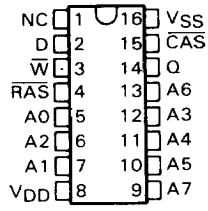
JULY 1985 — REVISED MAY 1988

- 65,536 × 1 Organization
- Single 5-V Supply (± 10% Tolerance)
- Upward Pin Compatible with '4116 (16K Dynamic RAM)
- Available Temperature Ranges with MIL-STD-883C High-Reliability Class B Processing:
  —S . . . −55°C to 110°C
  —L . . . 0°C to 70°C
- Long Refresh Period . . . 4 ms
- Low Refresh Overhead Time . . . As Low As 1.8% of Total Refresh Period
- All Inputs, Outputs, Clocks Fully TTL Compatible
- 3-State Unlatched Output
- Common I/O Capability with Early Write Feature
- Page-Mode Operation for Faster Access
- Low Power Dissipation
  —Operating . . . 125 mW (Typ)
  —Standby . . . 17.5 mW (Typ)
- Performance Ranges:

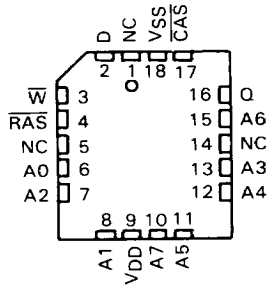
	ACCESS TIME ROW ADDRESS (MAX)	ACCESS TIME COLUMN ADDRESS (MAX)	READ OR WRITE CYCLE (MIN)	READ-MODIFY-WRITE CYCLE (MIN)
'4164-12	120 ns	70 ns	230 ns	260 ns
'4164-15	150 ns	85 ns	260 ns	285 ns
'4164-20	200 ns	135 ns	326 ns	345 ns

- SMOS (Scaled-MOS) N-Channel Technology

JD PACKAGE
(TOP VIEW)



FG PACKAGE
(TOP VIEW)



PIN NOMENCLATURE	
A0-A7	Address Inputs
$\overline{CAS}$	Column-Address Strobe
D	Data In
NC	No Connection
Q	Data Out
$\overline{RAS}$	Row-Address Strobe
V_{DD}	5-V Supply
V_{SS}	Ground
$\overline{W}$	Write Enable

description

The SMJ4164 is a Military high-speed, 65,536-bit, dynamic random-access memory, organized as 65,536 words of one bit each. It employs state-of-the-art SMOS (scaled MOS) N-channel double-level polysilicon gate technology for very high performance combined with low cost and improved reliability.

The SMJ4164 features $\overline{RAS}$ access times of 120 ns, 150 ns, and 200 ns maximum. Power dissipation is 125 mW typical operating and 17.5 mW typical standby.

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Refresh period is extended to 4 milliseconds, and during this period each of the 256 rows must be strobed with $\overline{RAS}$ in order to retain data. $\overline{CAS}$ can remain high during the refresh sequence to conserve power.

All inputs and outputs, including clocks, are compatible with Series 54/74 TTL. All address lines and data in are latched on-chip to simplify system design. Data out is unlatched to allow greater system flexibility. Pin 1 has no internal connection to allow compatibility with other 64K RAMs that use this pin for an additional function.

The SMJ4164 is offered in a 16-pin dual-in-line ceramic sidebraze package (JD suffix) and in a leadless ceramic chip carrier package (FG suffix). The JD package is designed for insertion in mounting-hole rows on 7,62-mm (300-mil) centers, whereas the FG package is intended for surface mounting on solder lands on 1,27-mm (0.050-inch) centers. The FG package is a three-layer, 18-pad, rectangular ceramic chip carrier with dimensions of 7,37 × 10,8 × 1,65 mm (0.290 × 0.425 × 0.065 inches).

operation

address (A0 through A7)

Sixteen address bits are required to decode 1 of 65,536 storage cell locations. Eight row-address bits are set up on pins A0 through A7 and latched onto the chip by the row-address strobe ($\overline{RAS}$). Then the eight column-address bits are set up on pins A0 through A7 and latched onto the chip by the column-address strobe ($\overline{CAS}$). All addresses must be stable on or before the falling edges of $\overline{RAS}$ and $\overline{CAS}$. $\overline{RAS}$ is similar to a chip enable in that it activates the sense amplifiers as well as the row decoder. $\overline{CAS}$ is used as a chip select activating the column decoder and the input and output buffers.

write enable ($\overline{W}$)

The read or write mode is selected through the write-enable ($\overline{W}$) input. A logic high on the $\overline{W}$ input selects the read mode and a logic low selects the write mode. The write-enable terminal can be driven from standard TTL circuits without a pull-up resistor. The data input is disabled when the read mode is selected. When $\overline{W}$ goes low prior to $\overline{CAS}$, data-out will remain in the high-impedance state for the entire cycle, permitting common I/O operation.

data in (D)

Data is written during a write or read-modify-write cycle. Depending on the mode of operation, the falling edge of $\overline{CAS}$ or $\overline{W}$ strobes data into the on-chip data latch. This latch can be driven from standard TTL circuits without a pull-up resistor. In an early write cycle, $\overline{W}$ is brought low prior to $\overline{CAS}$ and the data is strobed in by $\overline{CAS}$ with setup and hold times referenced to this signal. In a delayed write or read-modify-write cycle, $\overline{CAS}$ will already be low, thus the data will be strobed in by $\overline{W}$ with setup and hold times referenced to this signal.

data out (Q)

The three-state output buffer provides direct TTL compatibility (no pull-up resistor required) with a fanout of two Series 54/74 TTL loads. Data out is the same polarity as data in. The output is in the high-impedance (floating) state until $\overline{CAS}$ is brought low. In a read cycle the output goes active after the access time interval $t_{a(C)}$ that begins with the negative transition of $\overline{CAS}$ as long as $t_{a(R)}$ is satisfied. The output becomes valid after the access time has elapsed and remains valid while $\overline{CAS}$ is low; $\overline{CAS}$ going high returns it to a high-impedance state. In an early write cycle, the output is always in the high-impedance state. In a delayed-write or read-modify-write cycle, the output will follow the sequence for the read cycle.

refresh

A refresh operation must be performed at least every four milliseconds to retain data. Since the output buffer is in the high-impedance state unless $\overline{CAS}$ is applied, the $\overline{RAS}$-only refresh sequence avoids any output during refresh. Strobing each of the 256 row addresses (A0 through A7) with $\overline{RAS}$ causes all bits in each row to be refreshed. $\overline{CAS}$ can remain high (inactive) for this refresh sequence to conserve power.

