMA Modes 0 thru 3

**Table C. IDE Interface Pin Assignments**

Pin Mnemonic	Pin Description
DD[15-0]	IDE Data bus
IDEDA[2-0]	IDE Device address
IDECSn[0,1]	IDE Chip Select 0 and 1
DIORn	IDE Read Strobe
DIOWn	IDE Write Strobe
DMACKn	IDE DMA acknowledge

## Ethernet Media Access Controller (MAC)

The MAC subsystem is compliant with the ISO/TEC 802.3 topology for a single shared medium with several stations. Multiple MII-compliant PHYs are supported. Features include:

- Supports 1/10/100 Mbps transfer rates for home / small-business / large-business applications
- Interfaces to an off-chip PHY through industry standard Media Independent Interface (MII)

**Table D. Ethernet Media Access Controller Pin Assignments**

Pin Mnemonic	Pin Description
MDC	Management Data Clock
MDIO	Management Data I/O
RXCLK	Receive Clock
MIIRXD[3:0]	Receive Data
RXDVAL	Receive Data Valid
RXERR	Receive Data Error
TXCLK	Transmit Clock
MIITXD[3:0]	Transmit Data
TXEN	Transmit Enable
TXERR	Transmit Error
CRS	Carrier Sense
CLD	Collision Detect

## Serial Interfaces (SPI, I<sup>2</sup>S, and AC '97)

The SPI port can be configured as a master or a slave, supporting the National Semiconductor®, Motorola®, and Texas Instruments® signaling protocols.

The AC'97 port supports multiple codecs for multichannel audio output with a single stereo input. Three I<sup>2</sup>S ports can be configured to support six-channel, 24-bit audio.

These ports are multiplexed so that I<sup>2</sup>S port 0 will take over either the AC'97 pins or the SPI pins. The second and third I<sup>2</sup>S ports' serial input and serial output pins are multiplexed with EGPIO[4,5,6,13]. The clocks supplied in the first I<sup>2</sup>S port are also used for the second and third I<sup>2</sup>S ports.

- Normal Mode: One SPI Port and one AC'97 Port
- I<sup>2</sup>S on SSP Mode: One AC'97 Port and up to three I<sup>2</sup>S Ports
- I<sup>2</sup>S on AC'97 Mode: One SPI Port and up to three I<sup>2</sup>S Ports

**Table E. Audio Interfaces Pin Assignment**

Pin Name	Normal Mode	I <sup>2</sup> S on SSP Mode	I <sup>2</sup> S on AC'97 Mode
	Pin Description	Pin Description	Pin Description
SCLK1	SPI Bit Clock	I <sup>2</sup> S Serial Clock	SPI Bit Clock
SFRM1	SPI Frame Clock	I <sup>2</sup> S Frame Clock	SPI Frame Clock
SSPRX1	SPI Serial Input	I <sup>2</sup> S Serial Input	SPI Serial Input
SSPTX1	SPI Serial Output	I <sup>2</sup> S Serial Output	SPI Serial Output
		(No I <sup>2</sup> S Master Clock)	
ARSTn	AC'97 Reset	AC'97 Reset	I <sup>2</sup> S Master Clock
ABITCLK	AC'97 Bit Clock	AC'97 Bit Clock	I <sup>2</sup> S Serial Clock
ASYNC	AC'97 Frame Clock	AC'97 Frame Clock	I <sup>2</sup> S Frame Clock
ASDI	AC'97 Serial Input	AC'97 Serial Input	I <sup>2</sup> S Serial Input
ASDO	AC'97 Serial Output	AC'97 Serial Output	I <sup>2</sup> S Serial Output

## Raster/LCD Interface

The Raster/LCD interface provides data and interface signals for a variety of display types. It features fully programmable video interface timing for non-interlaced flat panel or dual scan displays. Resolutions up to 1024 x 768 are supported from a unified SDRAM based frame buffer. A 16-bit PWM provides control for LCD panel contrast.



LCD-specific features include:

- Timing and interface signals for digital LCD and TFT displays
- Full programmability for either non-interlaced or dual-scan color and grayscale flat panel displays
- Dedicated data path to SDRAM controller for improved system performance
- Pixel depths of 4, 8, 16, or 24 bits per pixel or 256 levels of grayscale
- Hardware Cursor up to 64 x 64 pixels
- 256 x 18 Color Lookup Table
- Hardware Blinking
- 8-bit interface to low-end panel

Table F. LCD Interface Pin Assignments

Pin Mnemonic	Pin Description
SPCLK	Pixel Clock
P[17:0]	Pixel Data Bus [17:0]
HSYNC / LP	Horizontal Synchronization / Line Pulse
VCSYNC / FP	Vertical or Composite Synchronization / Frame Pulse
BLANK	Composite Blank
BRIGHT	Pulse Width Modulated Brightness

## Touch Screen Interface with 12-bit Analog-to-digital Converter (ADC)

The touch screen interface performs all sampling, averaging, ADC range checking, and control for a wide variety of analog resistive touch screens. This controller only interrupts the processor when a meaningful change occurs. The touch screen hardware may be disabled and the switch matrix and ADC controlled directly if desired. Features include:

- Support for 4-, 5-, 7-, or 8-wire analog resistive touch screens.
- Flexibility - unused lines may be used for temperature sensing or other functions.
- Touch screen interrupt function.

Table G. Touch Screen Interface with 12-bit Analog-to-Digital Converter Pin Assignments

Pin Mnemonic	Pin Description
Xp, Xm	Touch screen ADC X Axis

Table G. Touch Screen Interface with 12-bit Analog-to-Digital Converter Pin Assignments

Pin Mnemonic	Pin Description
Yp, Ym	Touch screen ADC Y Axis
SXp, SXm	Touch screen ADC X Axis Voltage Feedback
SYp, SYm	Touch screen ADC Y Axis Voltage Feedback

## 64-Key Keypad Interface

The keypad circuitry scans an 8 x 8 array of 64 normally open, single-pole switches. Any one or two keys depressed will be de-bounced and decoded. An interrupt is generated whenever a stable set of depressed keys is detected. If the keypad is not utilized, the 16 column/row pins may be used as general purpose I/O. The Keypad interface:

- Provides scanning, debounce, and decoding for a 64-key switch array.
- Scans an 8-row by 8-column matrix.
- May decode 2 keys at once.
- Generates an interrupt when a new stable key is determined.
- Also generates a 3-key reset interrupt.

Table H. 64-Key Keypad Interface Pin Assignments

Pin Mnemonic	Pin Description	Alternative Usage
COL[7:0]	Key Matrix Column Inputs	General Purpose I/O
ROW[7:0]	Key Matrix Row Inputs	General Purpose I/O

## Universal Asynchronous Receiver/Transmitters (UARTs)

Three 16550-compatible UARTs are supplied. Two provide asynchronous HDLC (High-level Data Link Control) protocol support for full duplex transmit and receive. The HDLC receiver handles framing, address matching, CRC checking, control-octet transparency, and optionally passes the CRC to the host at the end of the packet. The HDLC transmitter handles framing, CRC generation, and control-octet transparency. The host must assemble the frame in memory before transmission. The HDLC receiver and transmitter use the UART FIFOs to buffer the data streams. A third IrDA<sup>®</sup> compatible UART is also supplied.

- UART1 supports modem bit rates up to 115.2 Kbps, supports HDLC and includes a 16 byte FIFO for

receive and a 16 byte FIFO for transmit. Interrupts are generated on Rx, Tx and modem status change.

- UART2 contains an IrDA encoder operating at either the slow (up to 115 Kbps), medium (0.576 or 1.152 Mbps), or fast (4 Mbps) IR data rates. It also has a 16 byte FIFO for receive and a 16 byte FIFO for transmit.
- UART3 supports HDLC and includes a 16 byte FIFO for receive and a 16 byte FIFO for transmit. Interrupts are generated on Rx and Tx.

**Table I. Universal Asynchronous Receiver/Transmitters Pin Assignments**

Pin Mnemonic	Pin Name - Description
TXD0	UART1 Transmit
RXD0	UART1 Receive
CTS <sub>n</sub>	UART1 Clear To Send / Transmit Enable
DSR <sub>n</sub> / DCD <sub>n</sub>	UART1 Data Set Ready / Data Carrier Detect
DTR <sub>n</sub>	UART1 Data Terminal Ready
RTS <sub>n</sub>	UART1 Ready To Send
EGPIO[0] / RI	UART1 Ring Indicator
TXD1 / SIROUT	UART2 Transmit / IrDA Output
RXD1 / SIRIN	UART2 Receive / IrDA Input
TXD2	UART3 Transmit
RXD2	UART3 Receive
EGPIO[3] / TEN <sub>n</sub>	HDLC3 Transmit Enable

## Triple-port USB Host

The USB Open Host Controller Interface (Open HCI) provides full-speed serial communications ports at a baud rate of 12 Mbits/sec. Up to 127 USB devices (printer, mouse, camera, keyboard, etc.) and USB hubs can be connected to the USB host in the USB “tiered star” topology.

