

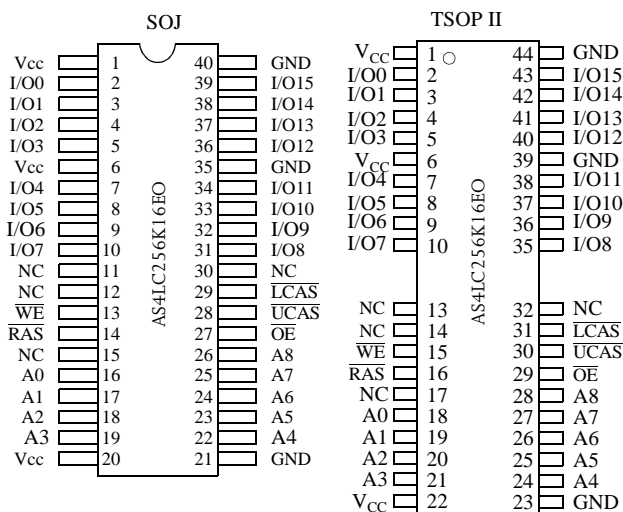


3.3V 256K X 16 CMOS DRAM (EDO)

Features

- Organization: 262,144 words × 16 bits
- High speed
  - 45/60 ns  $\overline{\text{RAS}}$  access time
  - 10/12/15/20 ns column address access time
  - 7/10/10 ns  $\overline{\text{CAS}}$  access time
- Low power consumption
  - Active: 280 mW max (AS4LC256K16EO-35)
  - Standby: 2.8 mW max, CMOS I/O (AS4LC256K16EO-35)
- EDO page mode
- 5V I/O tolerant
- 512 refresh cycles, 8 ms refresh interval
  - $\overline{\text{RAS}}$ -only or  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh or self refresh
- Read-modify-write
- LVTTTL-compatible, three-state I/O
- JEDEC standard packages
  - 400 mil, 40-pin SOJ
  - 400 mil, 40/44-pin TSOP II
- 3.3V power supply
- Latch-up current > 200 mA

Pin arrangement



Pin designation

Pin(s)	Description
A0 to A8	Address inputs
$\overline{\text{RAS}}$	Row address strobe
I/O0 to I/O15	Input/output
$\overline{\text{OE}}$	Output enable
$\overline{\text{UCAS}}$	Column address strobe, upper byte
$\overline{\text{LCAS}}$	Column address strobe, lower byte
$\overline{\text{WE}}$	Read/write control
V <sub>CC</sub>	Power (3.3V ± 0.3V)
GND	Ground

Selection guide

	Symbol	AS4LC256K16EO-35	AS4LC256K16EO-45	AS4LC256K16EO-60	Unit
Maximum $\overline{\text{RAS}}$ access time	t <sub>RAC</sub>	35	45	60	ns
Maximum column address access time	t <sub>CAA</sub>	17	20	25	ns
Maximum $\overline{\text{CAS}}$ access time	t <sub>CAC</sub>	7	10	10	ns
Maximum output enable ( $\overline{\text{OE}}$ ) access time	t <sub>OEA</sub>	7	10	10	ns
Minimum read or write cycle time	t <sub>RC</sub>	50	80	100	ns
Minimum EDO page mode cycle time	t <sub>PC</sub>	15	17	30	ns
Maximum operating current	I <sub>CC1</sub>	70	60	50	mA
Maximum CMOS standby current	I <sub>CC2</sub>	200	200	200	µA





## Absolute maximum ratings

Parameter	Symbol	Min	Max	Unit
Input voltage	$V_{in}$	-1.0	+7.0	V
Output voltage	$V_{out}$	-1.0	+7.0	V
Power supply voltage	$V_{CC}$	-1.0	+7.0	V
Operating temperature	$T_{OPR}$	0	+70	°C
Storage temperature (plastic)	$T_{STG}$	-55	+150	°C
Soldering temperature × time	$T_{SOLDER}$	–	$260 \times 10$	°C × sec
Power dissipation	$P_D$	–	1	W
Short circuit output current	$I_{out}$	–	50	mA
Latch-up current		200	–	mA