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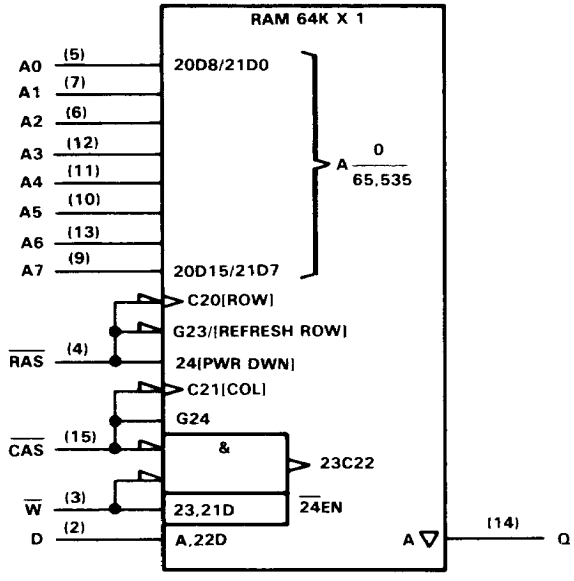
page mode

Page-mode operation allows effectively faster memory access by keeping the same row address and strobing successive column addresses onto the chip. Thus, the time required to set up and strobe sequential row addresses for the same page is eliminated. To extend beyond the 256 column locations on a single RAM, the row address and $\overline{RAS}$ are applied to multiple 64K RAMs. $\overline{CAS}$ is then decoded to select the proper RAM.

power up

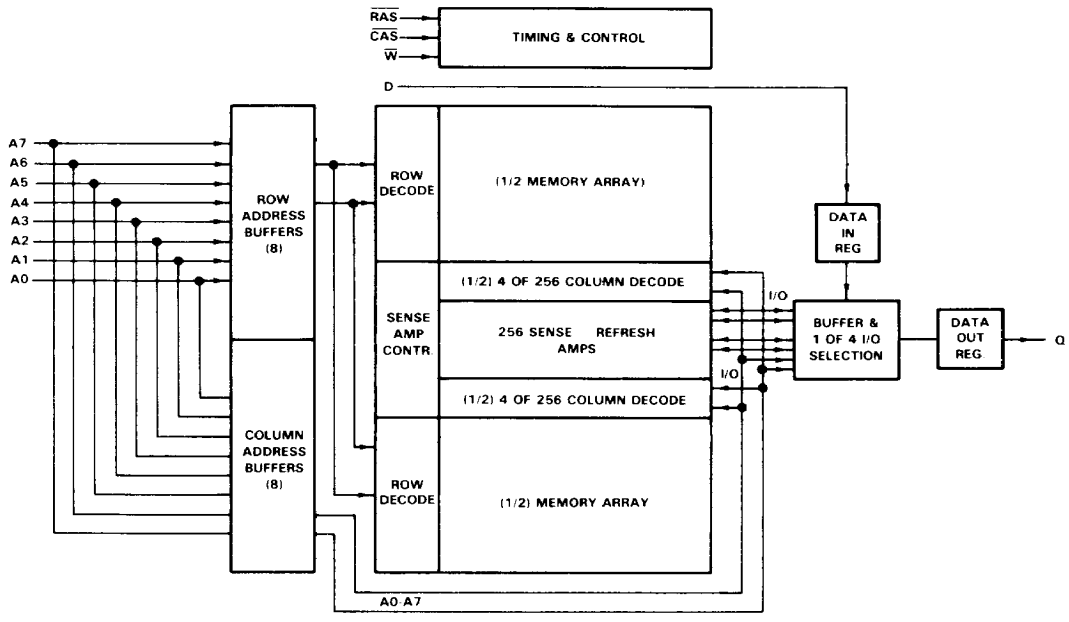
After power up, the power supply must remain at its steady-state value for 1 ms. In addition, $\overline{RAS}$ must remain high for 100 μs immediately prior to initialization. Initialization consists of performing eight $\overline{RAS}$ cycles before proper device operation is achieved.

logic symbol†



†This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.
Pin numbers shown are for the dual-in-line package.

functional block diagram



absolute maximum ratings over operating temperature range (unless otherwise noted)†

Voltage on any pin except V_{DD} and data out (see Note 1)	−1.5 V to 10 V
Voltage on V_{DD} supply and data out with respect to V_{SS}	−1 V to 6 V
Short circuit output current	50 mA
Power dissipation	1 W
Minimum operating free-air temperature: S version	−55°C
L version	0°C
Operating case temperature: S version	110°C
L version	70°C
Storage temperature range	−65°C to 150°C

†Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltage values in this data sheet are with respect to V_{SS}.

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recommended operating conditions

		S VERSION			L VERSION			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{DD}	Supply voltage	4.5	5	5.5	4.5	5	5.5	V
V_{SS}	Supply voltage		0			0		V
V_{IH}	High-level input voltage	2.4		$V_{CC}+0.3$	2.4		$V_{CC}+0.3$	V
V_{IL}	Low-level input voltage (see Notes 3 and 4)	−0.6		0.8	−0.6		0.8	V
T_A	Operating free-air temperature	−55			0			°C
T_C	Operating case temperature			110			70	°C

NOTES: 2. The algebraic convention, where the more negative (less positive) limit is designated as minimum, is used in this data sheet for logic voltage levels only.
3. Due to input protection circuitry, the applied voltage may begin to clamp at −0.6 V. Test conditions must comprehend this occurrence.

electrical characteristics over full ranges of recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	SMJ4164-12			SMJ4164-15			UNIT
			MIN	TYP†	MAX	MIN	TYP†	MAX	
V_{OH}	High-level output voltage	I_{OH} = −5 mA	2.4			2.4			V
V_{OL}	Low-level output voltage	I_{OL} = 4.2 mA			0.4			0.4	V
I_I	Input current (leakage)	V_I = 0 V to 5.8 V, V_{DD} = 5.5 V, All outputs open			±10			±10	μA
I_O	Output current (leakage)	V_O = 0.4 V to 5.5 V, V_{DD} = 5 V, $\overline{CAS}$ high			±10			±10	μA
I_{DD1}‡	Average operating current during read or write cycle	t_c = minimum cycle, All outputs open		40	48		35	45	mA
I_{DD2}§	Standby current	After 1 memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high, All outputs open		3.5	5		3.5	5	mA
I_{DD3}‡	Average refresh current	t_c = minimum cycle, $\overline{CAS}$ high and $\overline{RAS}$ cycling, All outputs open		28	40		25	37	mA
I_{DD4}	Average page-mode current	$t_{c(P)}$ = minimum cycle, $\overline{RAS}$ low and $\overline{CAS}$ cycling, All outputs open		28	40		25	37	mA

†All typical values are at T_C = 25°C and nominal supply voltages.
‡Additional information on last page of data sheet.
§V_{IL} § −0.6 V.