This includes the following features:

- Compliance with the USB 2.0 specification
- Compliance with the Open HCI Rev 1.0 specification
- Supports both low speed (1.5 Mbps) and full speed (12 Mbps) USB device connections
- Root HUB integrated with 3 downstream USB ports
- Transceiver buffers integrated, over-current protection on ports
- Supports power management
- Operates as a master on the bus

The Open HCI host controller initializes the master DMA transfer with the AHB bus:

- Fetches endpoint descriptors and transfer descriptors
- Accesses endpoint data from system memory
- Accesses the HC communication area
- Writes status and retire transfer descriptor

**Table J. Triple Port USB Host Pin Assignments**

Pin Mnemonic	Pin Name - Description
USBp[2:0]	USB Positive signals
USBm[2:0]	USB Negative Signals

## Two-wire Interface

The two-wire interface provides communication and control for synchronous-serial-driven devices.

**Table K. Two-Wire Port with EEPROM Support Pin Assignments**

Pin Mnemonic	Pin Name - Description	Alternative Usage
EECLK	Two-wire Interface Clock	General Purpose I/O
EEDATA	Two-wire Interface Data	General Purpose I/O

## Real-time Clock with Software Trim

The software trim feature on the real time clock (RTC) provides software controlled digital compensation of the 32.768 KHz input clock. This compensation is accurate to  $\pm 1.24$  sec/month.

*Note: A real time clock must be connected to RTCXTALI or the EP9312 device will not boot.*

**Table L. Real-Time Clock with Pin Assignments**

Pin Mnemonic	Pin Name - Description
RTCXTALI	Real-Time Clock Oscillator Input
RTCXTALO	Real-Time Clock Oscillator Output

## PLL and Clocking

The Processor and the Peripheral Clocks operate from a single 14.7456 MHz crystal.

The Real Time Clock operates from a 32.768 KHz external oscillator.

Table M. PLL and Clocking Pin Assignments

Pin Mnemonic	Pin Name - Description
XTALI	Main Oscillator Input
XTALO	Main Oscillator Output
VDD_PLL	Main Oscillator Power
GND_PLL	Main Oscillator Ground

## Timers

The Watchdog Timer ensures proper operation by requiring periodic attention to prevent a reset-on-time-out.

Two 16-bit timers operate as free-running down counters or as periodic timers for fixed-interval interrupts and have a range of 0.03 ms to 4.27 seconds.

One 32-bit timer, plus a 6-bit prescale counter, has a range of 0.03  $\mu$ s to 73.3 hours.

One 40-bit debug timer, plus a 6-bit prescale counter, has a range of 1.0  $\mu$ s to 12.7 days.

## Interrupt Controller

The interrupt controller allows up to 64 interrupts to generate an Interrupt Request (IRQ) or Fast Interrupt Request (FIQ) signal to the processor core. Thirty-two hardware priority assignments are provided for assisting IRQ vectoring, and two levels are provided for FIQ vectoring. This allows time-critical interrupts to be processed in the shortest time possible. Internal interrupts may be programmed as active high or active low level sensitive inputs. External interrupts may be programmed as active-high level-sensitive, active-low level-sensitive, rising-edge-triggered, falling-edge-triggered, or combined rising/falling-edge-triggered.

- Supports 64 interrupts from a variety of sources (such as UARTs, GPIO, and key matrix)
- Routes interrupt sources to either the ARM920T's IRQ or FIQ (Fast IRQ) inputs
- Four dedicated off-chip interrupt lines INT[3:0] operate as level-sensitive interrupts
- Any of the 16 GPIO lines maybe configured to generate interrupts
- Software-supported priority mask for all FIQs and IRQs

Table N. External Interrupt Controller Pin Assignment

Pin Mnemonic	Pin Name - Description
INT[3:0]	External Interrupt 3-0

## Dual LED Drivers

Two pins are assigned specifically to drive external LEDs.

Table O. Dual LED Pin Assignments

Pin Mnemonic	Pin Name - Description	Alternative Usage
GRLED	Green LED	General Purpose I/O
REDLED	Red LED	General Purpose I/O

## General Purpose Input/Output (GPIO)

The 16 EGPIO pins may each be configured individually as an output, an input, or an interrupt input.

There are 23 pins that may alternatively be used as input, output, but do not support interrupts. These pins are:

- Key Matrix ROW[7:0], COL[7:0]
- Ethernet MDIO
- Both LED Outputs
- Two-wire Clock and Data
- SLA [1:0]

6 pins may alternatively be used as inputs only:

- CTSn, DSRn / DCDn
- 4 Interrupt Lines

2 pins may alternatively be used as outputs only:

- RTSn
- ARSTn

Table P. General Purpose Input/Output Pin Assignment

Pin Mnemonic	Pin Name - Description
EGPIO[15:0]	Expanded General Purpose Input / Output Pins with Interrupts

## Reset and Power Management

The chip may be reset through the PRSTn pin or through the open drain common reset pin, RSTOn.

Clocks are managed on a peripheral-by-peripheral basis and may be turned off to conserve power.

The processor clock is dynamically adjustable from 0 to 200 MHz (184 MHz for industrial conditions).

Table Q. Reset and Power Management Pin Assignments

Pin Mnemonic	Pin Name - Description
PRSTn	Power On Reset
RSTOn	User Reset In/Out – Open Drain – Preserves Real Time Clock value

## Hardware Debug Interface

The JTAG interface allows use of ARM's Multi-ICE or other in-circuit emulators.

Table R. Hardware Debug Interface

Pin Mnemonic	Pin Name - Description
TCK	JTAG Clock
TDI	JTAG Data In
TDO	JTAG Data Out
TMS	JTAG Test Mode Select
TRSTn	JTAG Port Reset

## 12-channel DMA Controller

The DMA module contains 12 separate DMA channels. Ten of these may be used for peripheral-to-memory or memory-to-peripheral access. Two of these are dedicated to memory-to-memory transfers. Each DMA channel is connected to the 16-bit DMA request bus.

The request bus is a collection of requests, Serial Audio and UARTs. Each DMA channel can be used independently or dedicated to any request signal. For each DMA channel, source and destination addressing can be independently programmed to increment, decrement, or stay at the same value. All DMA addresses are physical, not virtual addresses.

## Internal Boot ROM

The Internal 16 Kbyte ROM allows booting from FLASH memory, SPI or UART. Consult the EP93xx User's Guide for operational details.

## Electrical Specifications

### Absolute Maximum Ratings

(All grounds = 0 V, all voltages with respect to 0 V)

Parameter	Symbol	Min	Max	Unit
Power Supplies	RVDD	-	3.96	V
	CVDD	-	2.16	V
	VDD_PLL	-	2.16	V
	VDD_ADC	-	3.96	V
Total Power Dissipation (Note 1)		-	2	W
Input Current per Pin, DC (Except supply pins)		-	±10	mA
Output current per pin, DC		-	±50	mA
Digital Input voltage (Note 2)		-0.3	RVDD+0.3	V
Storage temperature		-40	+125	°C

Note: 1. Includes all power generated by AC and/or DC output loading.  
 2. The power supply pins are at recommended maximum values.  
 3. At ambient temperatures above 70° C, total power dissipation must be limited to less than 2.5 Watts.

WARNING: Operation beyond these limits may result in permanent damage to the device.  
 Normal operation is not guaranteed at these extremes.