**NOTE:** Stresses greater than 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 outside those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## DC electrical characteristics

Parameter	Symbol	Test conditions	-35		-45		-60		Unit	Note
			Min	Max	Min	Max	Min	Max		
Input leakage current	$I_{IL}$	$0V \leq V_{in} \leq +5.5V$ pins not under test = 0V	-10	10	-10	10	-10	10	$\mu A$	
Output leakage current	$I_{OL}$	$D_{OUT}$ disabled, $0V \leq V_{out} \leq +5.5V$	-10	10	-10	10	-10	10	$\mu A$	
Operating power supply current	$I_{CC1}$	$\overline{RAS}$ , $\overline{UCAS}$ , $\overline{LCAS}$ , address cycling; $t_{RC} = \text{min}$	–	70	–	60	–	50	mA	1,2
TTL standby power supply current	$I_{CC2}$	$\overline{RAS} = \overline{UCAS} = \overline{LCAS} = V_{IH}$	–	200	–	200	–	200	$\mu A$	
Average power supply current, $\overline{RAS}$ refresh mode	$I_{CC3}$	$\overline{RAS}$ cycling, $\overline{UCAS} = \overline{LCAS} = V_{IH}$ , $t_{RC} = \text{min}$	–	50	–	45	–	40	mA	1
EDO page mode average power supply current	$I_{CC4}$	$\overline{RAS} = \overline{UCAS} = \overline{LCAS} = V_{IL}$ , address cycling: $t_{SC} = \text{min}$	–	40	–	35	–	35	mA	1,2
CMOS standby power supply current	$I_{CC5}$	$\overline{RAS} = \overline{UCAS} = \overline{LCAS} = V_{CC} - 0.2V$	–	400	–	400	–	400	$\mu A$	
$\overline{CAS}$ -before- $\overline{RAS}$ refresh power supply current	$I_{CC6}$	$\overline{RAS}$ , $\overline{UCAS}$ , $\overline{LCAS}$ , cycling; $t_{RC} = \text{min}$	–	50	–	50	–	50	mA	1
Output Voltage	$V_{OH}$	$I_{OUT} = -2 \text{ mA}$	2.4	–	2.4	–	2.4	–	V	
	$V_{OL}$	$I_{OUT} = 2 \text{ mA}$	–	0.4	–	0.4	–	0.4	V	
Self refresh current	$I_{CC7}$	$\overline{RAS} = \overline{UCAS} = \overline{LCAS} = V_{IL}$ , $\overline{WE} = \overline{OE} = A0-A8 = V_{CC} - 0.2V$ , $DQ0-DQ15 = V_{CC} - 0.2V$ , 0.2V are open	–	400	–	400	–	400	$\mu A$	





## AC parameters common to all waveforms

Std Symbol	Parameter	-35		-45		-60		Unit	Notes
		Min	Max	Min	Max	Min	Max		
$t_{RC}$	Random read or write cycle time	50	–	80	–	100	–	ns	
$t_{RP}$	$\overline{RAS}$ precharge time	15	–	20	–	20	–	ns	
$t_{RAS}$	$\overline{RAS}$ pulse width	35	75K	45	75K	60	75K	ns	
$t_{CAS}$	$\overline{CAS}$ pulse width	6	–	10	–	10	–	ns	
$t_{RCD}$	$\overline{RAS}$ to $\overline{CAS}$ delay time	12	18	18	32	15	45	ns	6
$t_{RAD}$	$\overline{RAS}$ to column address delay time	8	14	13	23	15	30	ns	7
$t_{RSH(R)}$	$\overline{CAS}$ to $\overline{RAS}$ hold time (read cycle)	10	–	10	–	12	–	ns	
$t_{CSH}$	$\overline{RAS}$ to $\overline{CAS}$ hold time	35	–	45	–	60	–	ns	
$t_{CRP}$	$\overline{CAS}$ to $\overline{RAS}$ precharge time	5	–	5	–	5	–	ns	
$t_{ASR}$	Row address setup time	0	–	0	–	0	–	ns	
$t_{RAH}$	Row address hold time	6	–	8	–	9	–	ns	
$t_T$	Transition time (rise and fall)	1.5	50	1.5	50	1.5	50	ns	4,5
$t_{REF}$	Refresh period	–	8	–	8	–	8	ms	3
$t_{CLZ}$	$\overline{CAS}$ to output in low Z	0	–	3	–	3	–	ns	8