electrical characteristics over full ranges of recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	SMJ4164-20			UNIT
			MIN	TYP†	MAX	
V_{OH}	High-level output voltage	I_{OH} = −5 mA	2.4			V
V_{OL}	Low-level output voltage	I_{OL} = 4.2 mA			0.4	V
I_I	Input current (leakage)	V_I = 0 V to 5.8 V, V_{DD} = 5.5 V, Output = open			±10	μA
I_O	Output current (leakage)	V_O = 0.4 V to 5.5 V, V_{DD} = 5 V, $\overline{CAS}$ high			±10	μA
I_{DD1}‡	Average operating current during read or write cycle	t_c = minimum cycle, All outputs open		27	37	mA
I_{DD2}§	Standby current	After 1 memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high, All outputs open		3.5	5	mA
I_{DD3}‡	Average refresh current	t_c = minimum cycle, $\overline{CAS}$ high and $\overline{RAS}$ cycling, All outputs open		20	32	mA
I_{DD4}	Average page-mode current	$t_{c(P)}$ = minimum cycle, $\overline{RAS}$ low and $\overline{CAS}$ cycling, All outputs open		20	32	mA

†All typical values are at T_C = 25°C and nominal supply voltages.
‡Additional information on last page of data sheet.
§V_{IL} > −0.6 V.

capacitance over recommended supply voltage range and recommended temparature range, f = 1 MHz¶

PARAMETER		SMJ4164		UNIT
		TYP†	MAX	
$C_{i(A)}$	Input capacitance, address inputs	4	7	pF
$C_{i(D)}$	Input capacitance, data input	4	7	pF
$C_{i(RC)}$	Input capacitance, strobe inputs	8	10	pF
$C_{i(W)}$	Input capacitance, write enable input	8	10	pF
C_o	Output capacitance	5	8	pF

†All typical values are at T_C = 25°C and nominal supply voltages.
¶These parameters are guaranteed but not tested.

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switching characteristics over recommended supply voltage range and recommended operating temperature range

PARAMETER		TEST CONDITIONS	ALT. SYMBOL	SMJ4164-12		SMJ4164-15		UNIT
				MIN	MAX	MIN	MAX	
$t_{a(C)}$	Access time from $\overline{CAS}$	C_L = 80 pF, see Figure 1	t_{CAC}		70		85	ns
$t_{a(R)}$	Access time from $\overline{RAS}$	C_L = 80 pF, t_{RLCL} = MAX, see Figure 1	t_{RAC}		120		150	ns
$t_{dis(CH)}$	Output disable time after $\overline{CAS}$ high	C_L = 80 pF, see Figure 1	t_{OFF}	0	40	0	40	ns

PARAMETER		TEST CONDITIONS	ALT. SYMBOL	SMJ4164-20		UNIT
				MIN	MAX	
$t_{a(C)}$	Access time from $\overline{CAS}$	C_L = 80 pF, see Figure 1	t_{CAC}		135	ns
$t_{a(R)}$	Access time from $\overline{RAS}$	C_L = 80 pF, t_{RLCL} = MAX, see Figure 1	t_{RAC}		200	ns
$t_{dis(CH)}$	Output disable time after $\overline{CAS}$ high	C_L = 80 pF, see Figure 1	t_{OFF}	0	50	ns

timing requirements over recommended supply voltage range and recommended operating temperature range

PARAMETER		ALT. SYMBOL	SMJ4164-12		SMJ4164-15		UNIT
			MIN	MAX	MIN	MAX	
$t_{c(P)}$	Page-mode cycle time	t_{PC}	130		160		ns
$t_{c(rd)}$	Read cycle time†	t_{RC}	230		260		ns
$t_{c(W)}$	Write cycle time	t_{WC}	230		260		ns
$t_{c(rdW)}$	Read-write/read-modify-write cycle time	t_{RWC}	260		285		ns
$t_{w(CH)}$	Pulse duration, $\overline{CAS}$ high (precharge time)‡	t_{CP}	50		50		ns
$t_{w(CL)}$	Pulse duration, $\overline{CAS}$ low§	t_{CAS}	70	10,000	85	10,000	ns
$t_{w(RH)}$	Pulse duration, $\overline{RAS}$ high (precharge time)	t_{RP}	80		100		ns
$t_{w(RL)}$	Pulse duration, $\overline{RAS}$ low¶	t_{RAS}	120	10,000	150	10,000	ns
$t_{w(W)}$	Write pulse duration	t_{WP}	40		45		ns
$t_{su(CA)}$	Column-address setup time	t_{ASC}	−5		−5		ns
$t_{su(RA)}$	Row-address setup time	t_{ASR}	0		0		ns
$t_{su(D)}$	Data setup time	t_{DS}	0		0		ns
$t_{su(rd)}$	Read-command setup time	t_{RCS}	0		0		ns
$t_{su(WCH)}$	Write-command setup time before $\overline{CAS}$ high	t_{CWL}	50		50		ns
$t_{su(WRH)}$	Write-command setup time before $\overline{RAS}$ high	t_{RWL}	50		50		ns
$t_{h(CLCA)}$	Column-address hold time after $\overline{CAS}$ low	t_{CAH}	40		45		ns
$t_{h(RA)}$	Row-address hold time	t_{RAH}	15		20		ns
$t_{h(RLCA)}$	Column-address hold time after $\overline{RAS}$ low	t_{AR}	85		95		ns
$t_{h(CLD)}$	Data hold time after $\overline{CAS}$ low	t_{DHC}	40		45		ns
$t_{h(RLD)}$	Data hold time after $\overline{RAS}$ low	t_{DHR}	85		95		ns
$t_{h(WLD)}$	Data hold time after $\overline{W}$ low	t_{DHW}	40		45		ns
$t_{h(CHrd)}$	Read-command hold time after $\overline{CAS}$ high‖	t_{RCH}	0		0		ns
$t_{h(RHrd)}$	Read-command hold time after $\overline{RAS}$ high‖	t_{RRH}	5		5		ns
$t_{h(CLW)}$	Write-command hold time after $\overline{CAS}$ low	t_{WCH}	40		45		ns
$t_{h(RLW)}$	Write-command hold time after $\overline{RAS}$ low	t_{WCR}	85		95		ns
t_{RLCH}	Delay time, $\overline{RAS}$ low to $\overline{CAS}$ high	t_{CSH}	120		150		ns
t_{CHRL}	Delay time, $\overline{CAS}$ high to $\overline{RAS}$ low	t_{CRP}	0		0		ns
t_{CLRH}	Delay time, $\overline{CAS}$ low to $\overline{RAS}$ high	t_{RSH}	70		85		ns

Continued next page.

NOTE 4: Timing measurements are made at the 10% and 90% points of input and clock transitions. In addition, V_{IL} max and V_{IH} min must be met at the 10% and 90% points.

