

**NN5116160A / NN5118160A series**  
**Fast Page Mode**  
**CMOS 1M × 16bit Dynamic RAM**



**DESCRIPTION**

**Preliminary Specification**

The NN5116160A/18160A series is a high performance CMOS Dynamic Random Access Memory organized as 1,048,576 words by 16 bits. The NN5116160A/18160A series is fabricated with advanced CMOS technology and designed with innovative design techniques resulting in high speed, extremely low power and wide operating margins at both component and system levels.

The NN5116160A/18160A series features a high speed page mode operation in which a high speed read, write or read-write is performed on any column address along a row address.

An extremely short row address capture time and an asynchronous column address decoder relax the timing constraints associated with address multiplexing.

The outputs are tri-stated by  $\overline{\text{CAS}}$  which, in essence, acts as an output enable independent of  $\overline{\text{RAS}}$  with very fast  $\overline{\text{CAS}}$  to output access time.

Refresh is accomplished by performing  $\overline{\text{RAS}}$  only refresh cycles, hidden refresh cycles,  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  refresh cycles, or normal read or write cycles on the 4096 address combinations of A0 to A11 during a 64 ms period for NN5116160A and the 1024 address combinations of A0 to A9 during a 16 ms period for NN5118160A.

Multiplexed address inputs permit the NN5116160A/18160A series to be packaged in a standard 42-pin plastic SOJ, 50-pin plastic TSOP TYPE II. The package sizes provide high system bit densities. System level features include single power supply of 5V ±10% tolerance and direct interface with high performance TTL logic families.

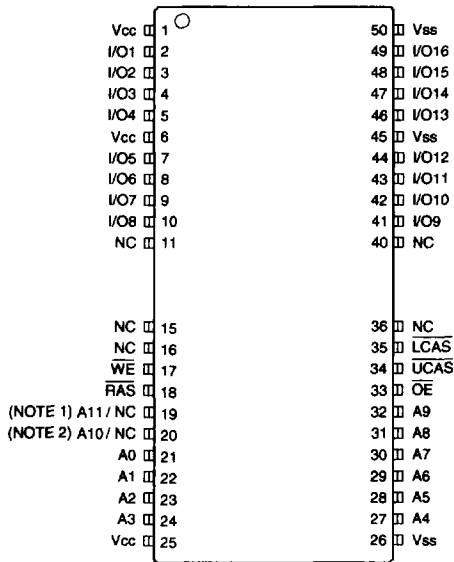
**FEATURES**

- 1,048,576 × 16 bit Organization
- Single 5V ±10% Power Supply
- Performance Ranges

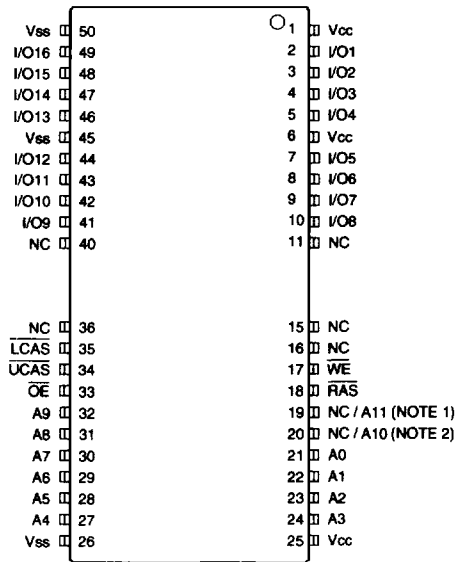
Parameter	-50	-60	-70
Max. $\overline{\text{RAS}}$ Access Time ( $t_{\text{RAC}}$ )	50ns	60ns	70ns
Max. $\overline{\text{CAS}}$ Access Time ( $t_{\text{CAC}}$ )	15ns	15ns	20ns
Max. Column Address Access Time ( $t_{\text{AA}}$ )	25ns	30ns	35ns
Max. Read/Write Cycle Time ( $t_{\text{RC}}$ )	90ns	110ns	130ns

- Fast Page Mode Operation
- Separate  $\overline{\text{CAS}}$  (UCAS, LCAS) for Byte Selection
- Byte Read/Write Mode Operation
- Low Power Operation
  - Low Standby Current (CMOS level input)
    - Standard 1mA
    - L version 150µA
- 4096 Refresh Cycles (NN5116160A)
  - Standard 64ms
  - L version 128ms
- 1024 Refresh Cycles (NN5118160A)
  - Standard 16ms
  - L version 128ms
- Self Refresh Mode (L version)
- All inputs/Outputs and Clocks fully TTL and CMOS compatible
- Refresh Modes
  - $\overline{\text{RAS}}$  only
  - $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$
  - Hidden Refresh
- High Reliability Package
  - Plastic 42pin SOJ (P42SJ-2B0)
  - Plastic 50pin TSOP TYPE II (P50TP-3B6)

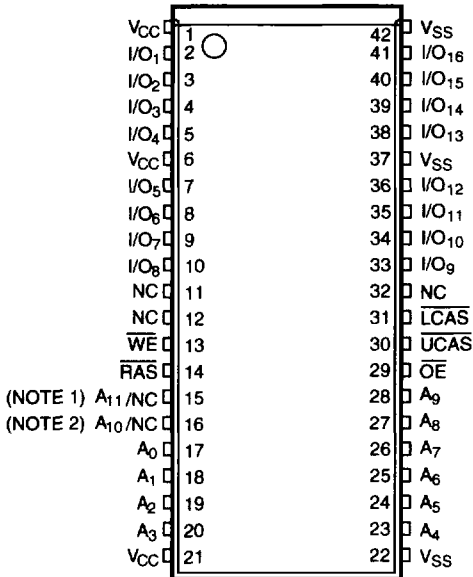
**PIN CONFIGURATION**



**50/44-pin TSOP TYPE ( II )**  
**Normal Bend (400mil)**  
**P50TP-3B6**



**50/44-pin TSOP TYPE ( II )**  
**Reverse Bend (400mil)**  
**P50TP-3B6-R**



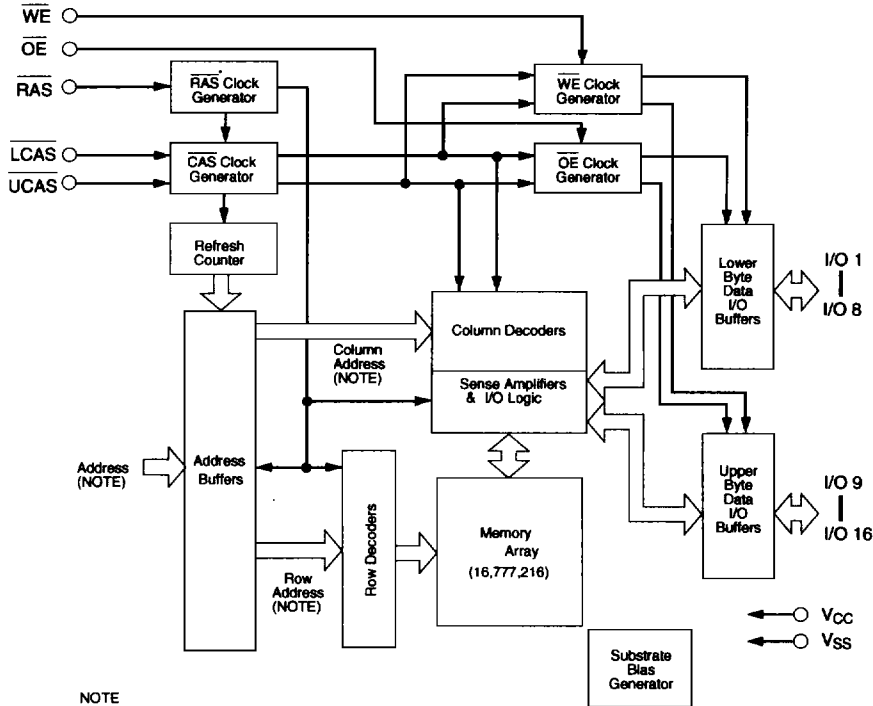
**42-pin SOJ (400mil)**  
**P42SJ-2B0**

	NN5116160A	NN5118160A
NOTE 1	A11	NC
NOTE 2	A10	NC

**PIN NAMES**

A0–A11	Address Inputs (NOTE 1,2)
RAS	Row Address Strobe
UCAS	Column Address Strobe Upper Byte Control
LCAS	Column Address Strobe Lower Byte Control
OE	Output Enable
I/O1–I/O16	Data-in / Data-out
WE	Write Enable
V <sub>CC</sub>	+5V Supply
V <sub>SS</sub>	Ground
NC	No Connection

**FUNCTIONAL BLOCK DIAGRAM**



NOTE

	Address / Row Address	Column Address
NN5116160A	A0 - A11	A0 - A7
NN5118160A	A0 - A9	A0 - A9

**ABSOLUTE MAXIMUM RATINGS**

RATING	SYMBOL	VALUE	UNIT
Voltage on Any Pin Relative to $V_{SS}$	$V_{in}, V_{out}$	-1 to 7	V
Voltage on $V_{CC}$ Relative to $V_{SS}$	$V_{CC}$	-1 to 7	V
Storage Temperature (Plastic)	$T_{stg}$	-55 to +125	°C
Power Dissipation	$P_d$	1.0	W
Ambient Operating Temperature	$T_a$	0 to +70	°C
Short Circuit Output Current	$I_{out}$	50	mA

Permanent device damage can occur if absolute maximum ratings are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods can affect device reliability.

**DC OPERATING CONDITIONS**

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
$V_{CC}$	Supply Voltage	4.5	5.0	5.5	V
$V_{SS}$	Supply Voltage	0	0	0	V
$V_{IH}$	Input High Voltage, All Inputs	2.4	—	6.5	V
$V_{IL}$	Input Low Voltage, All Inputs	-1.0	—	0.8	V

Note: All voltage values in this data sheet are with respect to  $V_{SS}$  unless otherwise specified.

**TRUTH TABLE**

INPUTS					I/O		OPERATION	NOTES
RAS	LCAS	UCAS	WE	OE	I/O1~I/O8	I/O9~I/O16		
H	H	H	H	H	High-Z	High-Z	Standby	1,3
L	H	H	H	H	High-Z	High-Z	Refresh	1,3
L	L	H	H	L	Dout	High-Z	Lower byte read	1,3
L	H	L	H	L	High-Z	Dout	Upper byte read	1,3
L	L	L	H	L	Dout	Dout	Word read	1,3
L	L	H	L	H	Din	Don't care	Lower byte write	1,2,3
L	H	L	L	H	Don't care	Din	Upper byte write	1,2,3
L	L	L	L	H	Din	Din	Word write	1,2,3
L	L	L	H	H	High-Z	High-Z		1,3
H→L	L	H	—	—	High-Z	High-Z	CBR refresh or Self refresh	1,3
H→L	H	L	—	—	High-Z	High-Z		
H→L	L	L	—	—	High-Z	High-Z		

Notes: 1. H:high (inactive) , L:low (active) , —:unconcerned with H or L.

2.  $t_{wCS} \geq 0ns$  : early write mode.

$t_{wCS} < 0ns$  :  $\overline{OE}$  controlled write mode.

3. Operation mode is set by the earliest of  $\overline{LCAS}$  and  $\overline{UCAS}$  active edge and reset by the latest of  $\overline{LCAS}$  and  $\overline{UCAS}$  inactive edge.

However write operation and High-Z control are done independently by each  $\overline{LCAS}$ ,  $\overline{UCAS}$ .