### Recommended Operating Conditions

(All grounds = 0 V, all voltages with respect to 0 V)

Parameter	Symbol	Min	Typ	Max	Unit
Power Supplies	RVDD	3.0	3.3	3.6	V
	CVDD	1.65	1.80	1.94	V
	VDD_PLL	1.65	1.80	1.94	V
	VDD_ADC	3.0	3.3	3.6	V
Operating Ambient Temperature - Commercial	T <sub>A</sub>	0	+25	+70	°C
Operating Ambient Temperature - Industrial	T <sub>A</sub>	-40	+25	+85	°C
Processor Clock Speed - Commercial	FCLK	-	-	200	MHz
Processor Clock Speed - Industrial	FCLK	-	-	184	MHz
System Clock Speed - Commercial	HCLK	-	-	100	MHz
System Clock Speed - Industrial	HCLK	-	-	92	MHz

## DC Characteristics

( $T_A = 0$  to  $70^\circ\text{C}$ ;  $CVDD = VDD\_PLL = 1.8$ ;  $RVDD = 3.3\text{ V}$ ;

All grounds =  $0\text{ V}$ ; all voltages with respect to  $0\text{ V}$  unless otherwise noted)

Parameter			Symbol	Min	Max	Unit
High level output voltage	$I_{out} = -4\text{ mA}$	(Note 4)	$V_{oh}$	$0.85 \times RVDD$	-	V
Low level output voltage	$I_{out} = 4\text{ mA}$		$V_{ol}$	-	$0.15 \times RVDD$	V
High level input voltage		(Note 5)	$V_{ih}$	$0.65 \times RVDD$	$VDD + 0.3$	V
Low level input voltage		(Note 5)	$V_{il}$	-0.3	$0.35 \times RVDD$	V
High level leakage current	$V_{in} = 3.3\text{ V}$	(Note 5)	$I_{ih}$	-	10	$\mu\text{A}$
Low level leakage current	$V_{in} = 0$	(Note 5)	$I_{il}$	-	-10	$\mu\text{A}$

Parameter		Min	Typ	Max	Unit
Power Supply Pins (Outputs Unloaded)					
Power Supply Current:	CVDD / VDD_PLL Total	-	190	240	mA
	RVDD	-	45	80	mA
Low-Power Mode Supply Current	CVDD / VDD_PLL Total	-	2	3.5	mA
	RVDD	-	1.0	2	mA

Note: 4. For open drain pins, high level output voltage is dependent on the external load.

5. All inputs that do not include internal pull-ups or pull-downs, must be externally driven for proper operation (See [Table S on page 59](#)). If an input is not driven, it should be tied to power or ground, depending on the particular function. If an I/O pin is not driven and programmed as an input, it should be tied to power or ground through its own resistor.

## Timings

### Timing Diagram Conventions

This data sheet contains one or more timing diagrams. The following key explains the components used in these diagrams. Any variations are clearly labelled when they occur. Therefore, no additional meaning should be attached unless specifically stated.

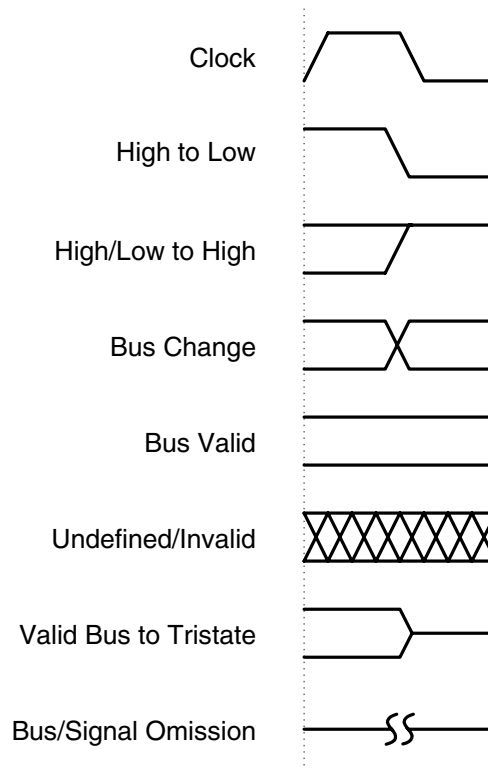


Figure 1. Timing Diagram Drawing Key

### Timing Conditions

Unless specified otherwise, the following conditions are true for all timing measurements.

- $T_A = 0$  to  $70^\circ\text{C}$
- $CVDD = VDD\_PLL = 1.8\text{V}$
- $RVDD = 3.3\text{V}$
- All grounds =  $0\text{V}$
- Logic 0 =  $0\text{V}$ , Logic 1 =  $3.3\text{V}$
- Output loading =  $50\text{pF}$
- Timing reference levels =  $1.5\text{V}$
- The Processor Bus Clock (HCLK) is programmable and is set by the user. The frequency is typically between  $33\text{MHz}$  and  $100\text{MHz}$  ( $92\text{MHz}$  for industrial conditions).

## Memory Interface

Figure 2 through Figure 5 define the timings associated with all phases of the SDRAM. The following table contains the values for the timings of each of the SDRAM modes.

Parameter	Symbol	Min	Typ	Max	Unit
SDCLK high time	$t_{\text{clk\_high}}$	-	$(t_{\text{HCLK}}) / 2$	-	ns
SDCLK low time	$t_{\text{clk\_low}}$	-	$(t_{\text{HCLK}}) / 2$	-	ns
SDCLK rise/fall time	$t_{\text{clkrf}}$	-	2	4	ns
Signal delay from SDCLK rising edge time	$t_d$	-	-	8	ns
Signal hold from SDCLK rising edge time	$t_h$	1	-	-	ns
DQMn delay from SDCLK rising edge time	$t_{\text{DQd}}$	-	-	8	ns
DQMn hold from SDCLK rising edge time	$t_{\text{DQh}}$	1	-	-	ns
DA valid setup to SDCLK rising edge time	$t_{\text{DAs}}$	2	-	-	ns
DA valid hold from SDCLK rising edge time	$t_{\text{DAh}}$	3	-	-	ns