† All cycle times assume t_t = 5 ns. The recommended rise and fall times for the $\overline{CAS}$ and $\overline{RAS}$ inputs are a minimum of 3 ns and a maximum of 50 ns.

‡ Page-mode only.

§ In a read-modify-write cycle, t_{CLWL} and $t_{su(WCH)}$ must be observed. Depending on the user's transition times, this may require additional $\overline{CAS}$ low time ($t_{w(CL)}$). This applies to page-mode read-modify-write also.

¶ In a read-modify-write cycle, t_{RLWL} and $t_{su(WRH)}$ must be observed. Depending on the user's transition times, this may require additional $\overline{RAS}$ low time ($t_{w(RL)}$).

‖ These parameters are guaranteed but not tested.

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timing requirements over recommended supply voltage range and recommended operating temperature range (continued)

PARAMETER		ALT. SYMBOL	SMJ4164-12		SMJ4164-15		UNIT
			MIN	MAX	MIN	MAX	
t_{CLWL}	Delay time, $\overline{CAS}$ low to $\overline{W}$ low (read-modify-write cycle only)	t_{CWD}	40		60		ns
t_{RLCL}	Delay time, $\overline{RAS}$ low to $\overline{CAS}$ low (maximum value specified only to guarantee access time)	t_{RCD}	15	45	20	50	ns
t_{RLWL}	Delay time, $\overline{RAS}$ low to $\overline{W}$ low (read-modify-write cycle only)	t_{RWD}	85		100		ns
t_{WLCL}	Delay time, $\overline{W}$ low to $\overline{CAS}$ low (early write cycle)	t_{WCS}	−5		−5		ns
t_{rf}	Refresh time interval	t_{REF}		4		4	ms

timing requirements over recommended supply voltage range and recommended operating temperature range (continued)

PARAMETER		ALT. SYMBOL	SMJ4164-20		UNIT
			MIN	MAX	
$t_{c(P)}$	Page-mode cycle time	t_{PC}	225		ns
$t_{c(rd)}$	Read cycle time†	t_{RC}	330		ns
$t_{c(W)}$	Write cycle time	t_{WC}	330		ns
$t_{c(rdW)}$	Read-write/read-modify-write cycle time	t_{RWC}	345		ns
$t_{w(CH)}$	Pulse duration, $\overline{CAS}$ high (precharge time)‡	t_{CP}	80		ns
$t_{w(CL)}$	Pulse duration, $\overline{CAS}$ low§	t_{CAS}	135	10,000	ns
$t_{w(RH)}$	Pulse duration, $\overline{RAS}$ high (precharge time)	t_{RP}	120		ns
$t_{w(RL)}$	Pulse duration, $\overline{RAS}$ low¶	t_{RAS}	200	10,000	ns
$t_{w(W)}$	Write pulse duration	t_{WP}	55		ns
$t_{su(CA)}$	Column-address setup time	t_{ASC}	−5		ns
$t_{su(RA)}$	Row-address setup time	t_{ASR}	0		ns
$t_{su(D)}$	Data setup time	t_{DS}	0		ns
$t_{su(rd)}$	Read-command setup time	t_{RCS}	0		ns
$t_{su(WCH)}$	Write-command setup time before $\overline{CAS}$ high	t_{CWL}	80		ns
$t_{su(WRH)}$	Write-command setup time before $\overline{RAS}$ high	t_{RWL}	80		ns
$t_{h(CLCA)}$	Column-address hold time after $\overline{CAS}$ low	t_{CAH}	55		ns
$t_{h(RA)}$	Row-address hold time	t_{RAH}	25		ns
$t_{h(RLCA)}$	Column-address hold time after $\overline{RAS}$ low	t_{AR}	140		ns
$t_{h(CLD)}$	Data hold time after $\overline{CAS}$ low	t_{DHC}	80		ns
$t_{h(RLD)}$	Data hold time after $\overline{RAS}$ low	t_{DHR}	145		ns

Continued next page.

NOTE 4: Timing measurements are made at the 10% and 90% points of input and clock transitions. In addition, V_{IL} max and V_{IH} min must be met at the 10% and 90% points.

†All cycle times assume t_t = 5 ns. The recommended rise and fall times for the $\overline{CAS}$ and $\overline{RAS}$ inputs are a minimum of 3 ns and a maximum of 50 ns.

‡Page-mode only.

§In a read-modify-write cycle, t_{CLWL} and $t_{su(WCH)}$ must be observed. Depending on the user's transition times, this may require additional $\overline{CAS}$ low time ($t_{w(CL)}$). This applies to page-mode read-modify-write also.

¶In a read-modify-write cycle, t_{RLWL} and $t_{su(WRH)}$ must be observed. Depending on the user's transition times, this may require additional $\overline{RAS}$ low time ($t_{w(RL)}$).

timing requirements over recommended supply voltage range and recommended operating temperature range (concluded)

PARAMETERS		ALT. SYMBOL	SMJ4164-20		UNIT
			MIN	MAX	
$t_{h(WLD)}$	Data hold time after $\overline{W}$ low	t_{DHW}	55		ns
$t_{h(CHrd)}$	Read-command hold time after $\overline{CAS}$ high‖	t_{RCH}	0		ns
$t_{h(RHrd)}$	Read-command hold time after $\overline{RAS}$ high‖	t_{RRH}	5		ns
$t_{h(CLW)}$	Write-command hold time after $\overline{CAS}$ low	t_{WCH}	80		ns
$t_{h(RLW)}$	Write-command hold time after $\overline{RAS}$ low	t_{WCR}	145		ns
t_{RLCH}	Delay time, $\overline{RAS}$ low to $\overline{CAS}$ high	t_{CSH}	200		ns
t_{CHRL}	Delay time, $\overline{CAS}$ high to $\overline{RAS}$ low	t_{CRP}	0		ns
t_{CLRH}	Delay time, $\overline{CAS}$ low to $\overline{RAS}$ high	t_{RSH}	135		ns
t_{CLWL}	Delay time, $\overline{CAS}$ low to $\overline{W}$ low (read-modify-write cycle only)	t_{CWD}	65		ns
t_{RLCL}	Delay time, $\overline{RAS}$ low to $\overline{CAS}$ low (maximum value specified only to guarantee access time)	t_{RCD}	25	65	ns
t_{RLWL}	Delay time, $\overline{RAS}$ low to $\overline{W}$ low (read-modify-write cycle only)	t_{RWD}	130		ns
t_{WLCL}	Delay time, $\overline{W}$ low to $\overline{CAS}$ low (early write cycle)	t_{WCS}	−5		ns
t_{rf}	Refresh time interval	t_{REF}		4	ms

‖These parameters are guaranteed but not tested.