**DC ELECTRICAL CHARACTERISTICS (0°C ≤ Ta ≤ 70°C, V<sub>CC</sub> = 5.0V ±10%)**  
**(NN5116160A)**

SYMBOL	PARAMETER	SPEED	MIN.	MAX.	UNIT	TEST CONDITIONS	NOTES
I <sub>CC1</sub>	Operating Current	-50		120	mA	t <sub>RC</sub> = t <sub>RC</sub> (min.) RAS, CAS, Address cycling	1, 2
		-60		110	mA		
		-70		100	mA		
I <sub>CC2</sub>	Standby Current			1.0	mA	RAS = CAS ≥ (V <sub>CC</sub> - 0.2V)	
				2.0	mA	RAS = CAS ≥ V <sub>IH</sub>	
	Standby Current (L version)			150	µA	RAS = CAS ≥ (V <sub>CC</sub> - 0.2V) All other inputs are stable at (V <sub>CC</sub> - 0.2V) or (V <sub>SS</sub> + 0.2V)	
I <sub>CC3</sub>	Refresh Current (RAS only refresh)	-50		120	mA	t <sub>RC</sub> = t <sub>RC</sub> (min.) RAS cycling, CAS = V <sub>IH</sub>	1
		-60		110	mA		
		-70		100	mA		
I <sub>CC4</sub>	Fast Page Mode Current	-50		100	mA	t <sub>PC</sub> = t <sub>PC</sub> (min.) RAS = V <sub>IL</sub> CAS, Address cycling	1,2
		-60		90	mA		
		-70		80	mA		
I <sub>CC5</sub>	Refresh Current (CAS before RAS refresh)	-50		120	mA	t <sub>RC</sub> = t <sub>RC</sub> (min.) RAS, CAS cycling	1
		-60		110	mA		
		-70		100	mA		
I <sub>CC6</sub>	Refresh Current (L version : CAS before RAS refresh)			500	µA	4096 cycles / 128ms t <sub>RAS</sub> ≤ 200ns, WE ≥ (V <sub>CC</sub> - 0.2V) All other inputs are stable at (V <sub>CC</sub> - 0.2V) or (V <sub>SS</sub> + 0.2V)	
I <sub>CC7</sub>	Self Refresh Mode Current (L version)			300	µA	RAS = CAS ≤ (V <sub>SS</sub> + 0.2V) All other input high levels are (V <sub>CC</sub> - 0.2V) or input low levels are (V <sub>SS</sub> + 0.2V)	
I <sub>L1</sub>	Input Leakage Current (Any input pin)		-10	10	µA	0V ≤ V <sub>IH</sub> ≤ 5.5V, Others = 0V	
I <sub>L0</sub>	Output Leakage Current (For high impedance state)		-10	10	µA	RAS ≥ V <sub>IH</sub> (min.), CAS ≥ V <sub>IH</sub> (min.) 0V ≤ V <sub>OUT</sub> ≤ 5.5V	
V <sub>OH</sub>	Output High Voltage		2.4		V	I <sub>OH</sub> = -5.0 mA	
V <sub>OL</sub>	Output Low Voltage			0.4	V	I <sub>OL</sub> = 4.2 mA	

Notes: 1. I<sub>CC1</sub>, I<sub>CC3</sub>, I<sub>CC4</sub> and I<sub>CC5</sub> depend on cycle rate.

2. I<sub>CC1</sub> and I<sub>CC4</sub> depend on output loading. Specified values are obtained with the outputs open.

**CAPACITANCE (0°C ≤ Ta ≤ 70°C, V<sub>CC</sub> = 5.0V ±10%, f = 1MHz)**

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
C <sub>IN1</sub>	Address(A0 ~ A11)	—	5	pF
C <sub>IN2</sub>	RAS, LCAS, UCAS, WE, OE	—	5	pF
C <sub>OUT</sub>	I/O1 ~ I/O16	—	7	pF

**DC ELECTRICAL CHARACTERISTICS (0°C ≤ Ta ≤ 70°C, V<sub>CC</sub> = 5.0V ±10%)**

(NN5118160A)

SYMBOL	PARAMETER	SPEED	MIN.	MAX.	UNIT	TEST CONDITIONS	NOTES
I <sub>CC1</sub>	Operating Current	-50		190	mA	t <sub>RC</sub> = t <sub>RC</sub> (min.) RAS, CAS, Address cycling	1, 2
		-60		170	mA		
		-70		150	mA		
I <sub>CC2</sub>	Standby Current			1.0	mA	RAS = CAS ≥ (V <sub>CC</sub> - 0.2V)	
				2.0	mA	RAS = CAS ≥ V <sub>IH</sub>	
	Standby Current (L version)			250	μA	RAS = CAS ≥ (V <sub>CC</sub> - 0.2V) All other inputs are stable at (V <sub>CC</sub> - 0.2V) or (V <sub>SS</sub> + 0.2V)	
I <sub>CC3</sub>	Refresh Current (RAS only refresh)	-50		190	mA	t <sub>RC</sub> = t <sub>RC</sub> (min.) RAS cycling, CAS = V <sub>IH</sub>	1
		-60		170	mA		
		-70		150	mA		
I <sub>CC4</sub>	Fast Page Mode Current	-50		150	mA	t <sub>PC</sub> = t <sub>PC</sub> (min.) RAS = V <sub>IL</sub> CAS, Address cycling	1, 2
		-60		140	mA		
		-70		130	mA		
I <sub>CC5</sub>	Refresh Current (CAS before RAS refresh)	-50		170	mA	t <sub>RC</sub> = t <sub>RC</sub> (min.) RAS, CAS cycling	1
		-60		160	mA		
		-70		150	mA		
I <sub>CC6</sub>	Refresh Current (L version : CAS before RAS refresh)			500	μA	1024 cycles / 128ms t <sub>RAS</sub> ≤ 200ns, WE ≥ (V <sub>CC</sub> - 0.2V) All other inputs are stable at (V <sub>CC</sub> - 0.2V) or (V <sub>SS</sub> + 0.2V)	
I <sub>CC7</sub>	Self Refresh Mode Current (L version)			300	μA	RAS = CAS ≤ (V <sub>SS</sub> + 0.2V) All other input high levels are (V <sub>CC</sub> - 0.2V) or input low levels are (V <sub>SS</sub> + 0.2V)	
I <sub>L1</sub>	Input Leakage Current (Any input pin)		-10	10	μA	0V ≤ V <sub>IH</sub> ≤ 5.5V, Others = 0V	
I <sub>L0</sub>	Output Leakage Current (For high impedance state)		-10	10	μA	RAS ≥ V <sub>IH</sub> (min.), CAS ≥ V <sub>IH</sub> (min.) 0V ≤ V <sub>OUT</sub> ≤ 5.5V	
V <sub>OH</sub>	Output High Voltage		2.4		V	I <sub>OH</sub> = -5.0 mA	
V <sub>OL</sub>	Output Low Voltage			0.4	V	I <sub>OL</sub> = 4.2 mA	

Notes: 1. I<sub>CC1</sub>, I<sub>CC3</sub>, I<sub>CC4</sub> and I<sub>CC5</sub> depend on cycle rate.

2. I<sub>CC1</sub> and I<sub>CC4</sub> depend on output loading. Specified values are obtained with the outputs open.

**CAPACITANCE (0°C ≤ Ta ≤ 70°C, V<sub>CC</sub> = 5.0V ±10%, f = 1MHz)**

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
C <sub>IN1</sub>	Address(A0 ~ A9)	—	5	pF
C <sub>IN2</sub>	RAS, LCAS, UCAS, WE, OE	—	5	pF
C <sub>OUT</sub>	I/O1 ~ I/O16	—	7	pF

**A.C. OPERATING CONDITIONS ( 0 °C ≤ T<sub>a</sub> ≤ 70 °C, V<sub>CC</sub> = 5 V ± 10%, V<sub>SS</sub> = 0 V) (NOTES 3, 4, 5)**

NO.	SYMBOL		PARAMETER	-50		-60		-70		UNIT	NOTE
	JEDEC	STD		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
1	t <sub>CL1QV</sub>	t <sub>CAC</sub>	Access Time from CAS	—	15	—	15	—	20	ns	6,13
2	t <sub>CH2QV</sub>	t <sub>CPA</sub>	Access Time from CAS Precharge	—	30	—	35	—	40	ns	13,14
3	t <sub>AVQV</sub>	t <sub>AA</sub>	Access Time from Column Address	—	25	—	30	—	35	ns	7,13
4	t <sub>RL1QV</sub>	t <sub>RAC</sub>	Access Time from RAS	—	50	—	60	—	70	ns	6,7
5	t <sub>RL1CH1</sub>	t <sub>CSH</sub>	CAS Hold Time	50	—	60	—	70	—	ns	
6	t <sub>RL1CH1</sub>	t <sub>CHR</sub>	CAS Hold Time (CAS before RAS Refresh)	10	—	10	—	10	—	ns	
7	t <sub>RL1CX</sub>	t <sub>CHS</sub>	CAS Precharge Time (Self Refresh Mode)	-50	—	-50	—	-50	—	ns	
8	t <sub>CH2CL2</sub>	t <sub>CPN</sub>	CAS Precharge Time (CAS before RAS Refresh)	10	—	10	—	10	—	ns	
9	t <sub>CH2CL2</sub>	t <sub>CP</sub>	CAS Precharge Time (Fast Page Mode)	5	—	5	—	5	—	ns	14
10	t <sub>CL1CH1</sub>	t <sub>CAS</sub>	CAS Pulse Width	15	100K	15	100K	20	100K	ns	
11	t <sub>CL1RL2</sub>	t <sub>CSR</sub>	CAS Setup Time (CAS before RAS Refresh)	5	—	5	—	5	—	ns	
12	t <sub>CL1QX</sub>	t <sub>CLZ</sub>	CAS to Output in Low-Z	0	—	0	—	0	—	ns	8
13	t <sub>CH2RL2</sub>	t <sub>CRP</sub>	CAS to RAS Precharge Time	5	—	5	—	5	—	ns	
14	t <sub>CL1WL2</sub>	t <sub>CWD</sub>	CAS to WE Delay Time	45	—	45	—	50	—	ns	11
15	t <sub>CL1AX</sub>	t <sub>CAH</sub>	Column Address Hold Time	10	—	15	—	15	—	ns	
16	t <sub>RL1AX</sub>	t <sub>AR</sub>	Column Address Hold Time Referenced to RAS	35	—	40	—	40	—	ns	
17	t <sub>AVCL2</sub>	t <sub>ASC</sub>	Column Address Setup Time	0	—	0	—	0	—	ns	14
18	t <sub>AVRH1</sub>	t <sub>RAL</sub>	Column Address to RAS Lead Time	25	—	30	—	35	—	ns	
19	t <sub>AVWL2</sub>	t <sub>AWD</sub>	Column Address to WE Delay Time	57	—	60	—	65	—	ns	11
20	t <sub>CL1DX</sub> t <sub>WL1DX</sub>	t <sub>DH</sub>	Data Hold Time	10	—	10	—	15	—	ns	12
21	t <sub>DVCL2</sub> t <sub>DVWL2</sub>	t <sub>DS</sub>	Data Setup Time	0	—	0	—	0	—	ns	12
22	t <sub>OL1QV</sub>	t <sub>OE</sub>	OE Access Time	—	15	—	15	—	20	ns	
23	t <sub>WL1OL2</sub>	t <sub>OEH</sub>	OE Command Hold Time	15	—	15	—	20	—	ns	
24	t <sub>CH2QV</sub>	t <sub>OED</sub>	OE to Data Delay Time	15	—	15	—	20	—	ns	
25	t <sub>CH2QZ</sub>	t <sub>OFF</sub>	Output Buffer Turn-off Delay Time	0	13	0	15	0	20	ns	10
26	t <sub>OH2QX</sub>	t <sub>OEZ</sub>	Output Buffer Turn-off Delay Time Referenced to OE	0	15	0	15	0	20	ns	
27	t <sub>CL1RH1</sub>	t <sub>RSH</sub>	RAS Hold Time	15	—	15	—	20	—	ns	
28	t <sub>OL1RH1</sub>	t <sub>ROH</sub>	RAS Hold Time Referenced to OE	10	—	10	—	10	—	ns	
29	t <sub>RH2RL2</sub>	t <sub>RP</sub>	RAS Precharge Time	25	—	30	—	40	—	ns	
30	t <sub>RH2RL2</sub>	t <sub>RPS</sub>	RAS Precharge Time (Self Refresh Mode)	90	—	110	—	130	—	ns	
31	t <sub>RL1RH1</sub>	t <sub>RAS</sub>	RAS Pulse Width	50	100K	60	100K	70	100K	ns	
32	t <sub>RL1RH1</sub>	t <sub>RASP</sub>	RAS Pulse Width (Fast Page Mode)	50	100K	60	100K	70	100K	ns	
33	t <sub>RL1RH1</sub>	t <sub>RASS</sub>	RAS Pulse Width (Self Refresh Mode)	300	—	300	—	300	—	μs	
34	t <sub>RL1CL1</sub>	t <sub>RCD</sub>	RAS to CAS Delay Time	13	35	13	45	13	50	ns	6
35	t <sub>RH2CL2</sub>	t <sub>RPC</sub>	RAS to CAS Precharge Time	0	—	0	—	0	—	ns	
36	t <sub>RL1AV</sub>	t <sub>RAD</sub>	RAS to Column Address Delay Time	11	23	11	30	11	35	ns	7
37	t <sub>RL1WL2</sub>	t <sub>RWD</sub>	RAS to WE Delay Time	80	—	90	—	100	—	ns	11
38	t <sub>CH2WL2</sub>	t <sub>RCH</sub>	Read Command Hold Time	0	—	0	—	0	—	ns	9
39	t <sub>RH2WL2</sub>	t <sub>RRH</sub>	Read Command Hold Time Referenced to RAS	0	—	0	—	0	—	ns	9

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**CMOS 1M × 16bit Dynamic RAM**