## Read cycle

Std Symbol	Parameter	-35		-45		-60		Unit	Notes
		Min	Max	Min	Max	Min	Max		
$t_{RAC}$	Access time from $\overline{RAS}$	–	35	–	45	–	60	ns	6
$t_{CAC}$	Access time from $\overline{CAS}$	–	7	–	10	–	10	ns	6,13
$t_{AA}$	Access time from address	–	17	–	22	–	30	ns	7,13
$t_{AR(R)}$	Column add hold from $\overline{RAS}$	28	–	35	–	40	–	ns	
$t_{RCS}$	Read command setup time	0	–	0	–	0	–	ns	
$t_{RCH}$	Read command hold time to $\overline{CAS}$	0	–	0	–	0	–	ns	9
$t_{RRH}$	Read command hold time to $\overline{RAS}$	0	–	0	–	0	–	ns	9
$t_{RAL}$	Column address to $\overline{RAS}$ Lead time	18	–	25	–	30	–	ns	
$t_{CPN}$	$\overline{CAS}$ precharge time	4	–	5	–	5	–	ns	
$t_{OFF}$	Output buffer turn-off time	0	8	0	10	0	10	ns	8,10



## Write cycle

Std Symbol Parameter	-35		-45		-60		Unit	Notes
	Min	Max	Min	Max	Min	Max		
$t_{ASC}$ Column address setup time	0	–	0	–	0	–	ns	
$t_{CAH}$ Column address hold time	5	–	6	–	10	–	ns	
$t_{AWR}$ Column address hold time to $\overline{RAS}$	28	–	35	–	40	–	ns	
$t_{WCS}$ Write command setup time	0	–	0	–	0	–	ns	11
$t_{WCH}$ Write command hold time	0	–	0	–	0	–	ns	11
$t_{WCR}$ Write command hold time to $\overline{RAS}$	28	–	35	–	40	–	ns	
$t_{WP}$ Write command pulse width	5	–	6	–	10	–	ns	
$t_{RWL}$ Write command to $\overline{RAS}$ lead time	11	–	12	–	12	–	ns	
$t_{CWL}$ Write command to $\overline{CAS}$ lead time	11	–	12	–	12	–	ns	
$t_{DS}$ Data-in setup time	0	–	0	–	0	–	ns	12
$t_{DH}$ Data-in hold time	5	–	6	–	10	–	ns	12
$t_{DHR}$ Data-in hold time to $\overline{RAS}$	28	–	35	–	45	–	ns	

## Read-modify-write cycle

Std Symbol Parameter	-35		-45		-60		Unit	Notes
	Min	Max	Min	Max	Min	Max		
$t_{RWC}$ Read-write cycle time	105	–	115	–	120	–	ns	
$t_{RWD}$ $\overline{RAS}$ to $\overline{WE}$ delay time	54	–	58	–	60	–	ns	11
$t_{CWD}$ $\overline{CAS}$ to $\overline{WE}$ delay time	28	–	30	–	30	–	ns	11
$t_{AWD}$ Column address to $\overline{WE}$ delay time	35	–	38	–	40	–	ns	11
$t_{RSH(W)}$ $\overline{CAS}$ to $\overline{RAS}$ hold time (write)	10	–	10	–	12	–	ns	
$t_{CAS(W)}$ $\overline{CAS}$ pulse width (write)	15	–	15	–	15	–	ns	