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PARAMETER MEASUREMENT INFORMATION

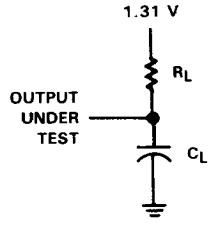
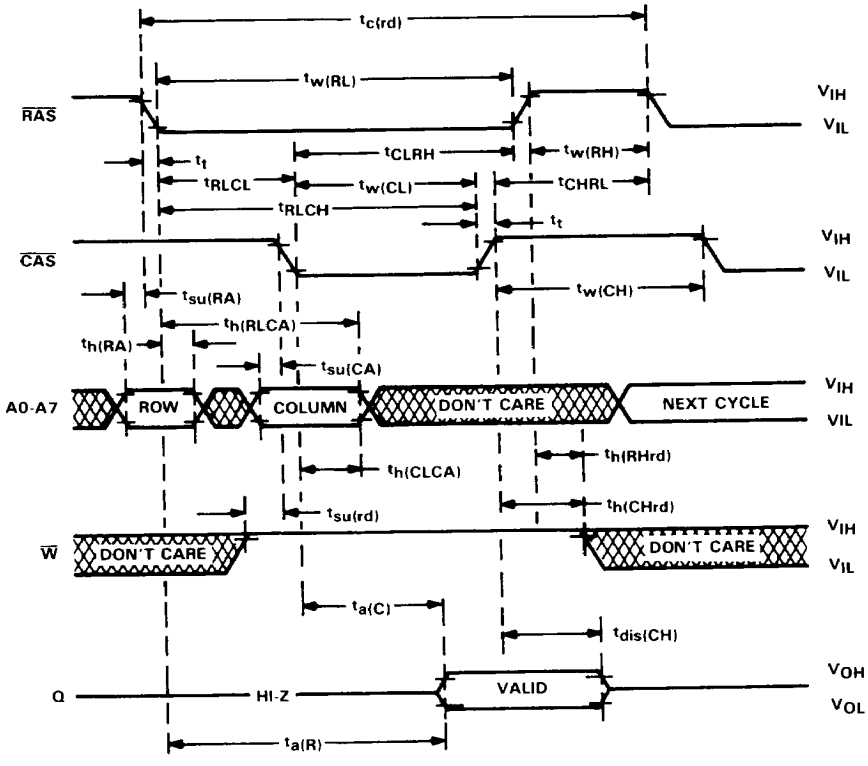
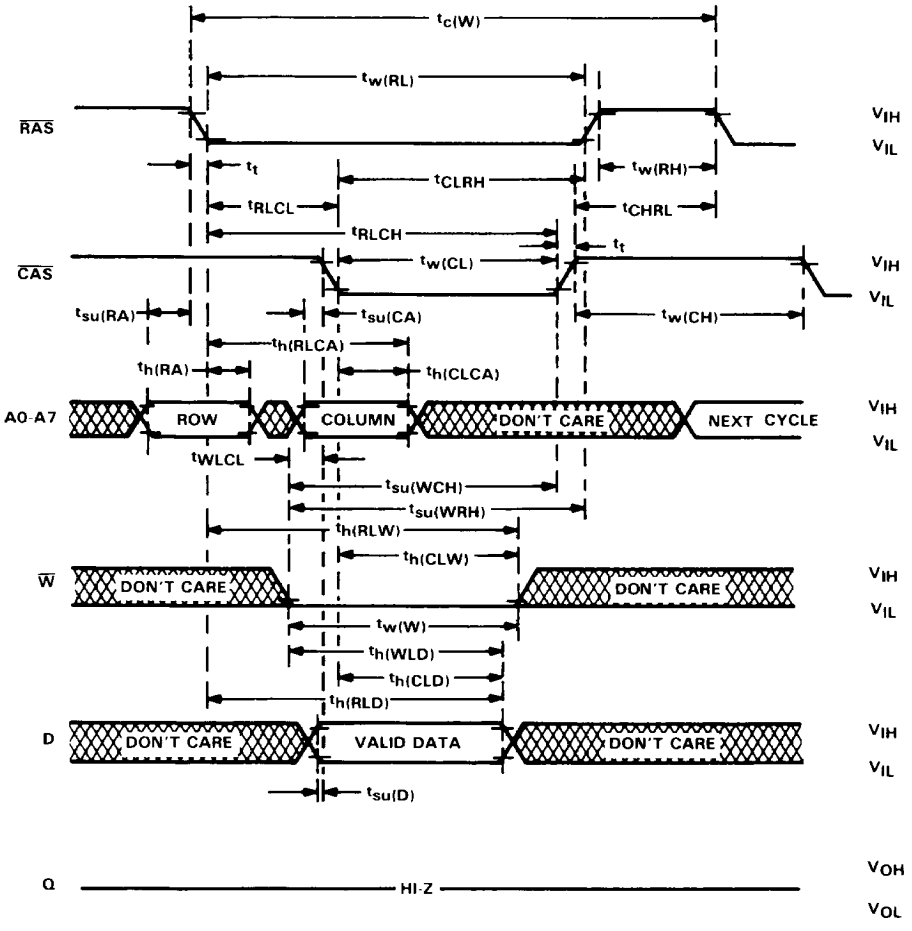