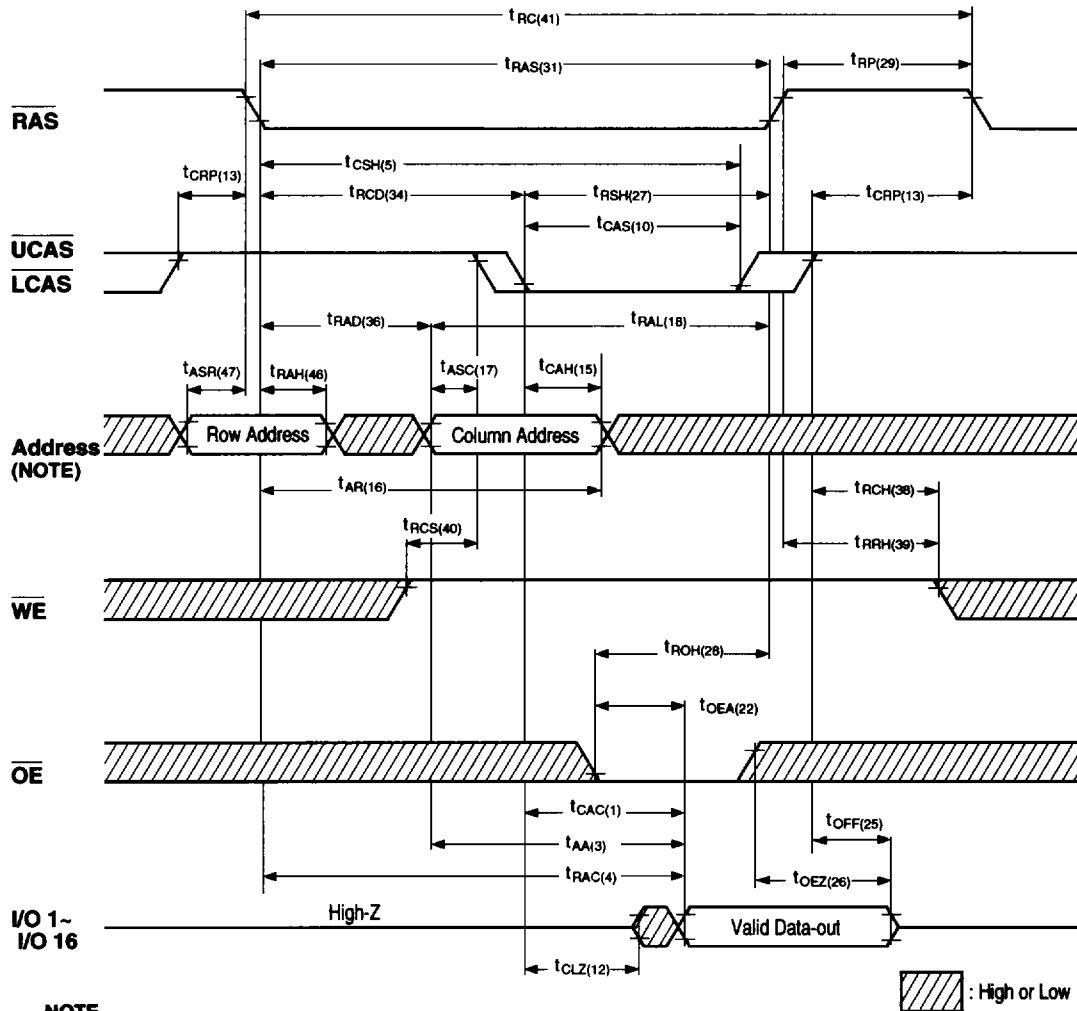
NO.	SYMBOL		PARAMETER	-50		-60		-70		UNIT	NOTE
	JEDEC	STD		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.		
40	$t_{WH2CL2}$	$t_{RCS}$	Read Command Setup Time	0	—	0	—	0	—	ns	
41	$t_{RL2RL2}$	$t_{RC}$	Random Read or Write Cycle Time	90	—	110	—	130	—	ns	
42	$t_{CL2CL2}$	$t_{PC}$	Read or Write Cycle Time (Fast Page Mode)	33	—	40	—	45	—	ns	13,14
43	$t_{RL2RL2}$	$t_{RMW}$	Read-Modify-Write Cycle Time	145	—	165	—	185	—	ns	
44	$t_{CL2CL2}$	$t_{PRMW}$	Read-Modify-Write Cycle Time (Fast Page Mode)	80	—	85	—	95	—	ns	13,14
45	$t_{REF}$	$t_{REF}$	Refresh Period	—	64	—	64	—	64	ms	15
				—	16	—	16	—	16		
46	$t_{RL1AX}$	$t_{RAH}$	Row Address Hold Time	8	—	8	—	8	—	ns	
47	$t_{AVRL2}$	$t_{ASR}$	Row Address Setup Time	0	—	0	—	0	—	ns	
48	$t_T$	$t_T$	Transition Time (Rise and Fall)	2	50	2	50	2	50	ns	4,5
49	$t_{CL1WH1}$	$t_{WCH}$	Write Command Hold Time	10	—	10	—	15	—	ns	
50	$t_{WL1WH1}$	$t_{WP}$	Write Command Pulse Width	10	—	10	—	15	—	ns	
51	$t_{WL1CL2}$	$t_{WCS}$	Write Command Setup Time	0	—	0	—	0	—	ns	11
52	$t_{WL1CH1}$	$t_{CWL}$	Write Command to $\overline{CAS}$ Lead Time	15	—	15	—	20	—	ns	
53	$t_{WL1RH1}$	$t_{RWL}$	Write Command to $\overline{RAS}$ Lead Time	15	—	15	—	20	—	ns	

**Notes:**

- Eight Initialization Cycles are required following a 200 $\mu$ s pause after Power Up. These Initialization Cycles may consist of any combination of the following :  $\overline{RAS}$  only refresh Cycles, Read Cycles, Write Cycles,  $\overline{CAS}$  before  $\overline{RAS}$  refresh Cycles.
- AC measurements assume  $t_T=3$ ns. All AC parameters are measured with  $V_{IL}(\text{min.}) \geq V_{SS}$  and  $V_{IH}(\text{max.}) \leq V_{CC}$  and with a load equivalent to two TTL loads and 100pF.
- $V_{IH}(\text{min.})$  and  $V_{IL}(\text{max.})$  are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{IH}$  and  $V_{IL}$ .
- Operation within the  $t_{RCD}(\text{max.})$  limit ensures that  $t_{RAC}(\text{max.})$  can be met.  $t_{RCD}(\text{max.})$  is specified as a reference point only. If  $t_{RCD}$  is greater than the specified  $t_{RCD}(\text{max.})$  limit, then access time is controlled by  $t_{CAC}$ .
- Operation within the  $t_{RAD}(\text{max.})$  limit ensures that  $t_{RAC}(\text{max.})$  can be met.  $t_{RAD}(\text{max.})$  is specified as a reference point only. If  $t_{RAD}$  is greater than the specified  $t_{RAD}(\text{max.})$  limit, then access time is controlled by  $t_{AA}$ .
- Assumes three state test load (5pF and a 220 ohm to 1.3V Thevenin equivalent).
- Either  $t_{RCH}$  or  $t_{RRH}$  must be satisfied for a read cycle.
- $t_{OFF}(\text{max.})$  defines the time at which the output achieves an open circuit condition and is not referenced to output voltage levels.
- $t_{WCS}$ ,  $t_{RWD}$ ,  $t_{CWD}$  and  $t_{AWD}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If  $t_{WCS} \geq t_{WCS}(\text{min.})$ , the cycle is an early write cycle and data-out pins will remain open circuit (high impedance) throughout the entire cycle. If  $t_{RWD} \geq t_{RWD}(\text{min.})$ ,  $t_{CWD} \geq t_{CWD}(\text{min.})$  and  $t_{AWD} \geq t_{AWD}(\text{min.})$ , the cycle is a read-modify-write cycle and the data-out will contain data read from the selected cell. If neither of the above conditions is satisfied, the condition of the data-out (at access time) is indeterminate.
- These parameters are referenced to  $\overline{CAS}$  leading edge in early write cycles and to  $\overline{WE}$  leading edge in read-modify-write cycles.
- Access time is determined by the longer of  $t_{AA}$ ,  $t_{CAC}$ , or  $t_{CPA}$ .
- $t_{ASC} \geq t_{CP}$  to achieve  $t_{PC}(\text{min.})$  and  $t_{CPA}(\text{max.})$  values.
- $t_{REF}=128$ msec for Long Refresh version (L version).