### SDRAM Load Mode Register Cycle

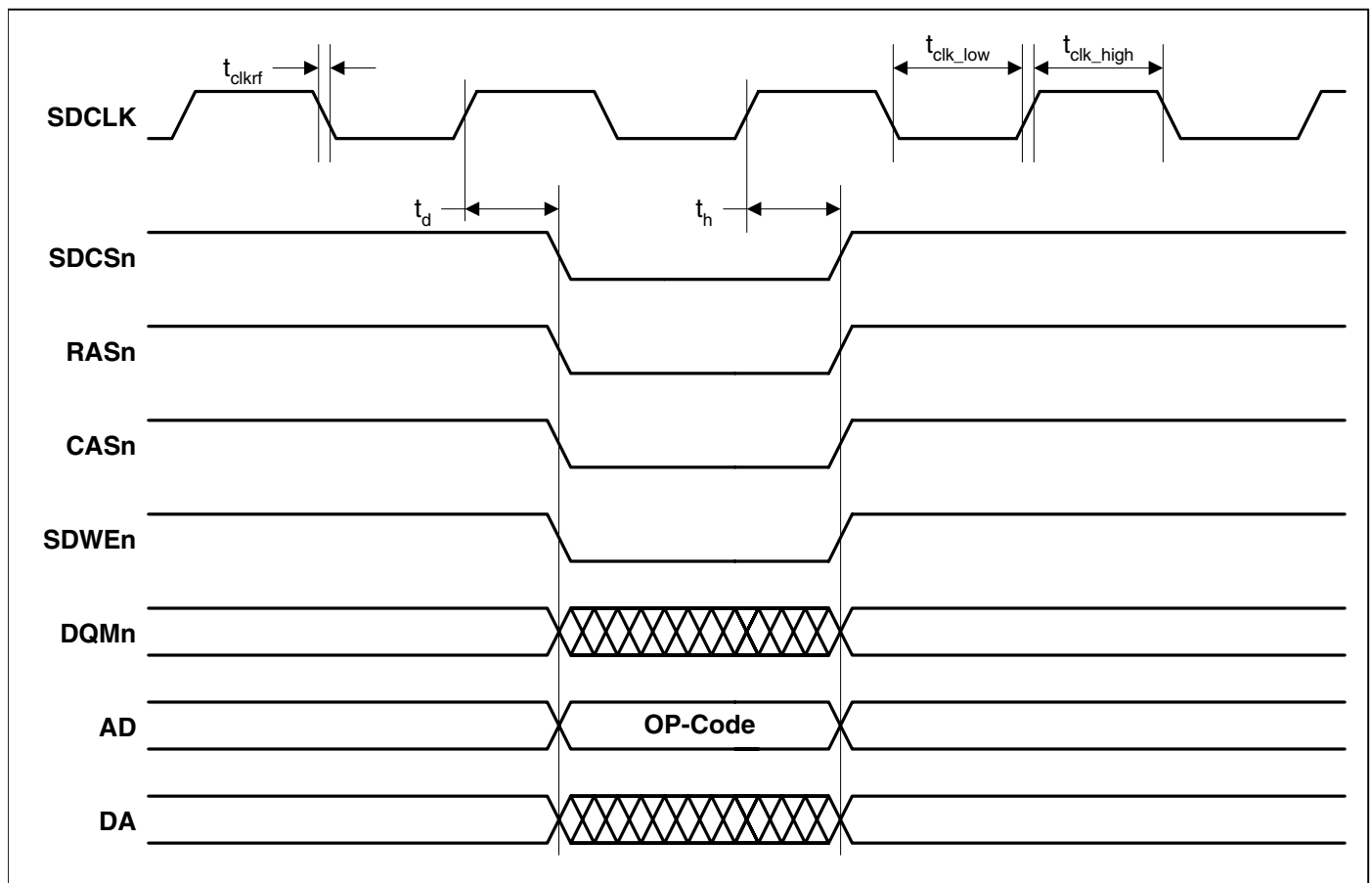


Figure 2. SDRAM Load Mode Register Cycle Timing Measurement



**SDRAM Burst Read Cycle**

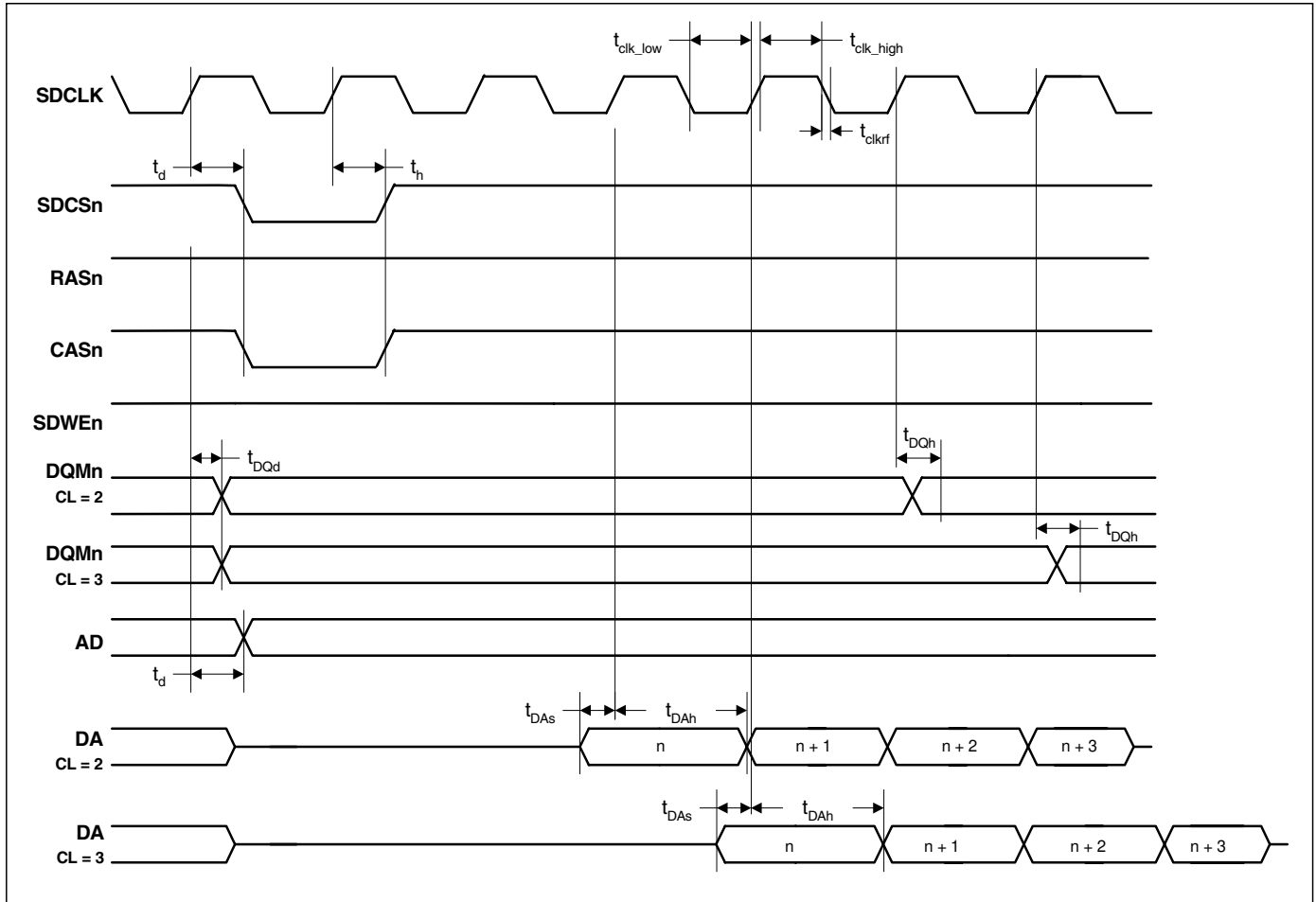
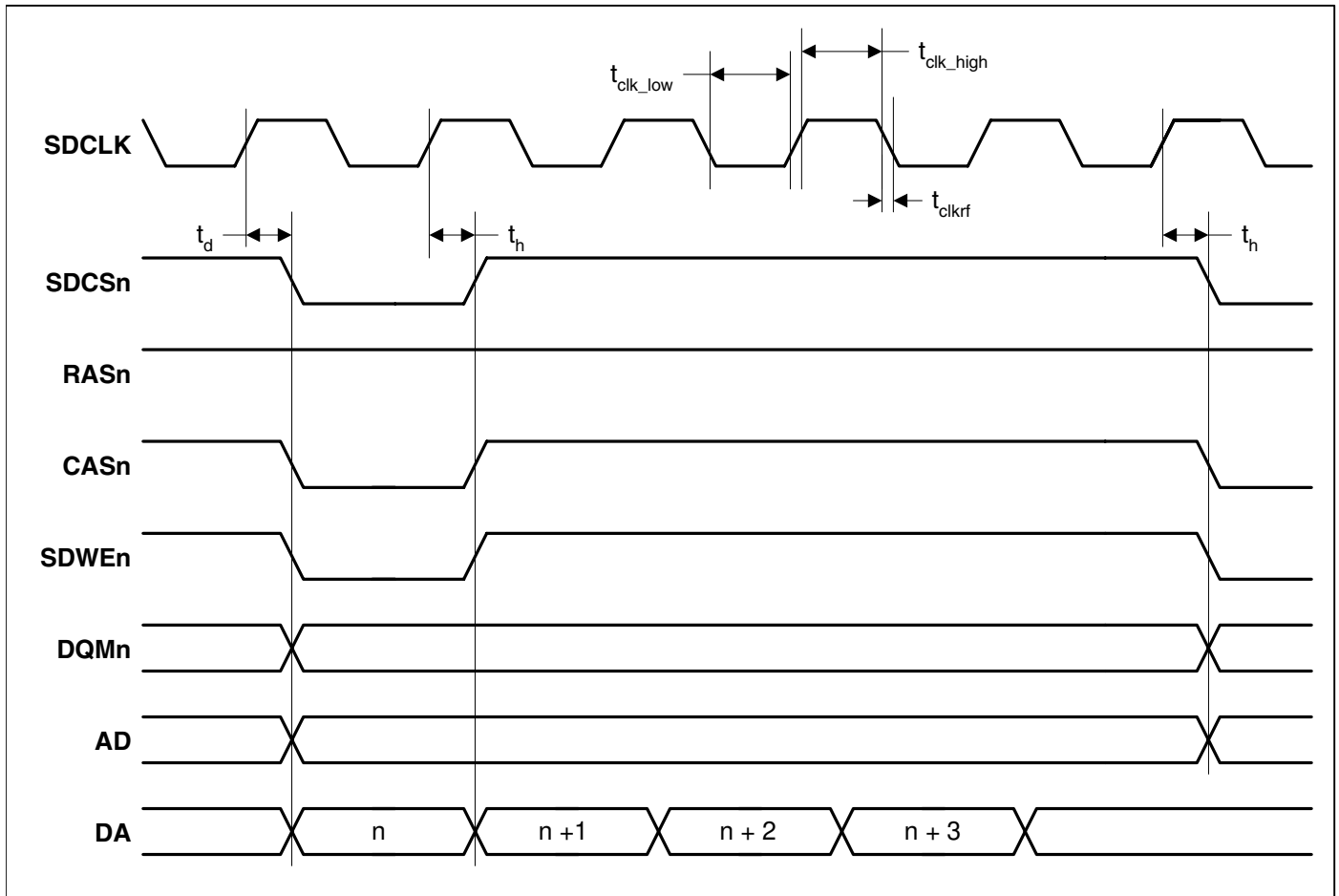
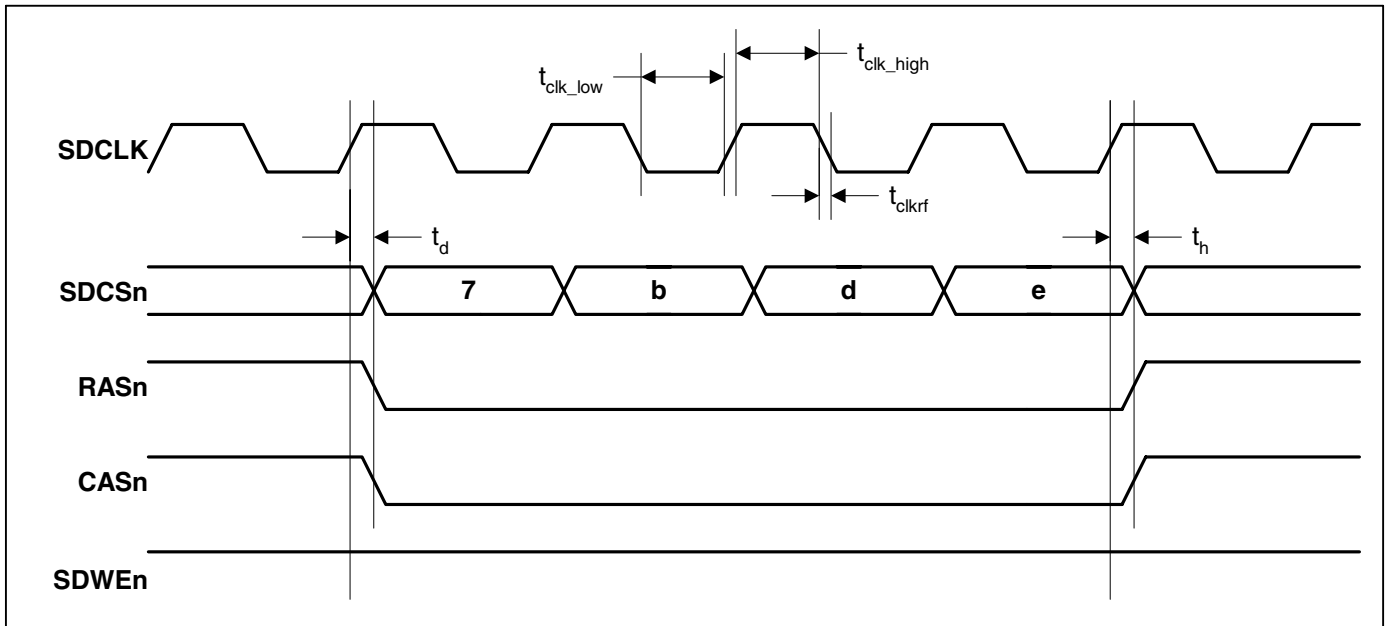