FIGURE 1. LOAD CIRCUIT

read cycle timing



early write cycle timing



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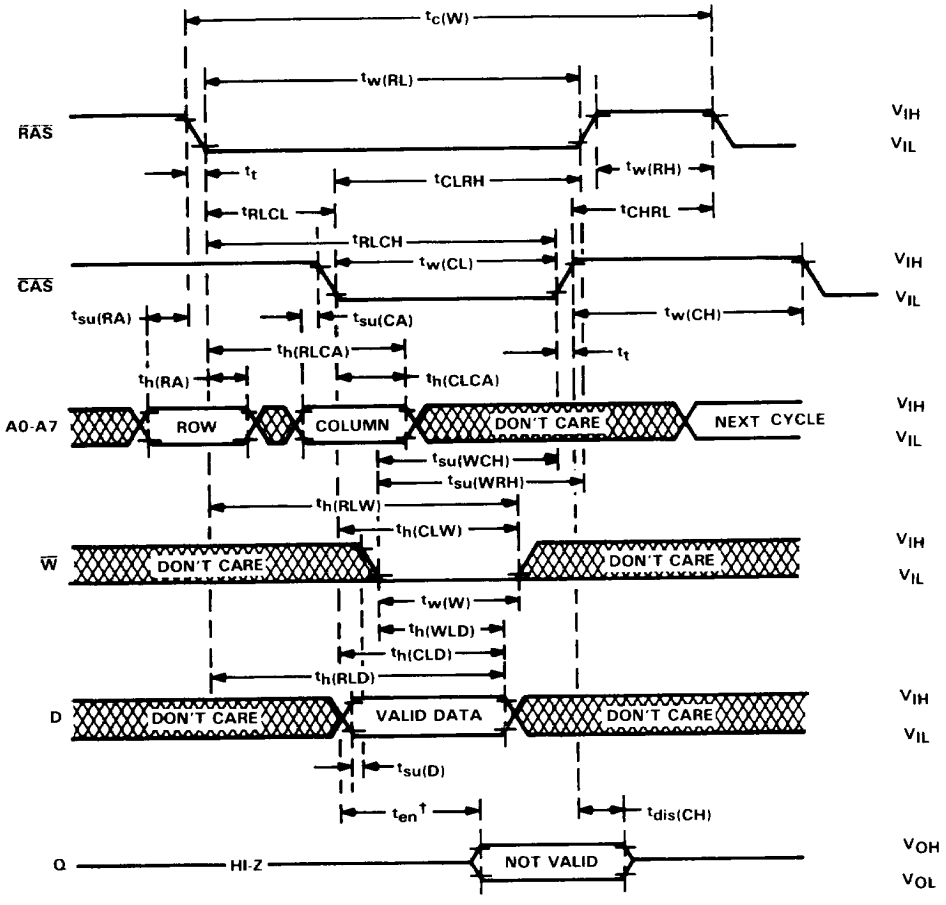
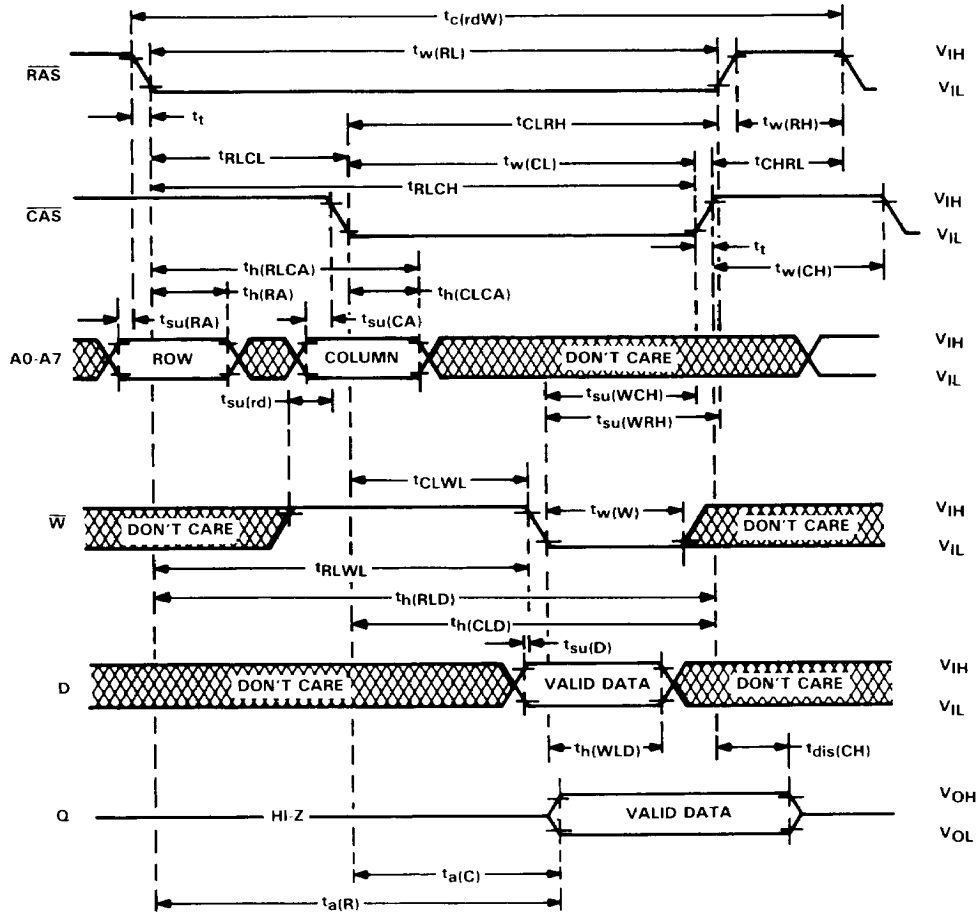
write cycle timing