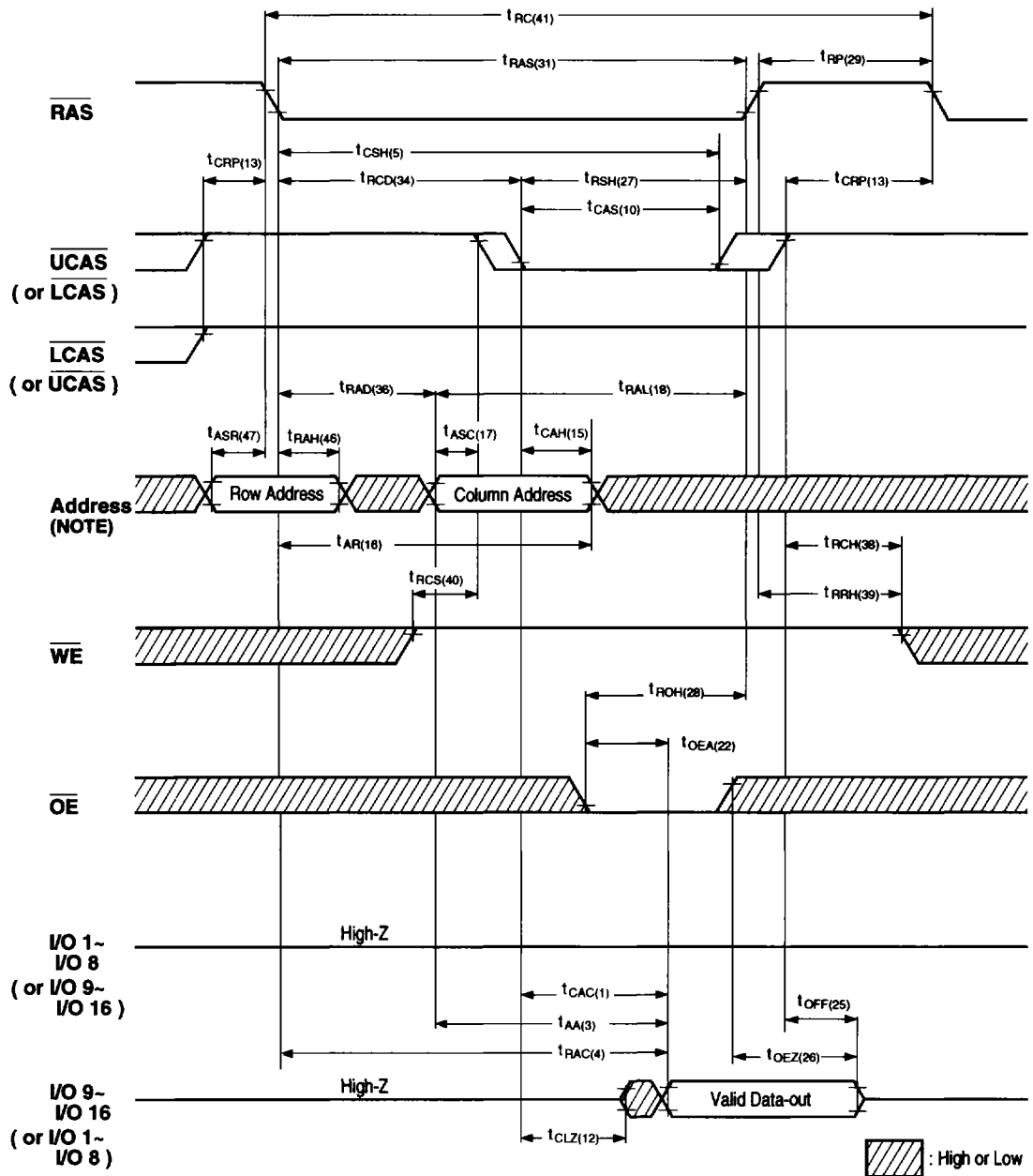
WORD READ CYCLE



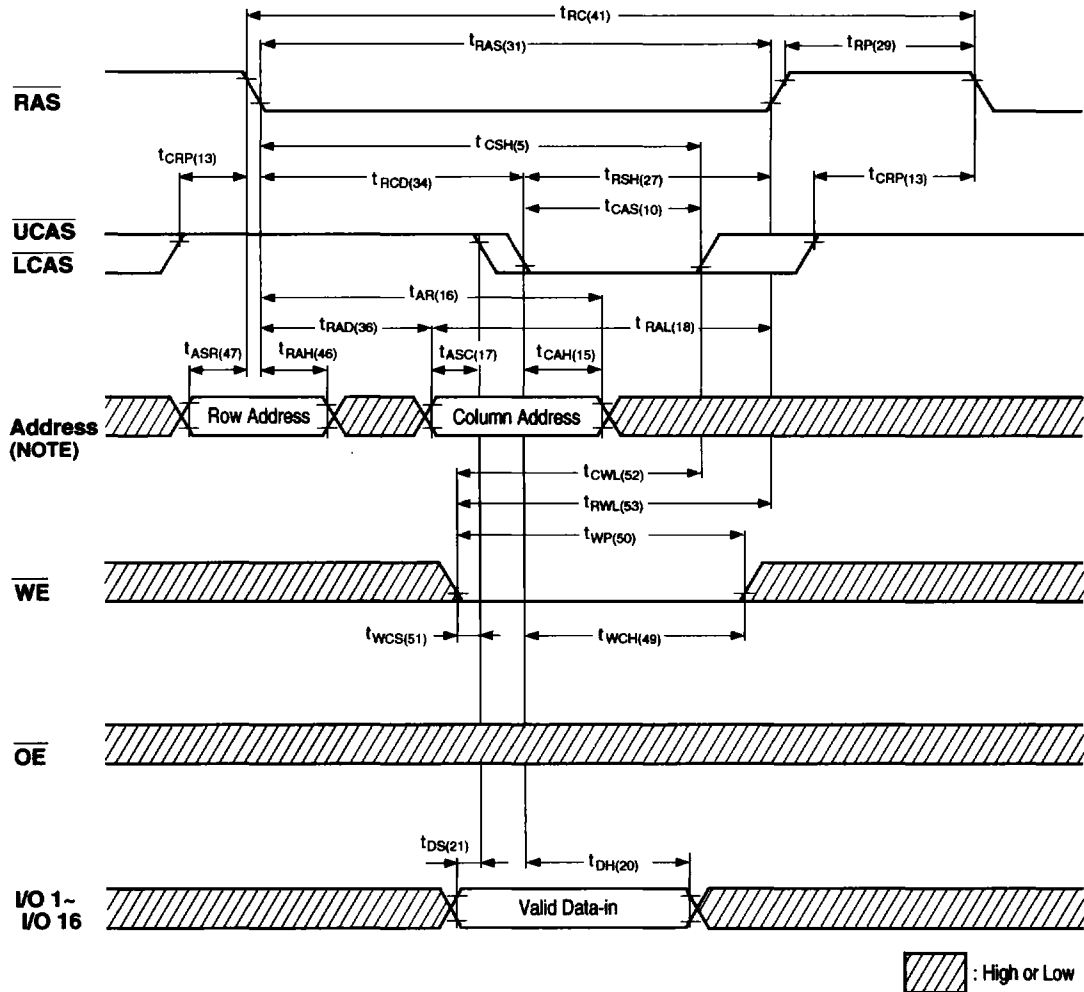
NOTE

Address A0 - A11: NN5116160A  
A0 - A9: NN5118160A

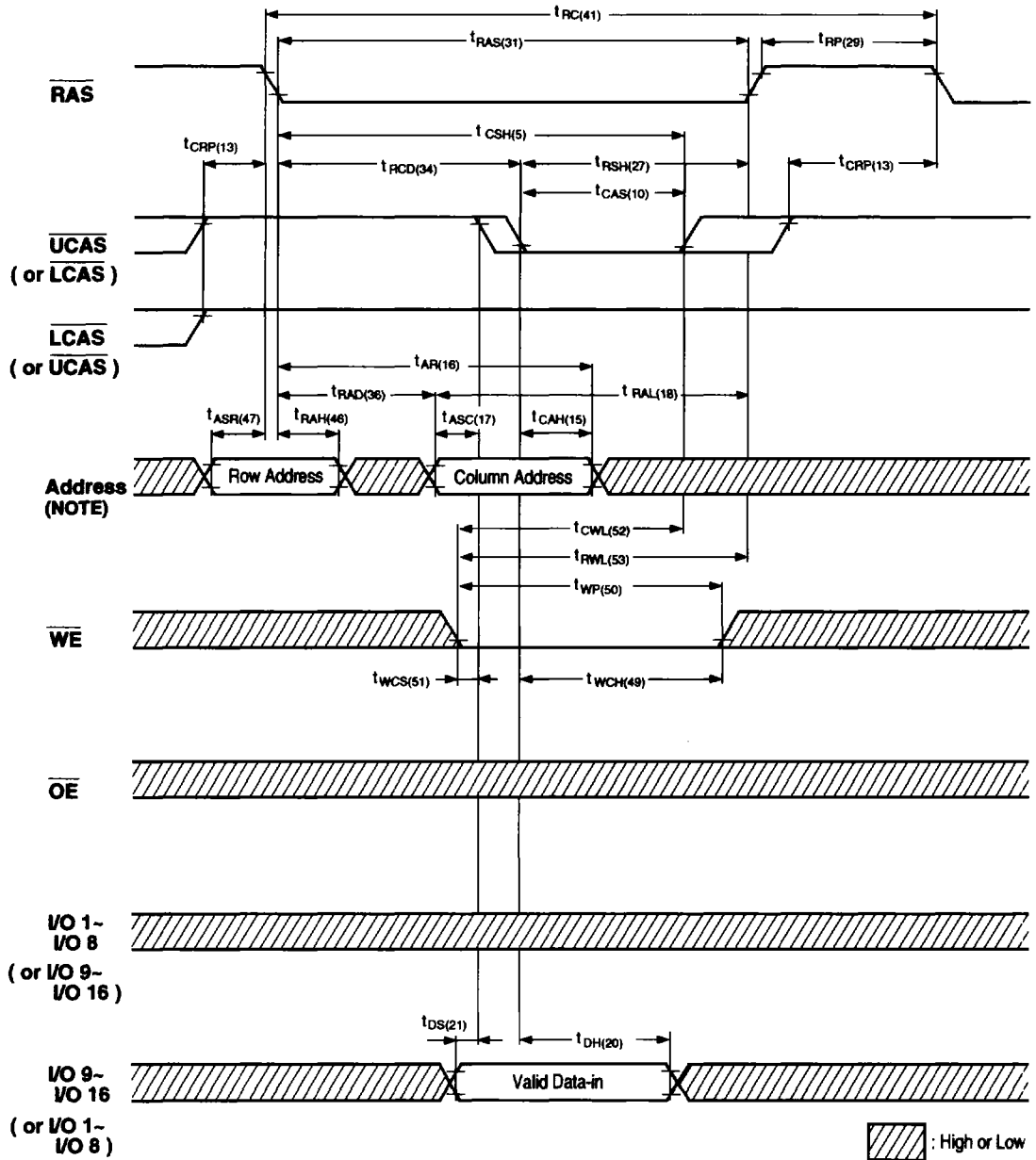
**BYTE READ CYCLE**



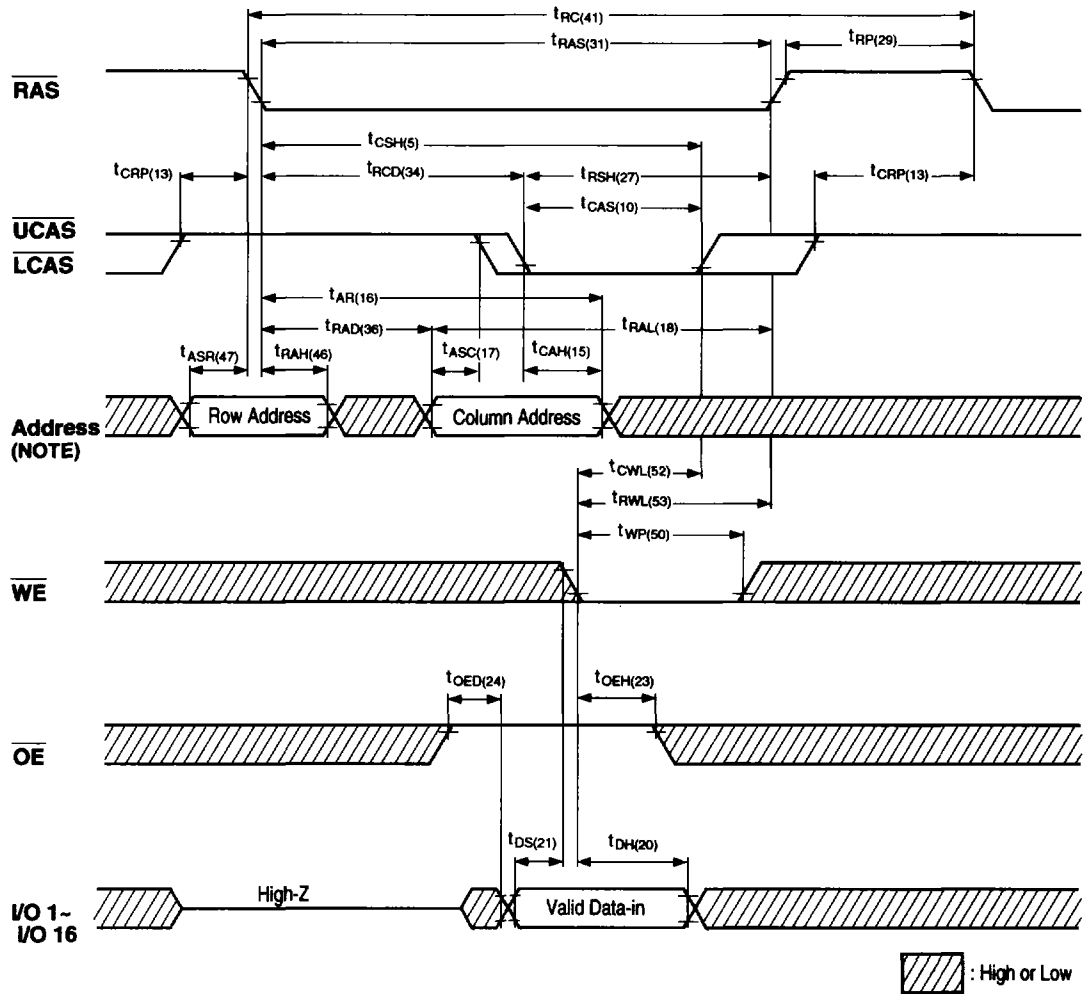
WORD WRITE CYCLE (EARLY WRITE)