Figure 3. SDRAM Burst Read Cycle Timing Measurement

**SDRAM Burst Write Cycle**

**Figure 4. SDRAM Burst Write Cycle Timing Measurement**

### SDRAM Auto Refresh Cycle



Note: Chip select shown as bus to illustrate multiple devices being put into auto refresh in one access

Figure 5. SDRAM Auto Refresh Cycle Timing Measurement

**Static Memory Single Word Read Cycle**

Parameter	Symbol	Min	Typ	Max	Unit
AD setup to CSn assert time	$t_{ADs}$	0	-	-	ns
AD hold from CSn deassert time	$t_{ADh}$	$t_{HCLK}$	-	-	ns
RDn assert time	$t_{RDpw}$	-	$t_{HCLK} \times (WST1 + 2)$	-	ns
CSn to RDn delay time	$t_{RDd}$	-	-	3	ns
CSn assert to DQMn assert delay time	$t_{DQMd}$	-	-	1	ns
DA setup to RDn deassert time	$t_{DAs}$	$t_{HCLK} + 12$	-	-	ns
DA hold from RDn deassert time	$t_{DAh}$	0	-	-	ns

See "Timing Conditions" on page 14 for definition of HCLK.

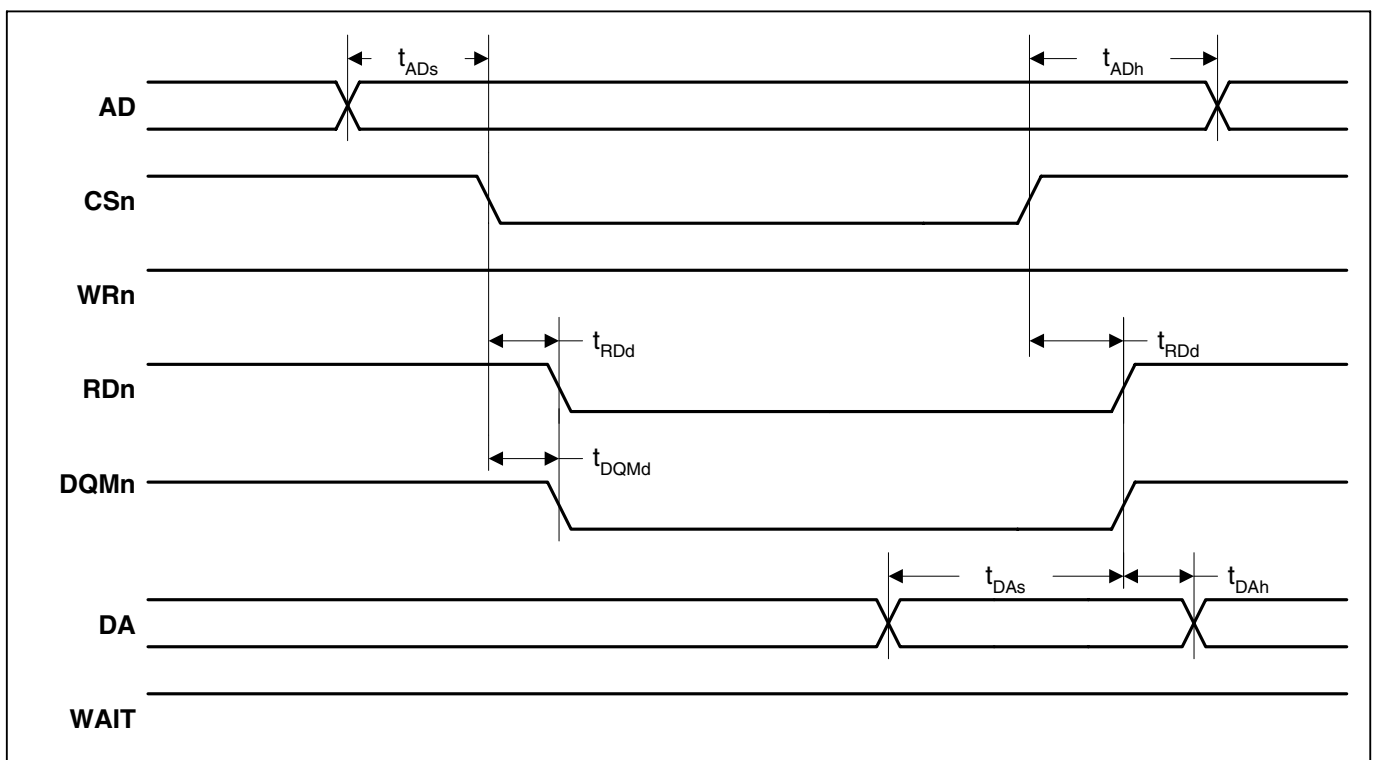


Figure 6. Static Memory Single Word Read Cycle Timing Measurement

### Static Memory Single Word Write Cycle

Parameter	Symbol	Min	Typ	Max	Unit
AD setup to WRn assert time	$t_{ADs}$	$t_{HCLK} - 3$	-	-	ns
AD hold from WRn deassert time	$t_{ADh}$	$t_{HCLK} \times 2$	-	-	ns
WRn deassert to CSn deassert time	$t_{CSH}$	7	-	-	ns
CSn to WRn assert delay time	$t_{WRd}$	-	-	2	ns
WRn assert time	$t_{WRpw}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
CSn to DQMn assert delay time	$t_{DQMd}$	-	-	1	ns
WRn deassert to DA transition time	$t_{DAh}$	$t_{HCLK}$	-	-	ns
WRn assert to DA valid	$t_{DAV}$	-	-	8	ns