read-write/read-modify-write cycle timing



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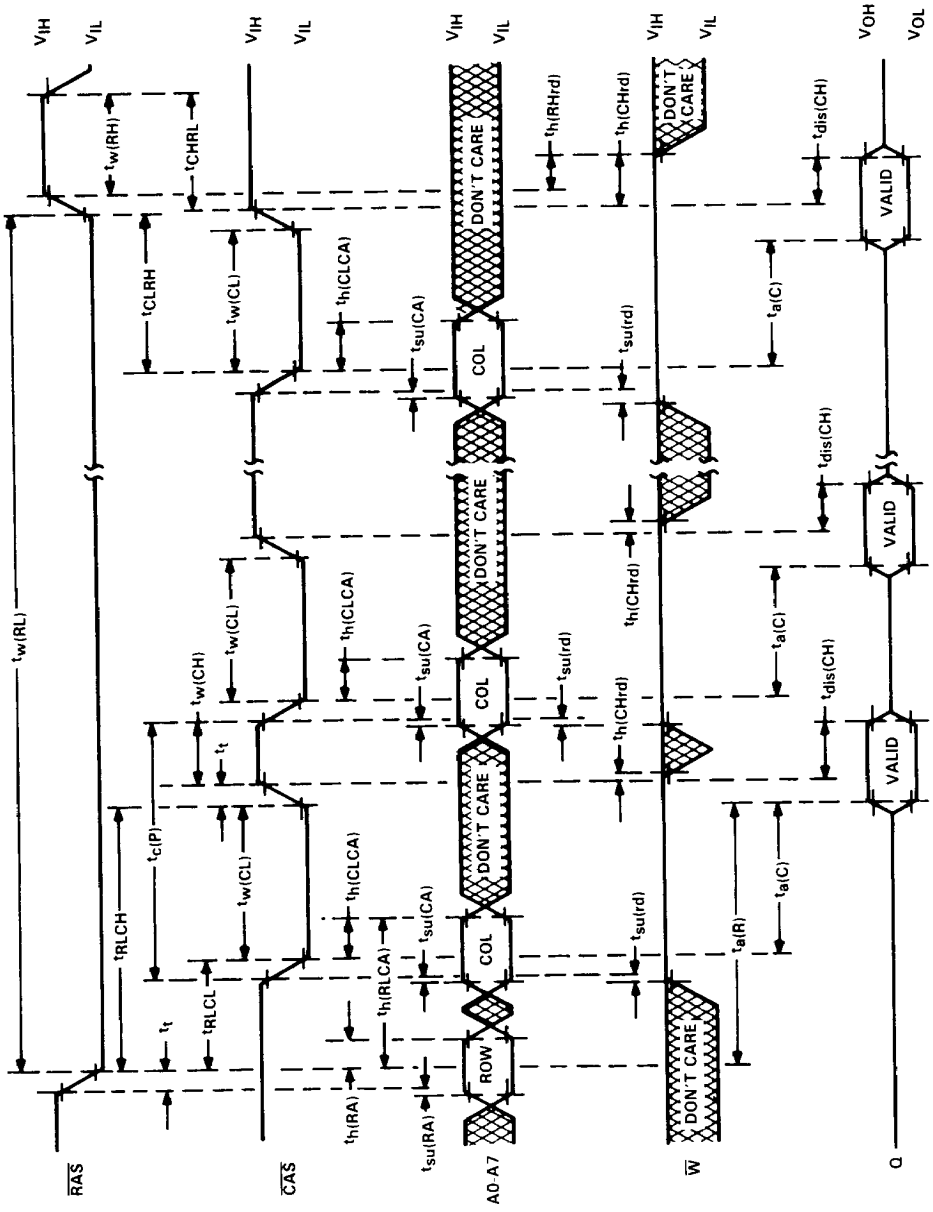
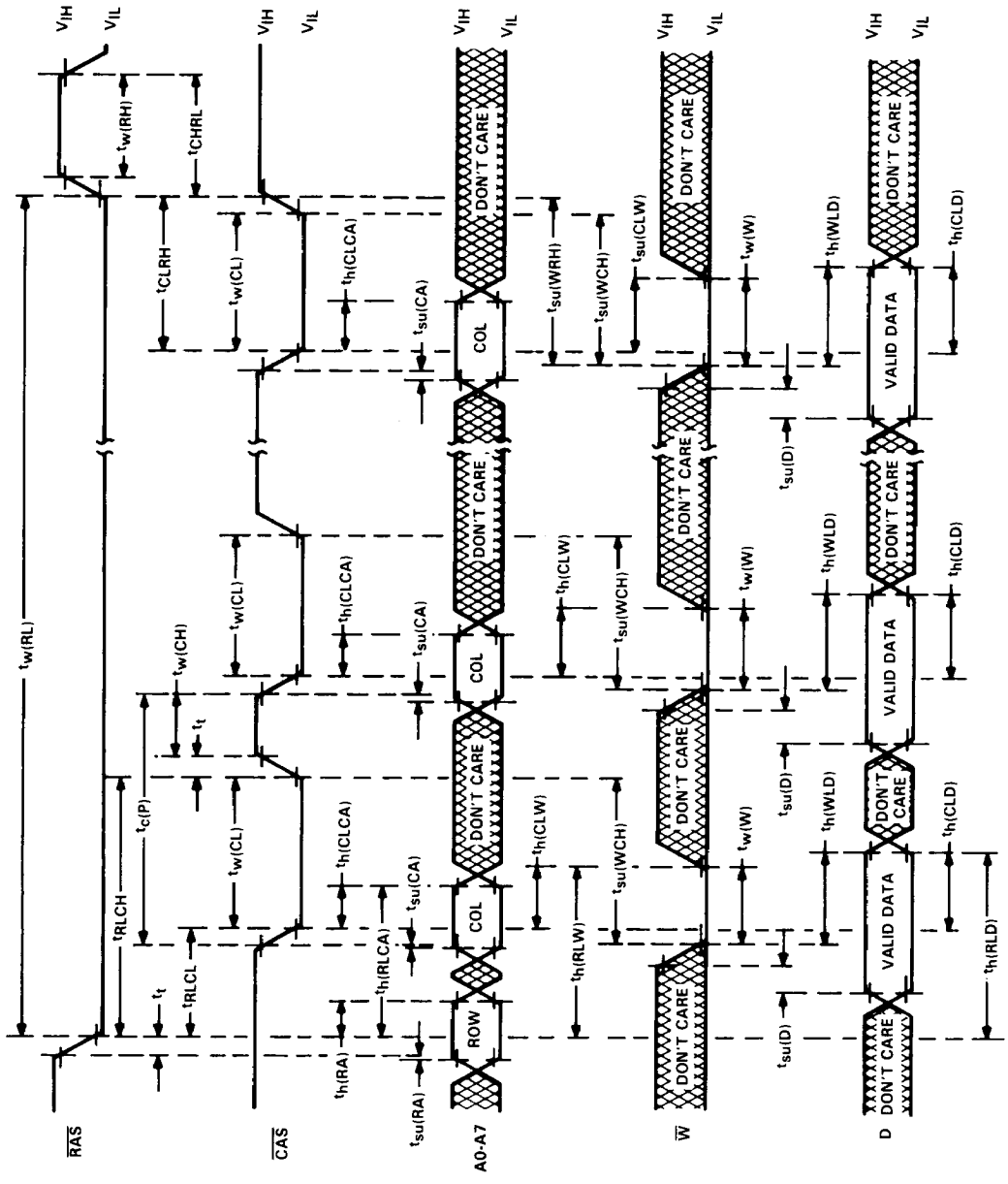
page-mode read cycle timing



NOTE 5: A write cycle or a read-modify-write cycle can be intermixed with read cycles as long as the write and read-modify-write timing specifications are not violated.

page-mode write cycle timing



NOTE 6: A read cycle or a read-modify-write cycle can be intermixed with write cycles as long as the read and read-modify-write timing specifications are not violated.