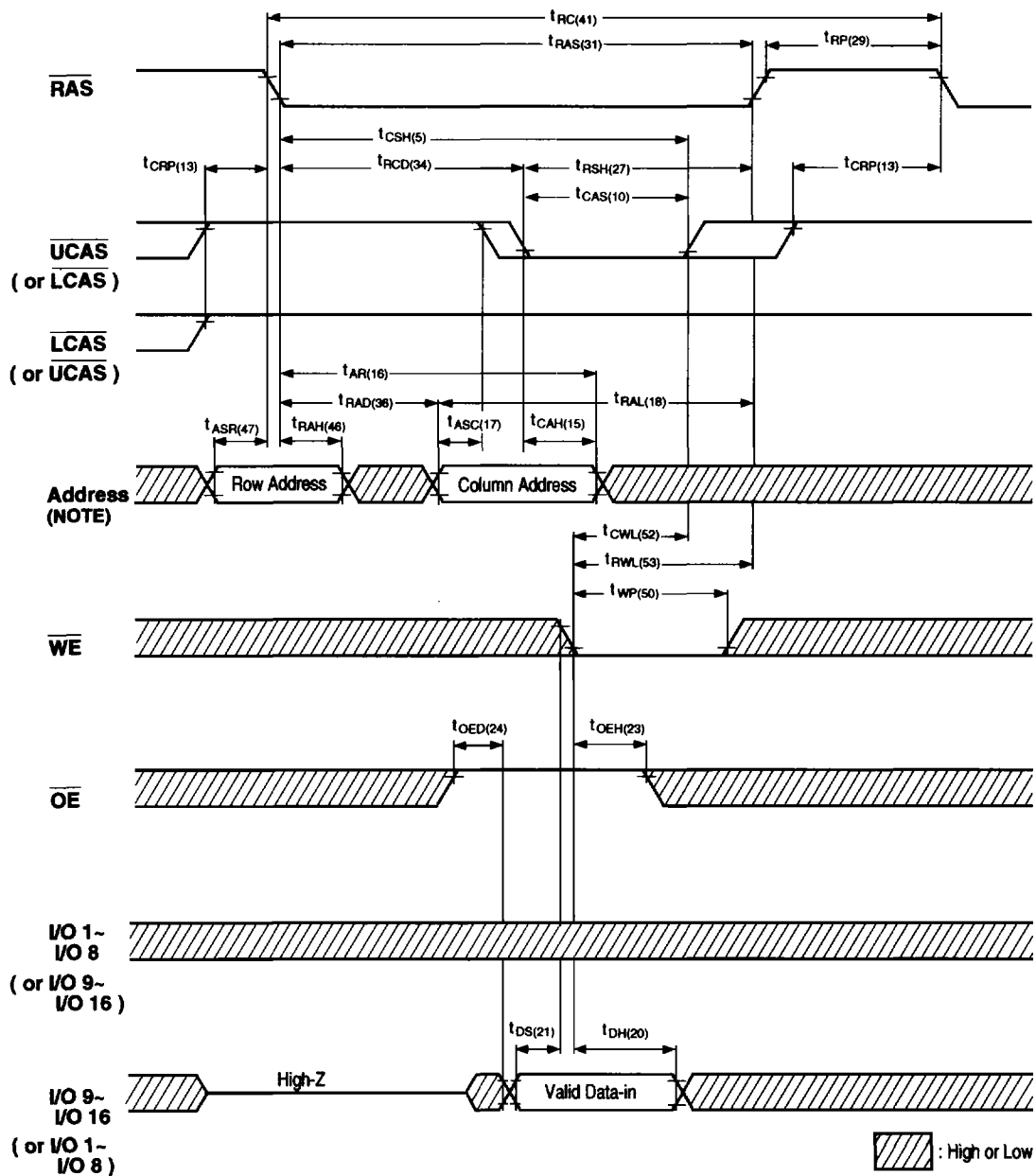
**BYTE WRITE CYCLE (EARLY WRITE)**



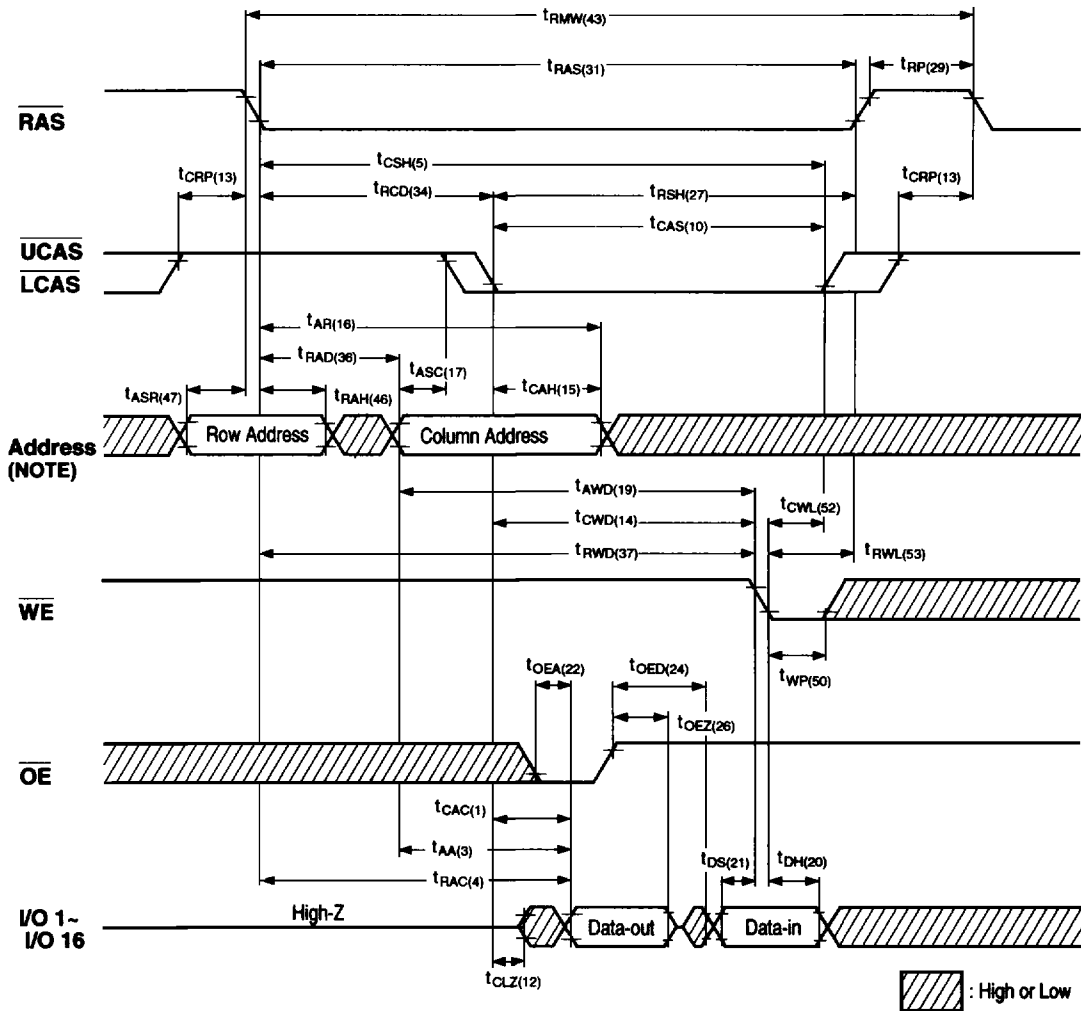
WORD WRITE CYCLE (OE-CONTROLLED WRITE)



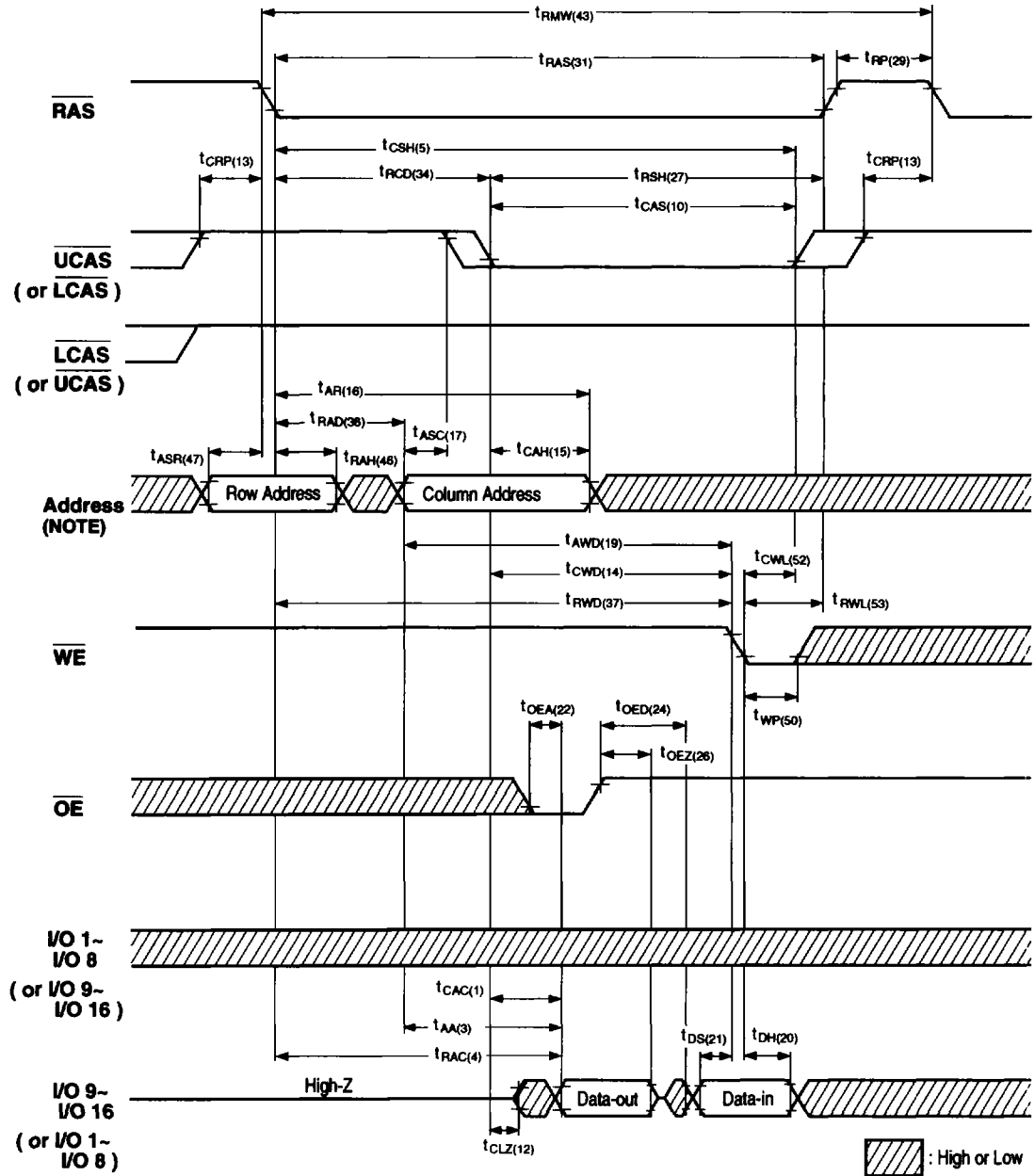
**BYTE WRITE CYCLE ( $\overline{\text{OE}}$ -CONTROLLED WRITE)**