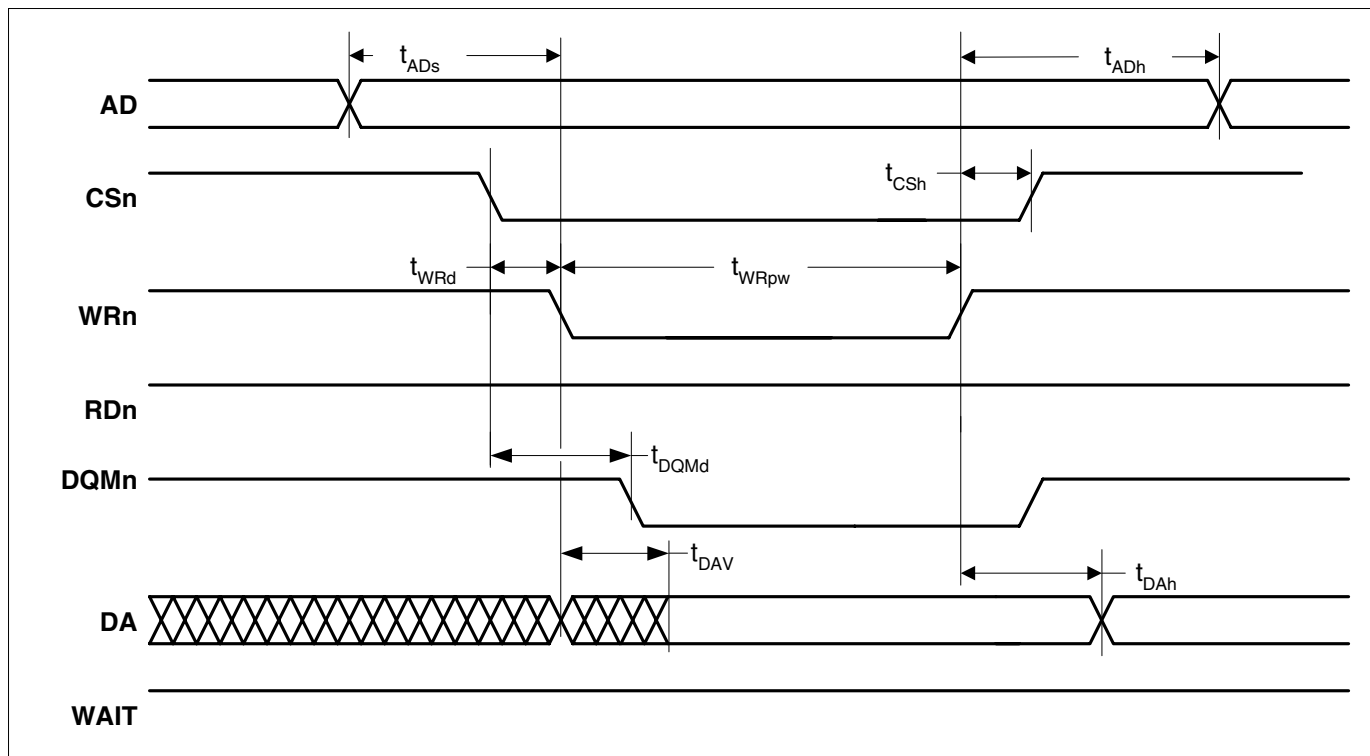
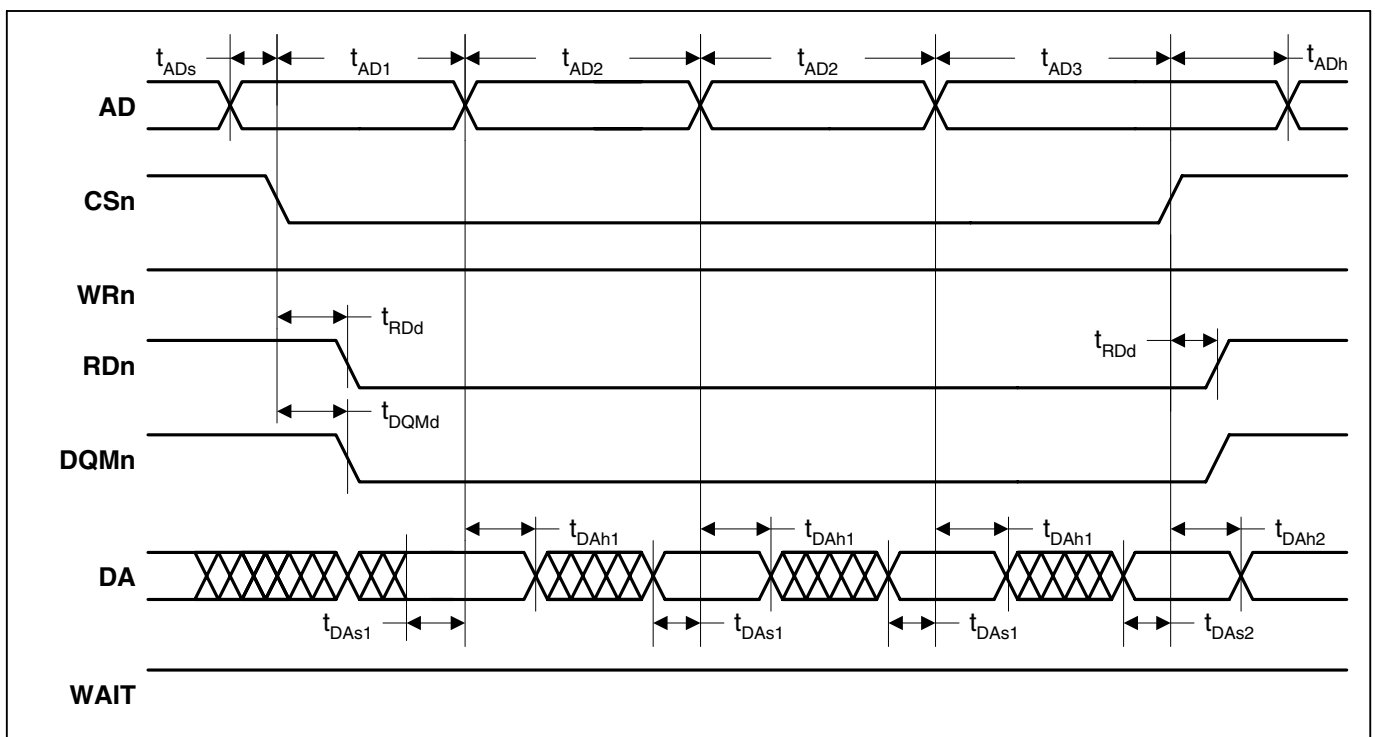


Figure 7. Static Memory Single Word Write Cycle Timing Measurement

**Static Memory 32-bit Read on 8-bit External Bus**

Parameter	Symbol	Min	Typ	Max	Unit
AD setup to CSn assert time	$t_{ADs}$	$t_{HCLK}$	-	-	ns
CSn assert to Address transition time	$t_{AD1}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
Address assert time	$t_{AD2}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
AD transition to CSn deassert time	$t_{AD3}$	-	$t_{HCLK} \times (WST1 + 2)$	-	ns
AD hold from CSn deassert time	$t_{ADh}$	$t_{HCLK}$	-	-	ns
RDn assert time	$t_{RDpwL}$	-	$t_{HCLK} \times (4 \times WST1 + 5)$	-	ns
CSn to RDn delay time	$t_{RDd}$	-	-	3	ns
CSn assert to DQMn assert delay time	$t_{DQMd}$	-	-	1	ns
DA setup to AD transition time	$t_{DAs1}$	15	-	-	ns
DA setup to RDn deassert time	$t_{DAs2}$	$t_{HCLK} + 12$	-	-	ns
DA hold from AD transition time	$t_{DAh1}$	0	-	-	ns
DA hold from RDn deassert time	$t_{DAh2}$	0	-	-	ns


**Figure 8. Static Memory Multiple Word Read 8-bit Cycle Timing Measurement**

**Static Memory 32-bit Write on 8-bit External Bus**

Parameter	Symbol	Min	Typ	Max	Unit
AD setup to WRn assert time	$t_{ADs}$	$t_{HCLK} - 3$	-	-	ns
WRn/DQMn deassert to AD transition time	$t_{ADd}$	-	-	$t_{HCLK} + 6$	ns
AD hold from WRn deassert time	$t_{ADh}$	$t_{HCLK} \times 2$	-	-	ns
CSn hold from WRn deassert time	$t_{CSH}$	7	-	-	ns
CSn to WRn assert delay time	$t_{WRd}$	-	-	2	ns
WRn assert time	$t_{WRpwL}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
WRn deassert time	$t_{WRpwH}$	-	$t_{HCLK} \times 2$	$(t_{HCLK} \times 2) + 14$	ns
CSn to DQMn assert delay time	$t_{DQMd}$	-	-	1	ns
DQMn assert time	$t_{DQMpwL}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
DQMn deassert time	$t_{DQMpwH}$	-	-	$(t_{HCLK} \times 2) + 7$	ns
WRn / DQMn deassert to DA transition time	$t_{DAh}$	$t_{HCLK}$	-	-	ns
WRn / DQMn assert to DA valid time	$t_{DAV}$	-	-	8	ns