## EDO page mode cycle

Std Symbol	Parameter	-35		-45		-60		Unit	Notes
		Min	Max	Min	Max	Min	Max		
t <sub>PC</sub>	Read or write cycle time (fast page)	15	–	17	–	25	–	ns	14
t <sub>CAP</sub>	Access time from $\overline{\text{CAS}}$ precharge	–	19	–	21	–	23	ns	13
t <sub>CP</sub>	$\overline{\text{CAS}}$ precharge time (fast page)	4	–	5	–	6	–	ns	
t <sub>PCM</sub>	EDO page mode RMW cycle	56	–	58	–	60	–	ns	
t <sub>CRW</sub>	Page mode $\overline{\text{CAS}}$ pulse width (RMW)	44	–	46	–	50	–	ns	
t <sub>RASP</sub>	$\overline{\text{RAS}}$ pulse width	35	75K	45	75K	60	75K	ns	

## Refresh cycle

Std Symbol	Parameter	-35		-45		-60		Unit	Notes
		Min	Max	Min	Max	Min	Max		
t <sub>CSR</sub>	$\overline{\text{CAS}}$ setup time ( $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ )	10	–	10	–	10	–	ns	3
t <sub>CHR</sub>	$\overline{\text{CAS}}$ hold time ( $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ )	8	–	8	–	10	–	ns	3
t <sub>RPC</sub>	$\overline{\text{RAS}}$ precharge to $\overline{\text{CAS}}$ hold time	0	–	0	–	0	–	ns	
t <sub>CPT</sub>	$\overline{\text{CAS}}$ precharge time ( $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ counter test)	8	–	8	–	8	–	ns	

## Output enable

Std Symbol	Parameter	-35		-45		-60		Unit	Notes
		Min	Max	Min	Max	Min	Max		
t <sub>ROH</sub>	$\overline{\text{RAS}}$ hold time referenced to $\overline{\text{OE}}$	5	–	5	–	5	–	ns	
t <sub>OEA</sub>	$\overline{\text{OE}}$ access time	–	10	–	10	–	10	ns	
t <sub>OED</sub>	$\overline{\text{OE}}$ to data delay	5	–	5	–	8	–	ns	
t <sub>OEZ</sub>	Output buffer turnoff delay from $\overline{\text{OE}}$	–	8	–	8	–	8	ns	8
t <sub>OEH</sub>	$\overline{\text{OE}}$ command hold time	8	–	8	–	8	–	ns	

## Self refresh cycle

Std Symbol	Parameter	-35		-45		-60		Unit	Notes
		Min	Max	Min	Max	Min	Max		
t <sub>RASS</sub>	$\overline{\text{RAS}}$ pulse width (CBR self refresh)	100K	–	100K	–	100K	–	ns	
t <sub>RPS</sub>	$\overline{\text{RAS}}$ precharge time (CBR self refresh)	85	–	85	–	85	–	ns	
t <sub>CHS</sub>	$\overline{\text{CAS}}$ hold time (CBR self refresh)	30	–	30	–	30	–	ns	