WORD READ-MODIFY-WRITE CYCLE

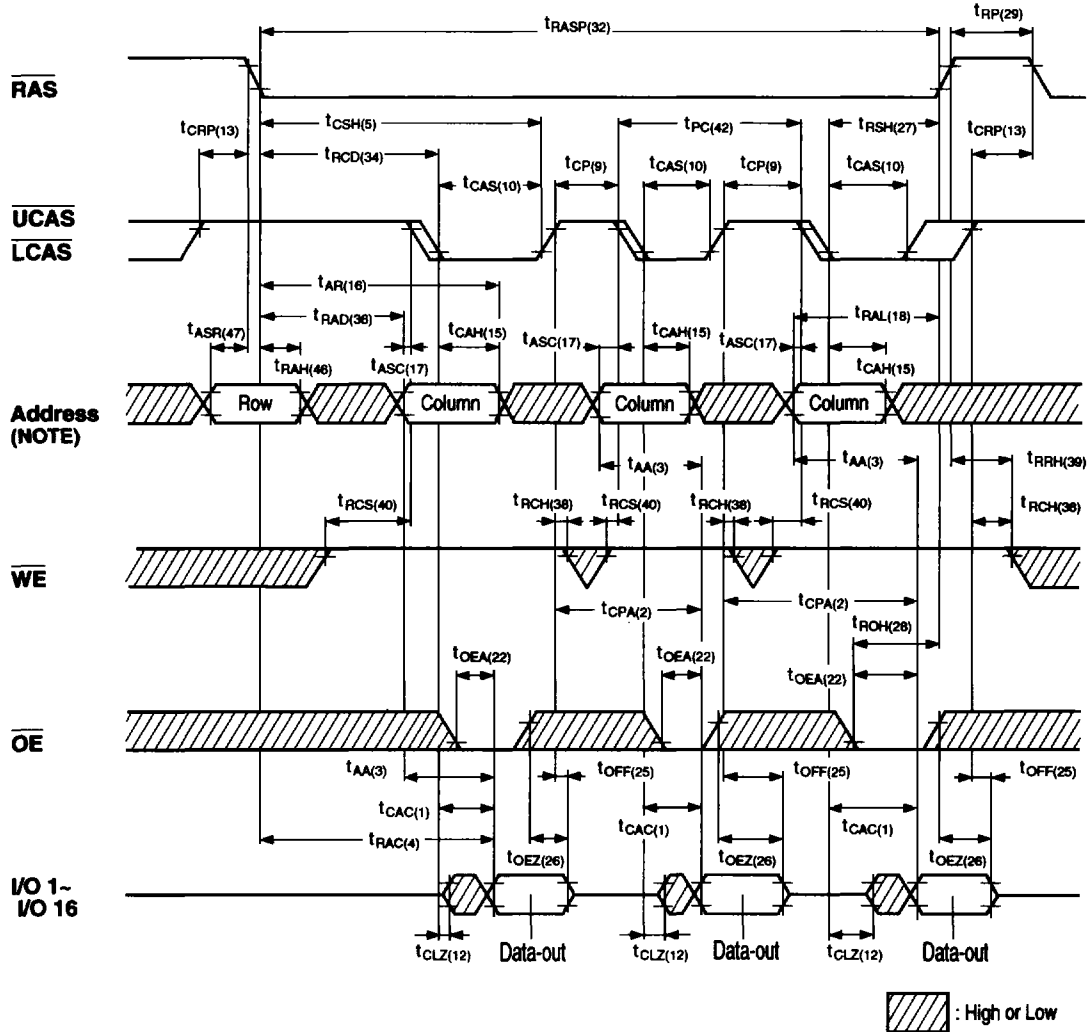


**BYTE READ-MODIFY-WRITE CYCLE**

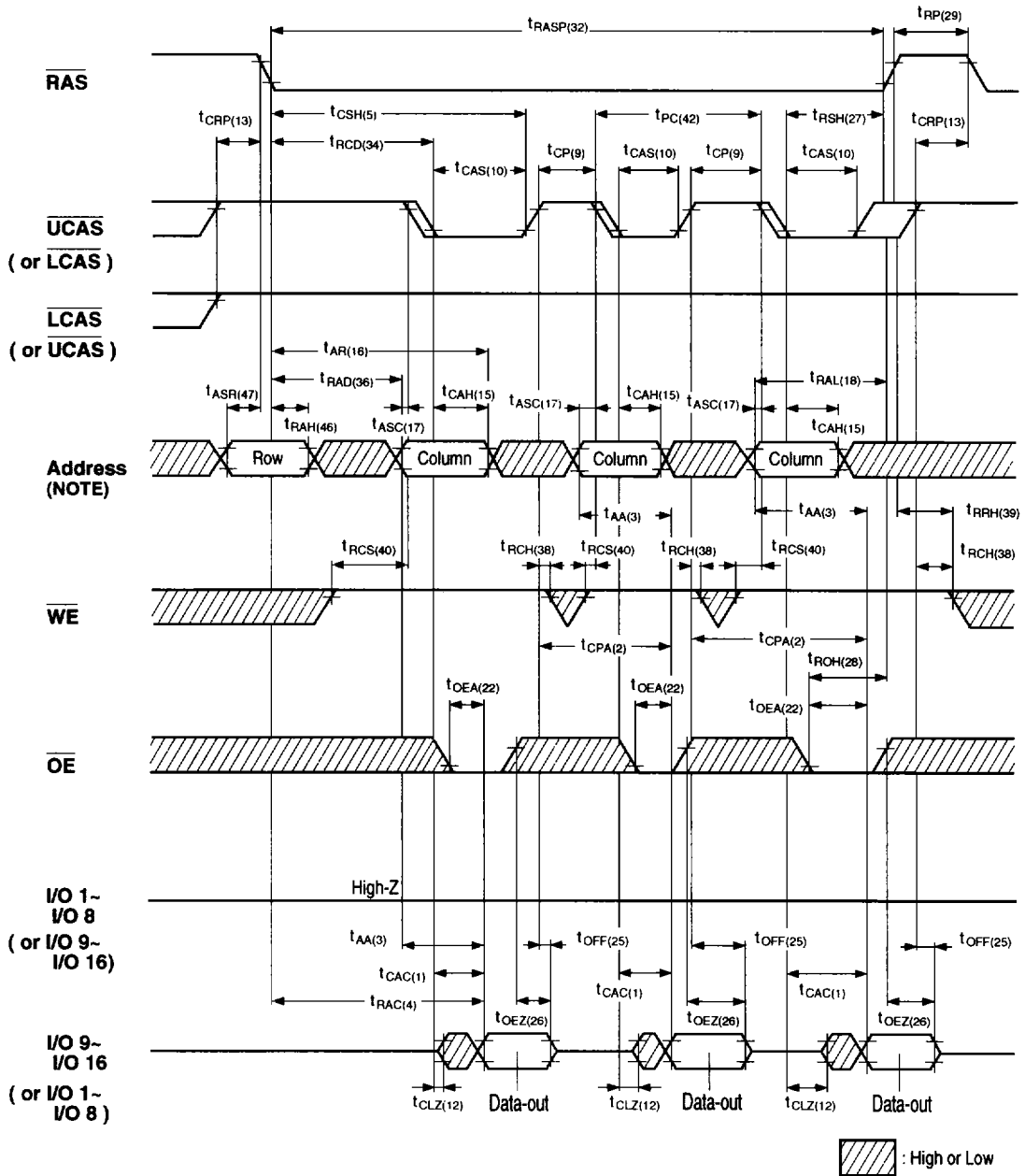




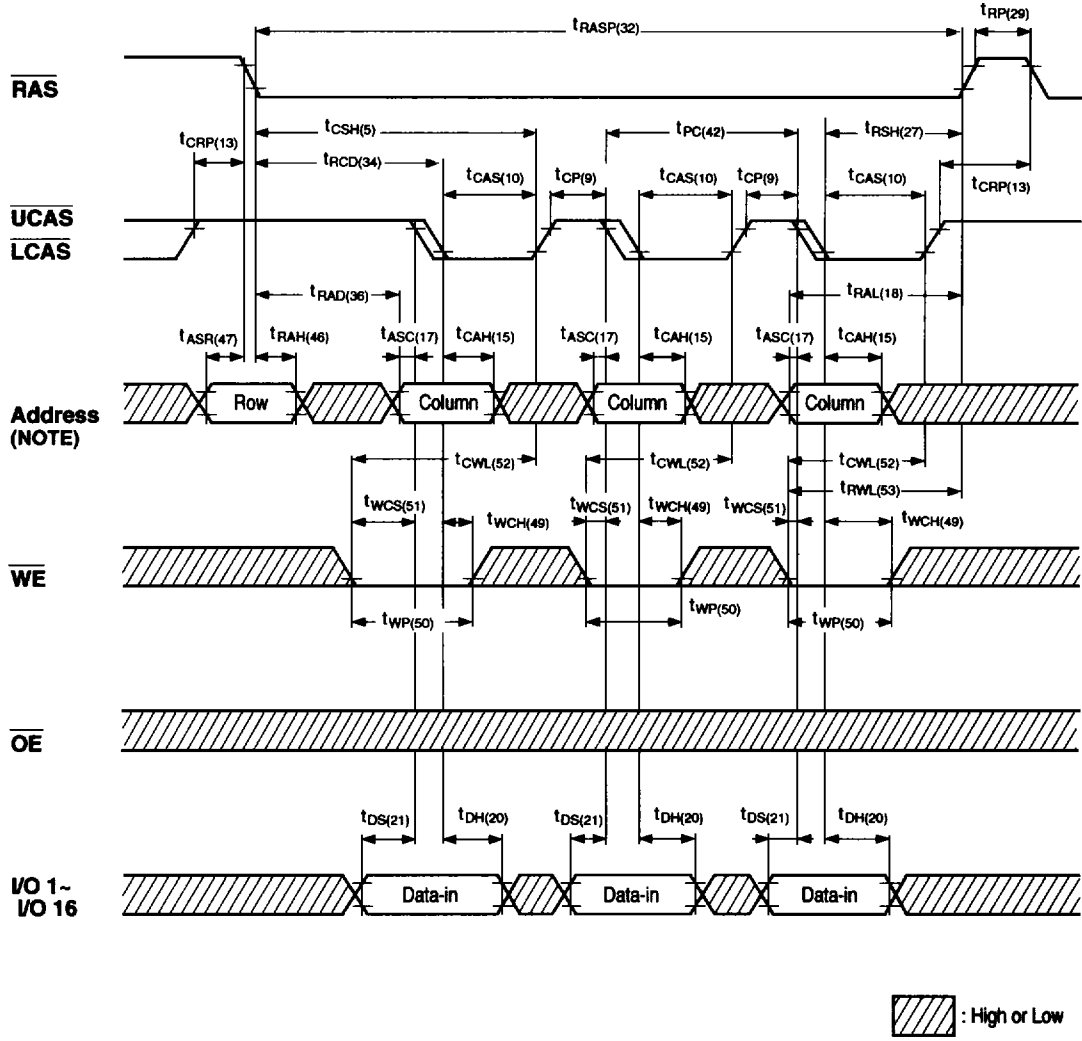
FAST PAGE MODE WORD READ CYCLE



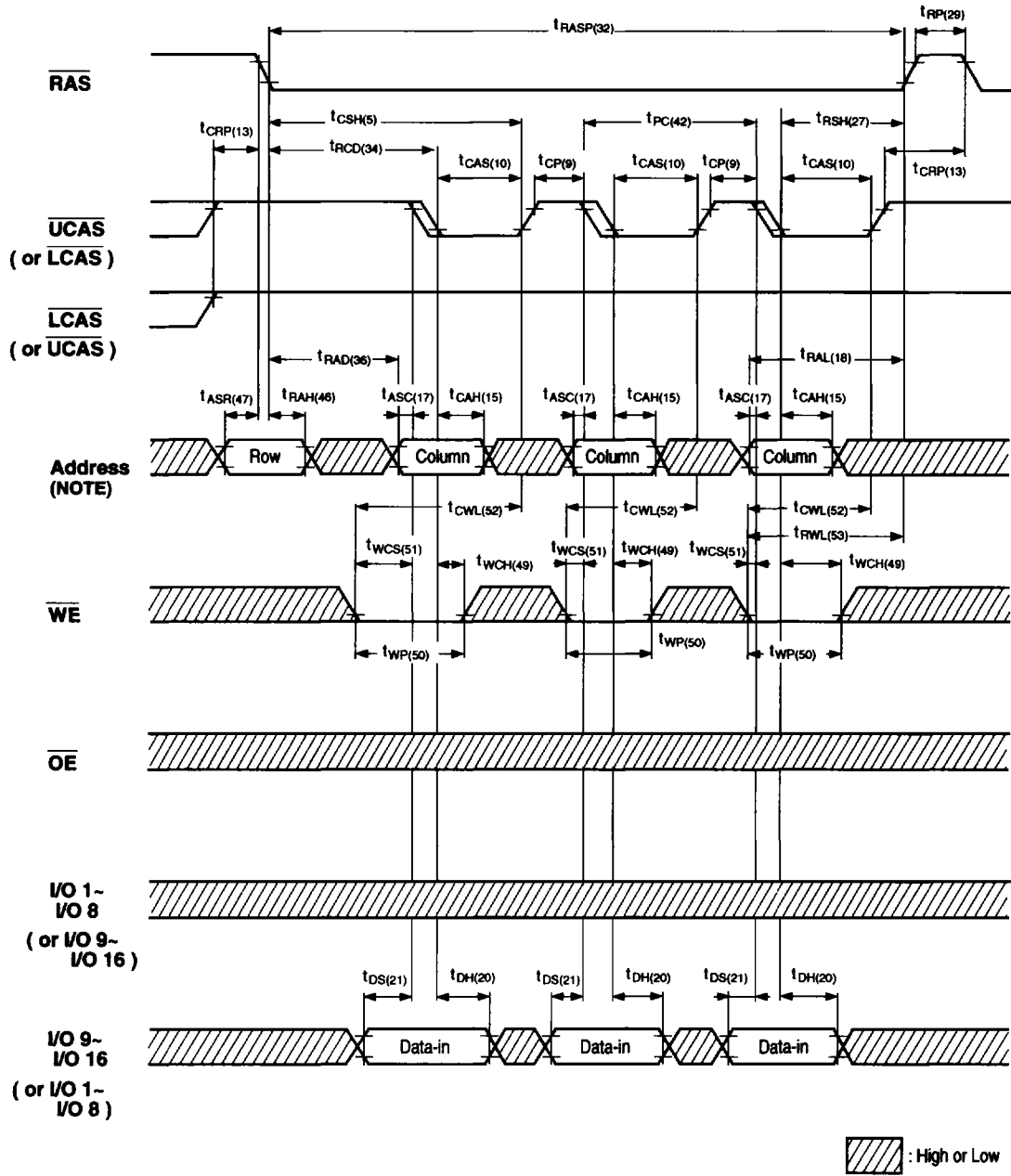
**FAST PAGE MODE BYTE READ CYCLE**



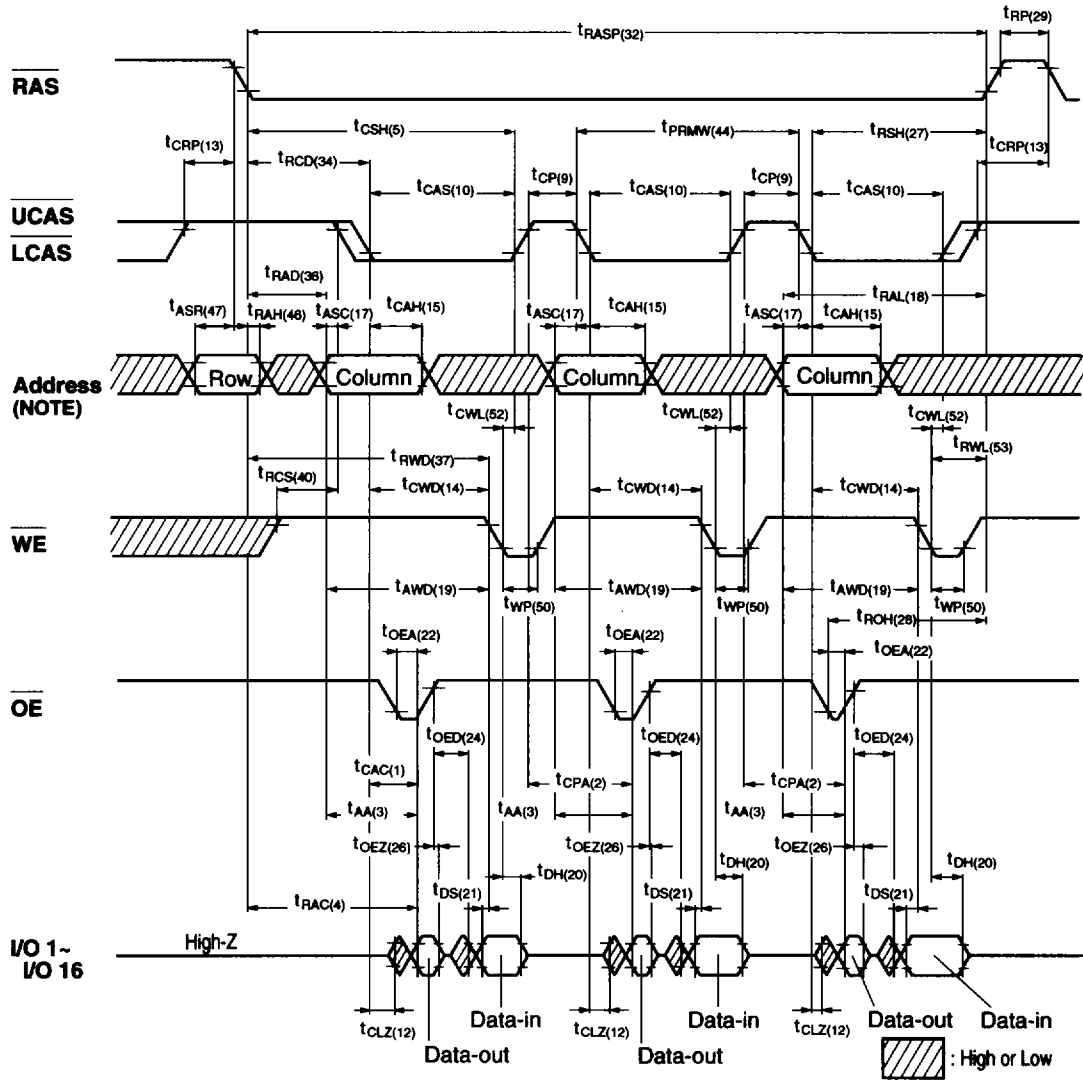
FAST PAGE MODE EARLY WORD WRITE CYCLE



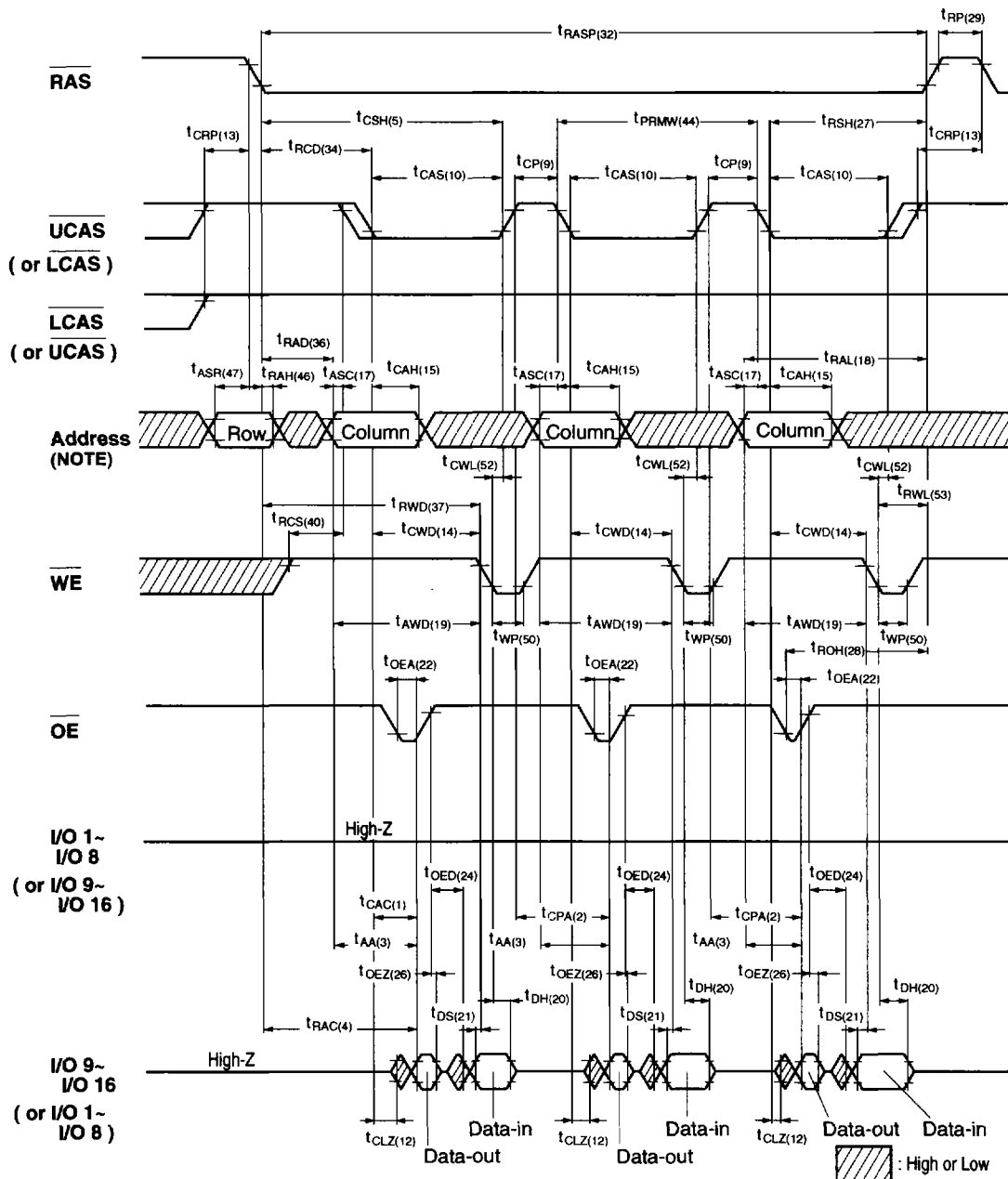