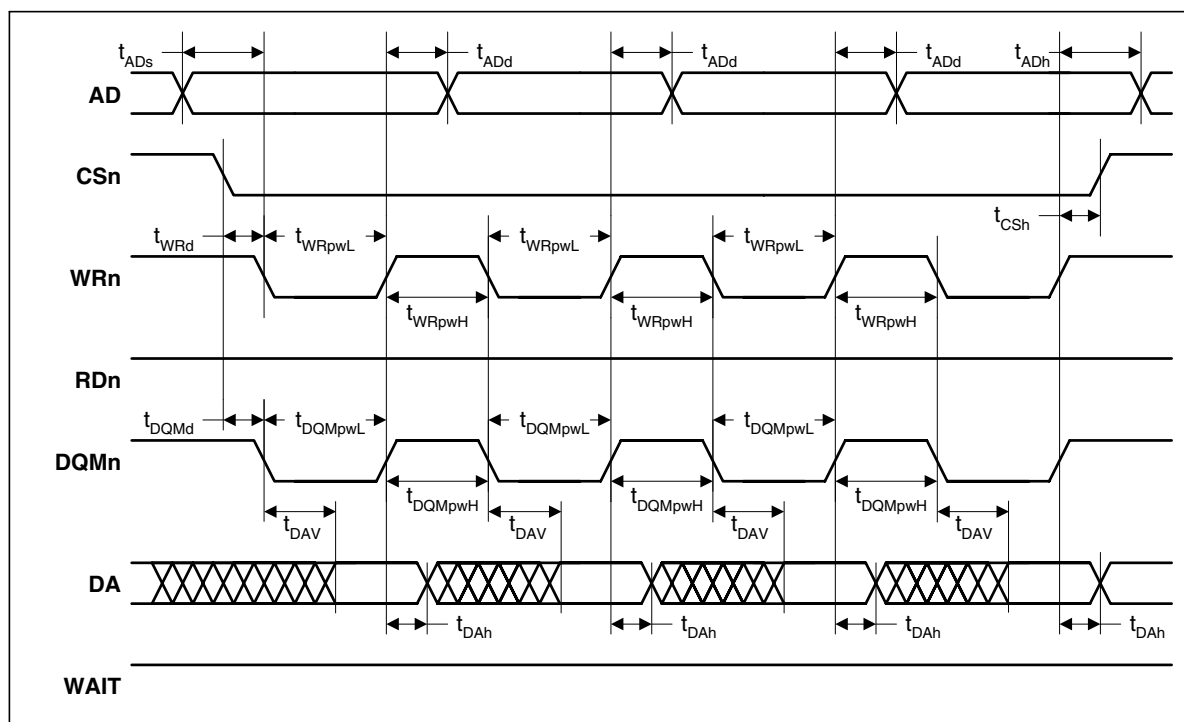
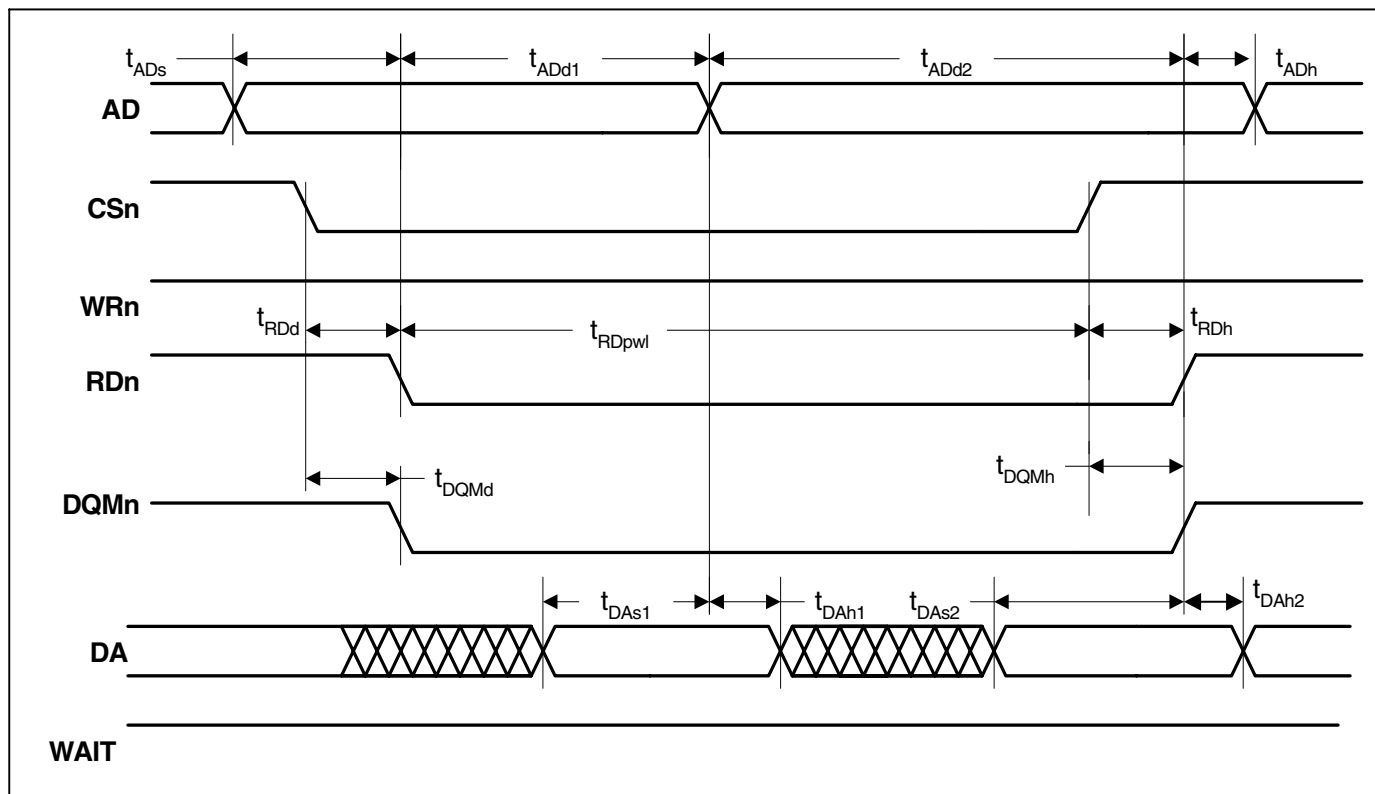


Figure 9. Static Memory Multiple Word Write 8-bit Cycle Timing Measurement

**Static Memory 32-bit Read on 16-bit External Bus**

Parameter	Symbol	Min	Typ	Max	Unit
AD setup to CSn assert time	$t_{ADs}$	$t_{HCLK}$	-	-	ns
CSn assert to AD transition time	$t_{ADd1}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
AD transition to CSn deassert time	$t_{ADd2}$	-	$t_{HCLK} \times (WST1 + 2)$	-	ns
AD hold from CSn deassert time	$t_{ADh}$	$t_{HCLK}$	-	-	ns
RDn assert time	$t_{RDpwl}$	-	$t_{HCLK} \times ((2 \times WST1) + 3)$	-	ns
CSn to RDn delay time	$t_{RDd}$	-	-	3	ns
CSn assert to DQMn assert delay time	$t_{DQMd}$	-	-	1	ns
DA setup to AD transition time	$t_{DAs1}$	15	-	-	ns
DA to RDn deassert time	$t_{DAh1}$	$t_{HCLK} + 12$	-	-	ns
DA hold from AD transition time	$t_{DAh2}$	0	-	-	ns
DA hold from RDn deassert time	$t_{DAh2}$	0	-	-	ns


**Figure 10. Static Memory Multiple Word Read 16-bit Cycle Timing Measurement**



**Static Memory 32-bit Write on 16-bit External Bus**

Parameter	Symbol	Min	Typ	Max	Unit
AD setup to WRn assert time	$t_{ADs}$	$t_{HCLK} - 3$	-	-	ns
WRn/DQMn deassert to AD transition time	$t_{ADd}$	-	-	$t_{HCLK} + 6$	ns
AD hold from WRn deassert time	$t_{ADh}$	$t_{HCLK} \times 2$	-	-	ns
CSn hold from WRn deassert time	$t_{CSH}$	7	-	-	ns
CSn to WRn assert delay time	$t_{WRd}$	-	-	2	ns
WRn assert time	$t_{WRpwL}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
WRn deassert time	$t_{WRpwH}$	-	-	$(t_{HCLK} \times 2) + 14$	ns
CSn to DQMn assert delay time	$t_{DQMd}$	-	-	1	ns
DQMn assert time	$t_{DQMpwL}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
DQMn deassert time	$t_{DQMpwH}$	-	-	$(t_{HCLK} \times 2) + 7$	ns
WRn / DQMn deassert to DA transition time	$t_{DAh1}$	$t_{HCLK}$	-	-	ns
WRn / DQMn assert to DA valid time	$t_{DAV}$	-	-	8	ns