## Notes

- $I_{CC1}$ ,  $I_{CC3}$ ,  $I_{CC4}$ , and  $I_{CC6}$  depend on cycle rate.
- $I_{CC1}$  and  $I_{CC4}$  depend on output loading. Specified values are obtained with the output open.
- An initial pause of 200  $\mu$ s is required after power-up followed by any 8  $\overline{\text{RAS}}$  cycles before proper device operation is achieved. In the case of an internal refresh counter, a minimum of 8  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  initialization cycles instead of 8  $\overline{\text{RAS}}$  cycles are required. 8 initialization cycles are required after extended periods of bias without clocks (greater than 8 ms).
- AC Characteristics assume  $t_T = 5$  ns. All AC parameters are measured with a load equivalent to two TTL loads and 60 pF,  $V_{IL}(\text{min}) \geq \text{GND}$  and  $V_{IH}(\text{max}) \leq V_{CC}$ .
- $V_{IH}(\text{min})$  and  $V_{IL}(\text{max})$  are reference levels for measuring timing of input signals. Transition times are measured between  $V_{IH}$  and  $V_{IL}$ .
- Operation within the  $t_{\text{RCD}}(\text{max})$  limit insures that  $t_{\text{RAC}}(\text{max})$  can be met.  $t_{\text{RCD}}(\text{max})$  is specified as a reference point only. If  $t_{\text{RCD}}$  is greater than the specified  $t_{\text{RCD}}(\text{max})$  limit, then access time is controlled exclusively by  $t_{\text{CAC}}$ .
- Operation within the  $t_{\text{RAD}}(\text{max})$  limit insures that  $t_{\text{RAC}}(\text{max})$  can be met.  $t_{\text{RAD}}(\text{max})$  is specified as a reference point only. If  $t_{\text{RAD}}$  is greater than the specified  $t_{\text{RAD}}(\text{max})$  limit, then access time is controlled exclusively by  $t_{\text{AA}}$ .
- Assumes three state test load (5 pF and a 380  $\Omega$  Thevenin equivalent).
- Either  $t_{\text{RCH}}$  or  $t_{\text{RRH}}$  must be satisfied for a read cycle.
- $t_{\text{OFF}}(\text{max})$  defines the time at which the output achieves the open circuit condition; it is not referenced to output voltage levels.
- $t_{\text{WCS}}$ ,  $t_{\text{WCH}}$ ,  $t_{\text{RWD}}$ ,  $t_{\text{CWD}}$  and  $t_{\text{AWD}}$  are not restrictive operating parameters. They are included in the datasheet as electrical characteristics only. If  $t_{\text{WS}} \geq t_{\text{WS}}(\text{min})$  and  $t_{\text{WH}} \geq t_{\text{WH}}(\text{min})$ , the cycle is an early write cycle and data out pins will remain open circuit, high impedance, throughout the cycle. If  $t_{\text{RWD}} \geq t_{\text{RWD}}(\text{min})$ ,  $t_{\text{CWD}} \geq t_{\text{CWD}}(\text{min})$  and  $t_{\text{AWD}} \geq t_{\text{AWD}}(\text{min})$ , the cycle is a read-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  $\overline{\text{CAS}}$  leading edge in early write cycles and to  $\overline{\text{WE}}$  leading edge in read-write cycles.
- Access time is determined by the longest of  $t_{\text{CAA}}$  or  $t_{\text{CAC}}$  or  $t_{\text{CAP}}$
- $t_{\text{ASC}} \geq t_{\text{CP}}$  to achieve  $t_{\text{PC}}(\text{min})$  and  $t_{\text{CAP}}(\text{max})$  values.
- These parameters are sampled and not 100% tested.