**FAST PAGE MODE EARLY BYTE WRITE CYCLE**



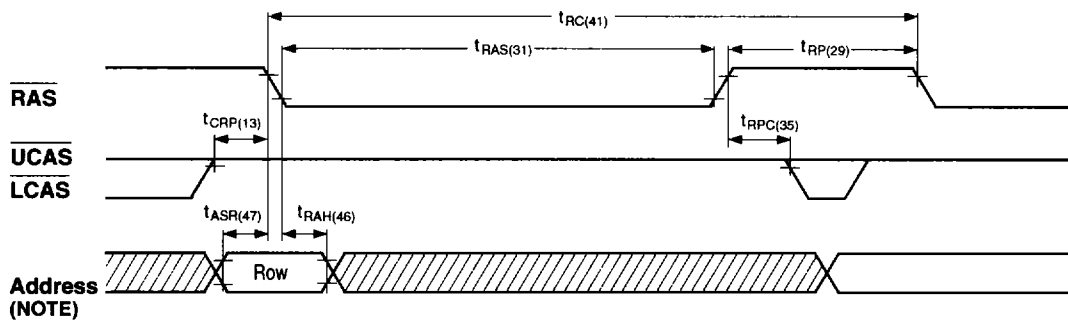
FAST PAGE MODE WORD READ-MODIFY-WRITE CYCLE




**FAST PAGE MODE BYTE READ-MODIFY-WRITE CYCLE**



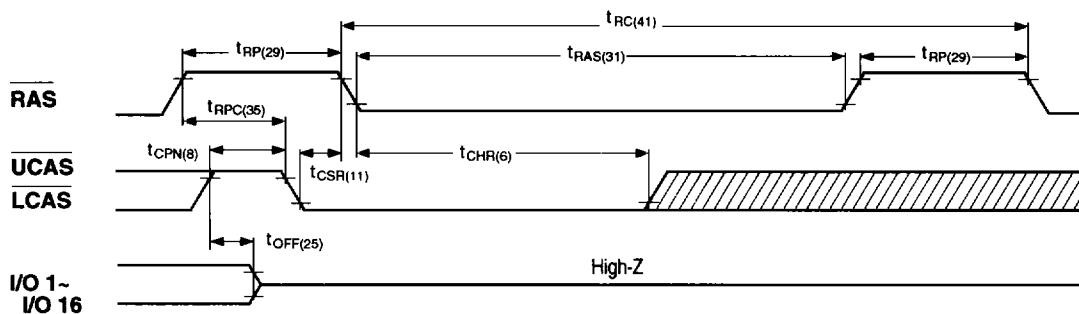
**RAS ONLY REFRESH CYCLE**




NOTE 2:  $\overline{WE}$ ,  $\overline{OE}$  = Don't care.

 : High or Low

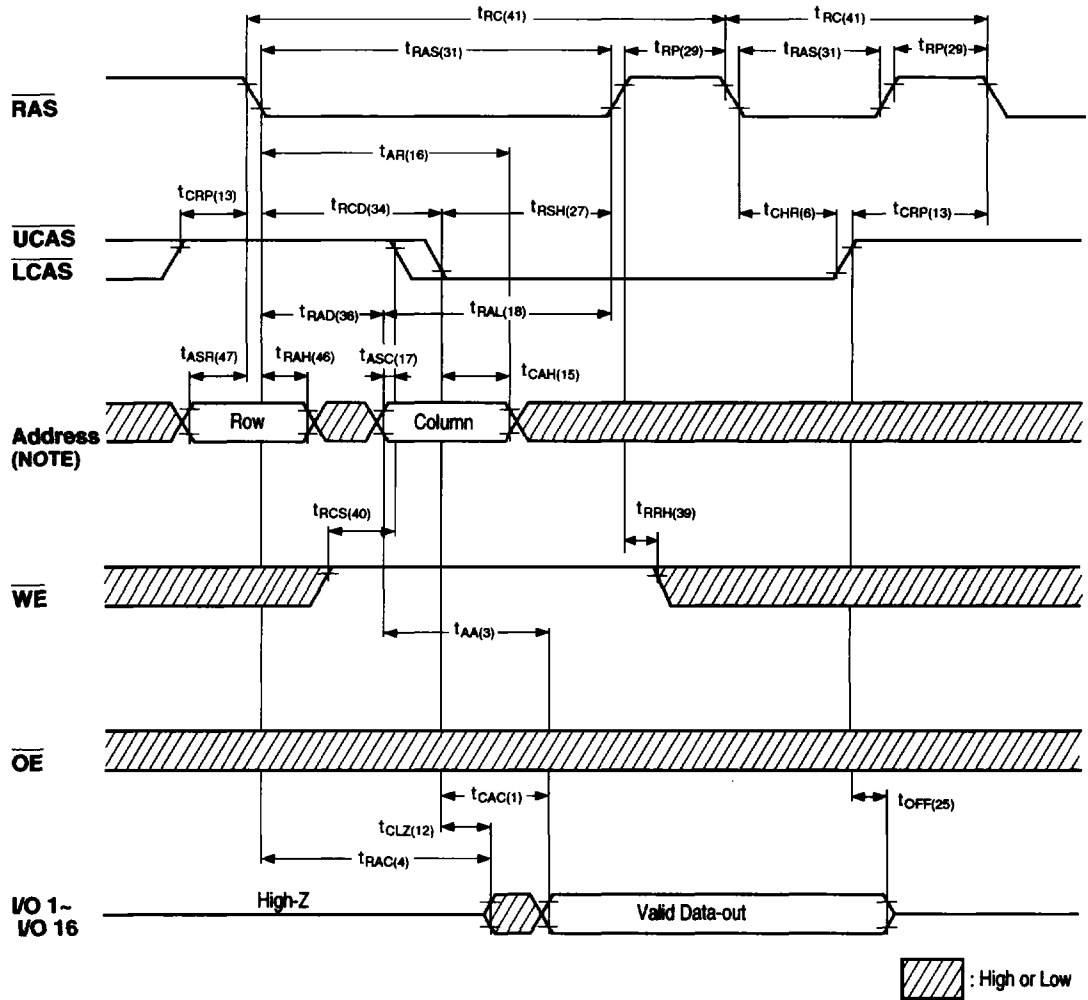
**CAS BEFORE RAS REFRESH CYCLE**



NOTE 3:  $\overline{WE}$ ,  $\overline{OE}$ , Address = Don't care.