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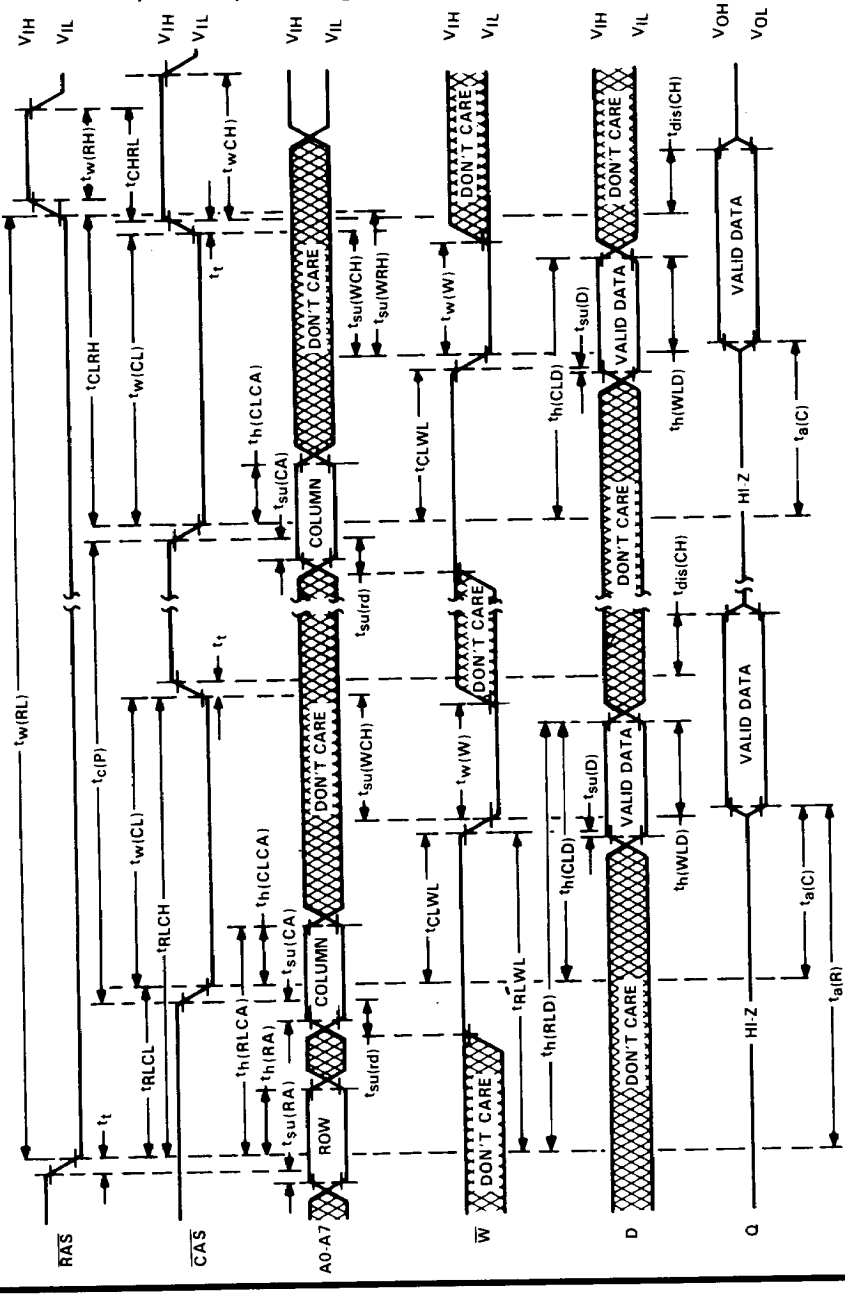
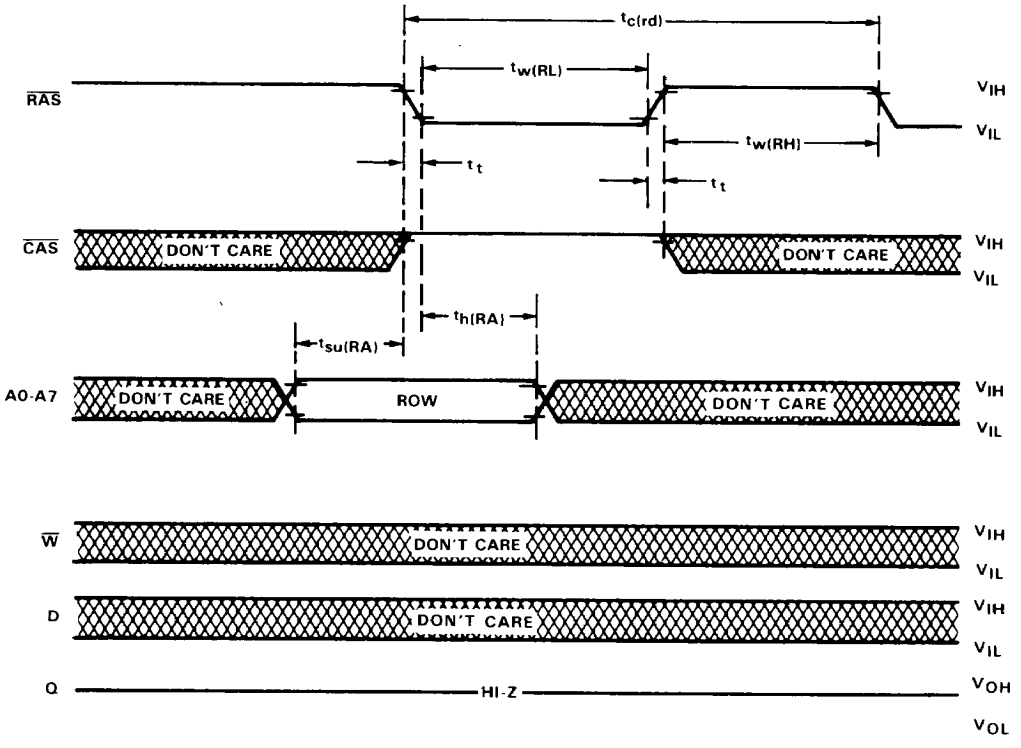
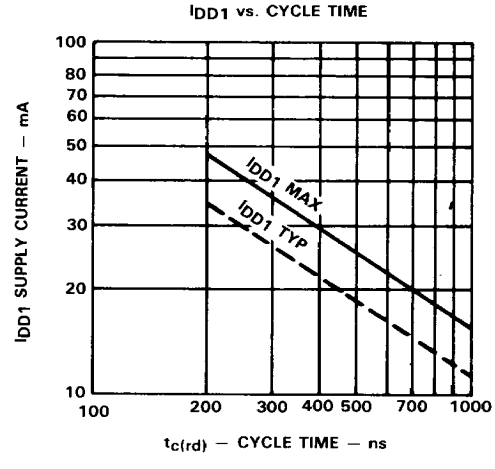
page-mode read-modify-write cycle timing

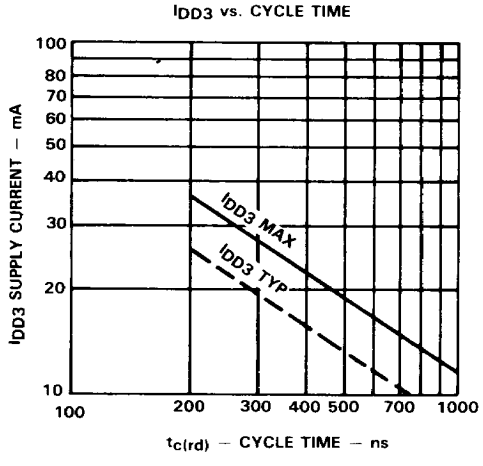


NOTE 7: A read or a write cycle can be intermixed with read-modify-write cycles as long as the read and the write timing specifications are not violated.

$\overline{\text{RAS}}$-only refresh timing







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