## Key to switching waveform



Undefined/don't care

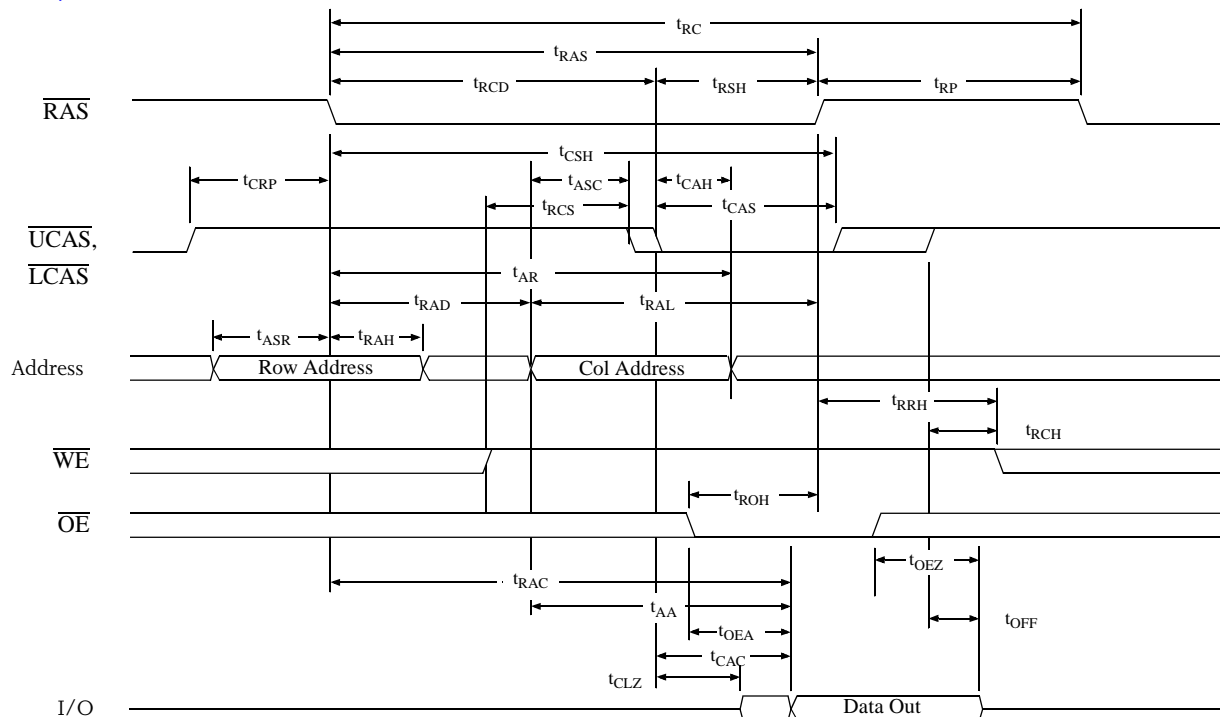


Rising input