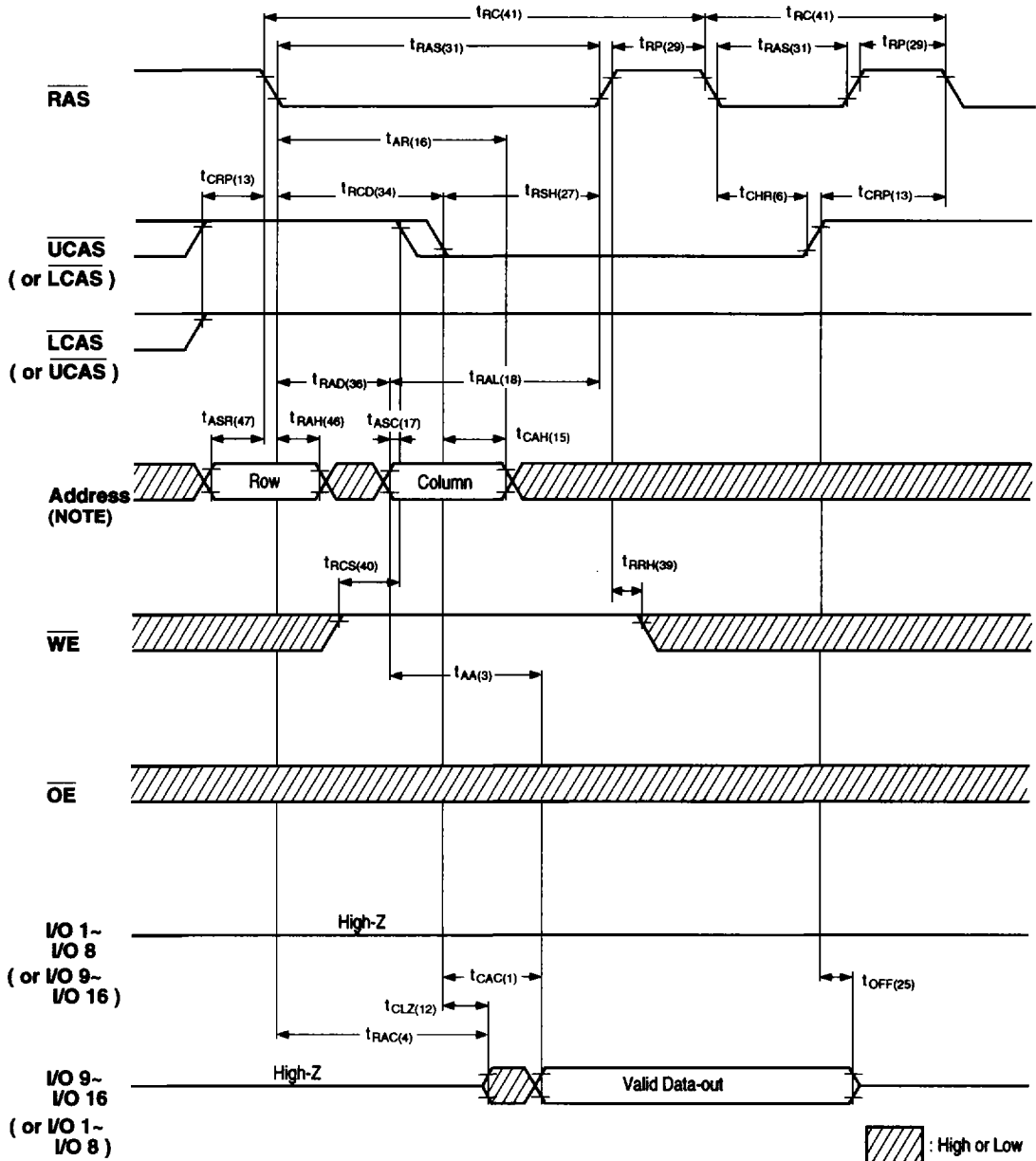
 : High or Low

**HIDDEN REFRESH CYCLE (WORD READ)**

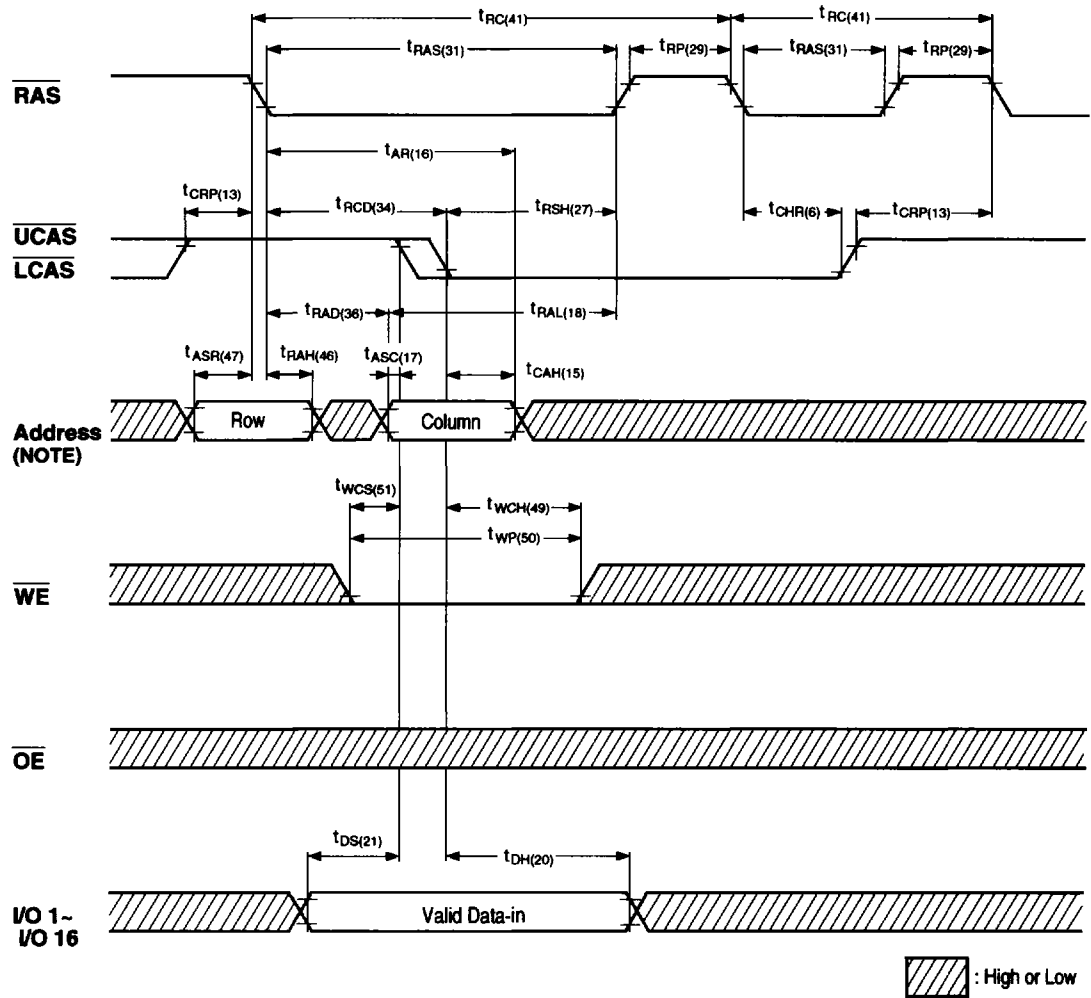




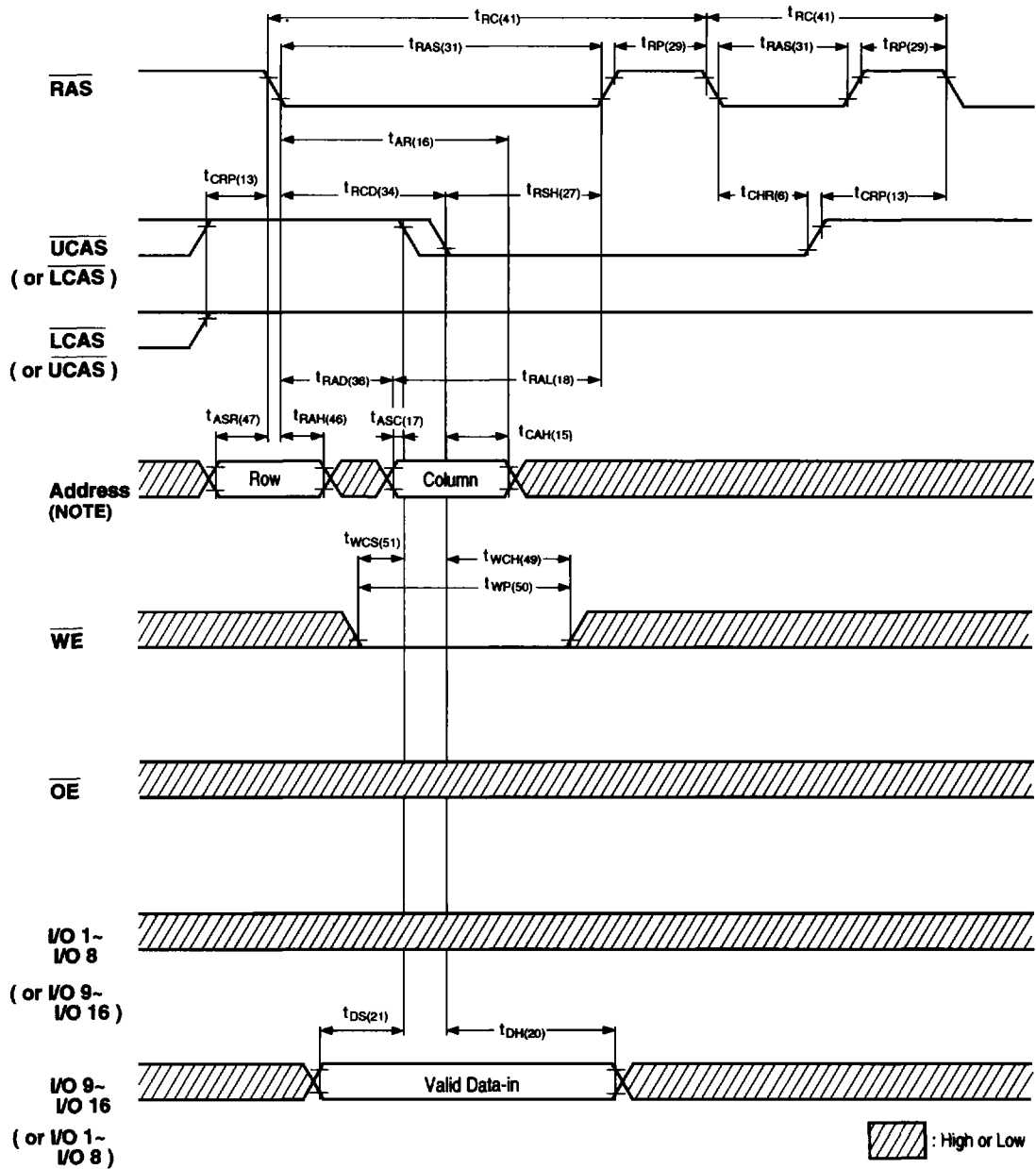
HIDDEN REFRESH CYCLE (BYTE READ)



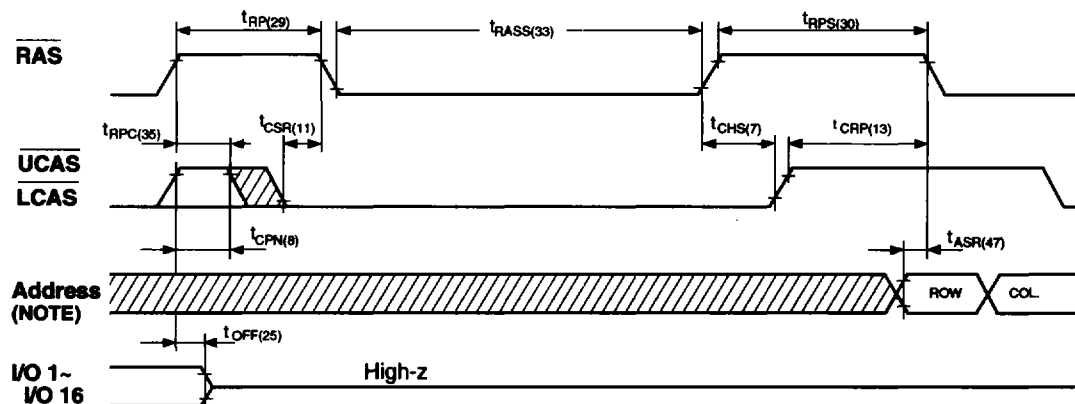
**HIDDEN REFRESH CYCLE (EARLY WORD WRITE)**



HIDDEN REFRESH CYCLE (EARLY BYTE WRITE)



**SELF REFRESH MODE**



Note:  $\overline{WE}$ ,  $\overline{OE}$  = Don't care.

 : High or Low

■ The NN5116160A/18160A (L version) has a Self Refresh Mode.

**a. Entering the Self Refresh Mode:**

The NN5116160AL/18160AL Self Refresh Mode is entered by using  $\overline{CAS}$  before  $\overline{RAS}$  cycle and holding  $\overline{RAS}$  and  $\overline{CAS}$  signal "low" longer than 300 $\mu$ s.

**b. Continuing the Self Refresh Mode:**

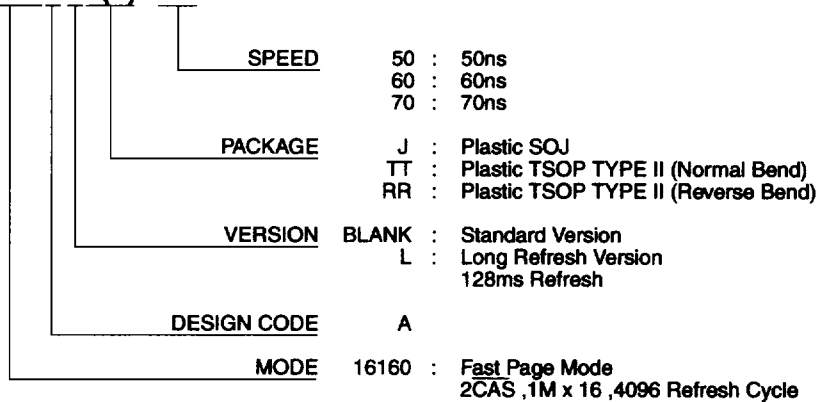
The Self Refresh Mode is continuing by holding  $\overline{RAS}$  "low" after entering the Self Refresh Mode. It does not depend on  $\overline{CAS}$  being "high" or "low" after entering the Self Refresh Mode to continue the Self Refresh Mode.

**c. Exiting the Self Refresh Mode:**

The NN5116160AL/18160AL exits will exit the Self Refresh Mode when the  $\overline{RAS}$  signal is brought "high".

**ORDERING INFORMATION**

**NN5116160AXX(X) - XX**



**NN5118160AXX(X) - XX**