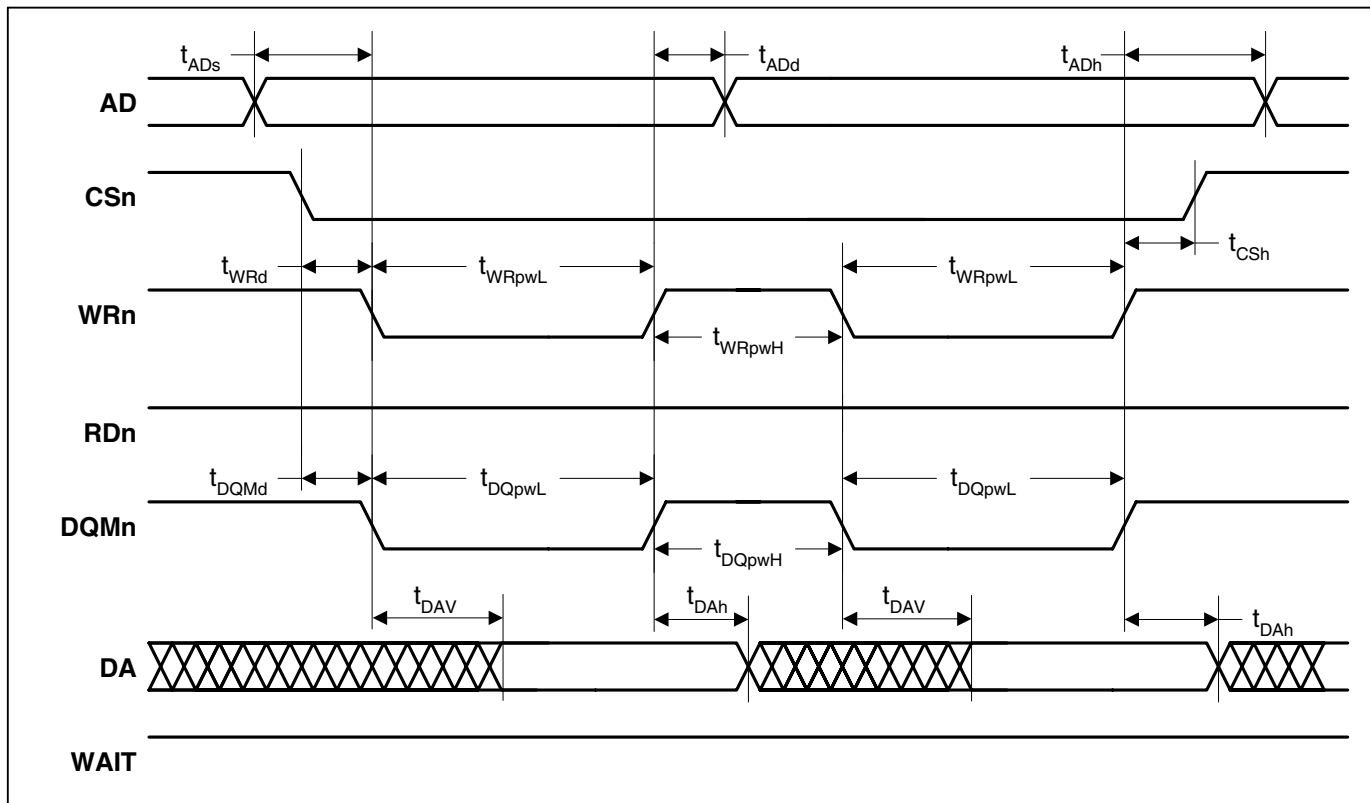


Figure 11. Static Memory Multiple Word Write 16-bit Cycle Timing Measurement

**Static Memory Burst Read Cycle**

Parameter	Symbol	Min	Typ	Max	Unit
CSn assert to Address 1 transition time	$t_{ADd1}$	-	$t_{HCLK} \times (WST1 + 1)$	-	ns
Address assert time	$t_{ADd2}$	-	$t_{HCLK} \times (WST2 + 1)$	-	ns
AD transition to CSn deassert time	$t_{ADd3}$	-	$t_{HCLK} \times (WST1 + 2)$	-	ns
AD hold from CSn deassert time	$t_{ADh}$	$t_{HCLK}$	-	-	ns
CSn to RDn delay time	$t_{RDd}$	-	-	3	ns
CSn to DQMn assert delay time	$t_{DQMd}$	-	-	1	ns
DA setup to AD transition time	$t_{DAs1}$	15	-	-	ns
DA setup to CSn deassert time	$t_{DAs2}$	$t_{HCLK} + 12$	-	-	ns
DA hold from AD transition time	$t_{DAh1}$	0	-	-	ns
DA hold from RDn deassert time	$t_{DAh2}$	0	-	-	ns

Note: These characteristics are valid when the Page Mode Enable (Burst Mode) bit is set. See the User's Guide for details.

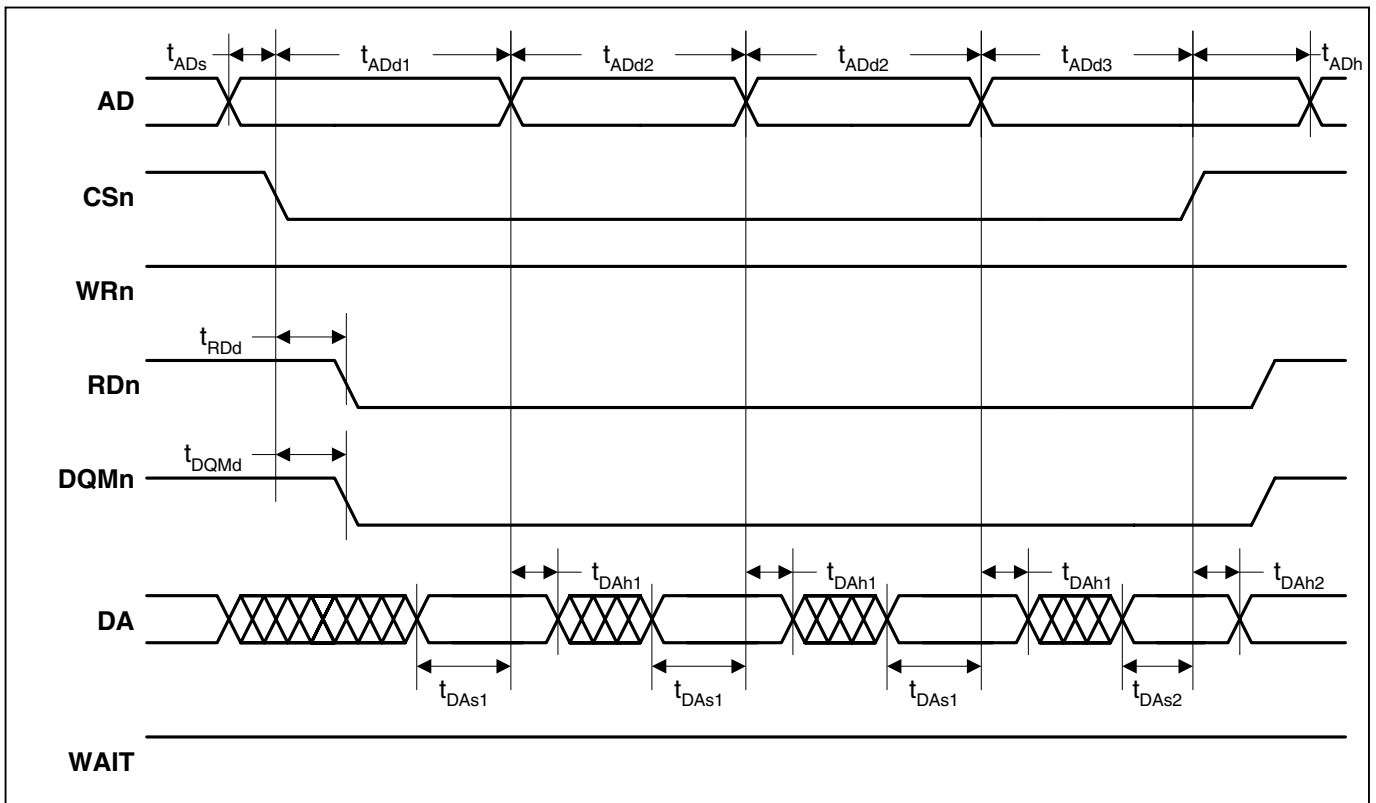


Figure 12. Static Memory Burst Read Cycle Timing Measurement