Falling input

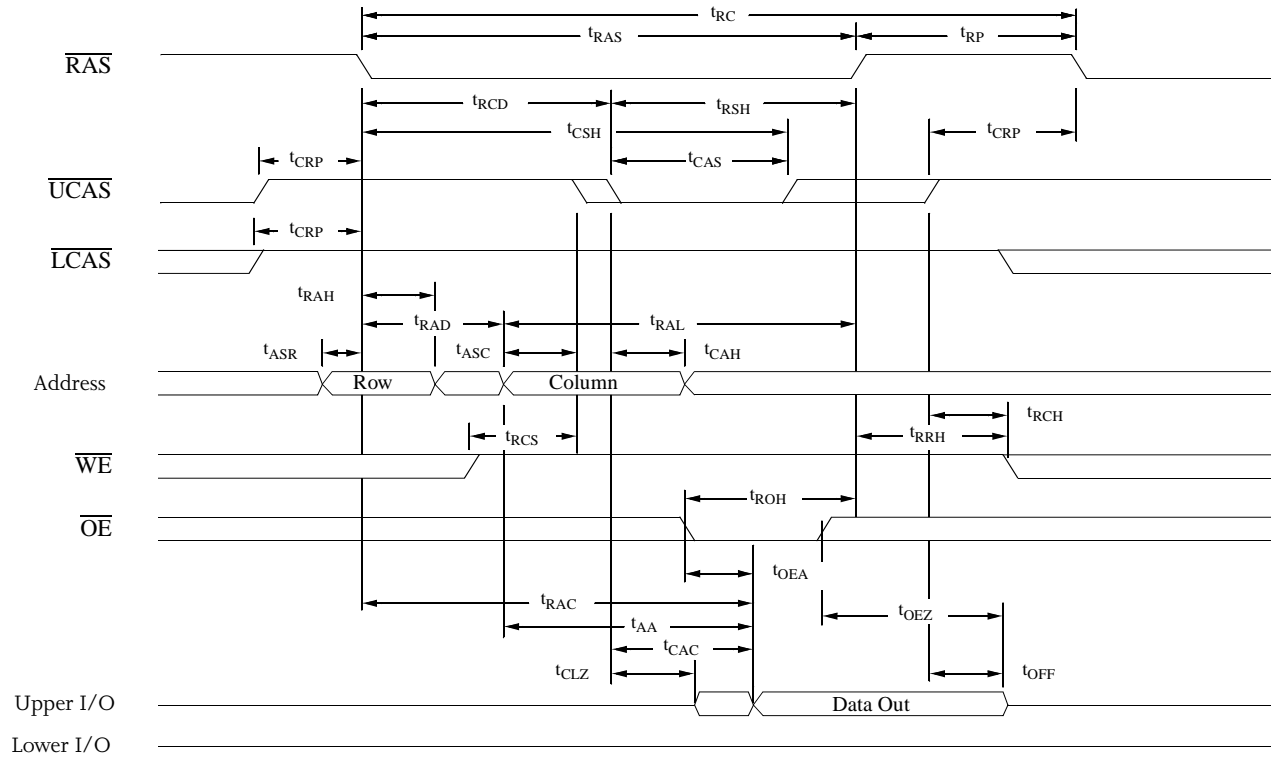
## Read cycle waveform



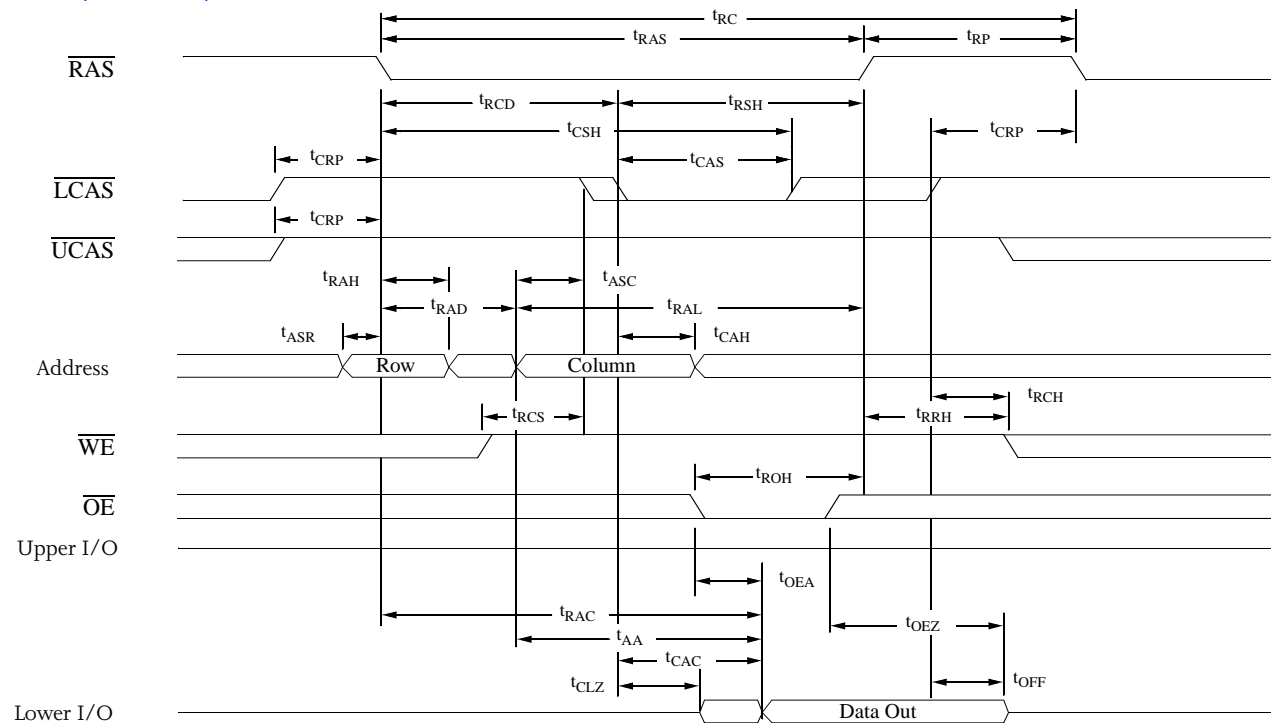




## Upper byte read cycle waveform

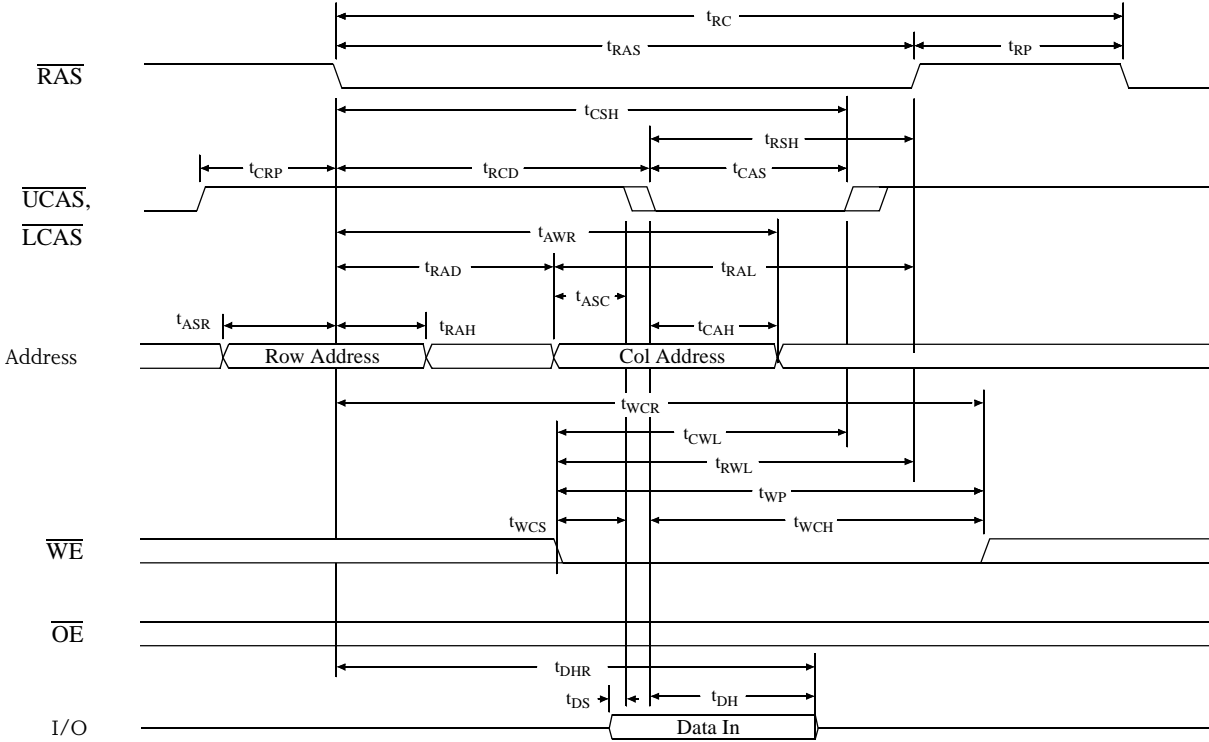


## Lower byte read cycle waveform

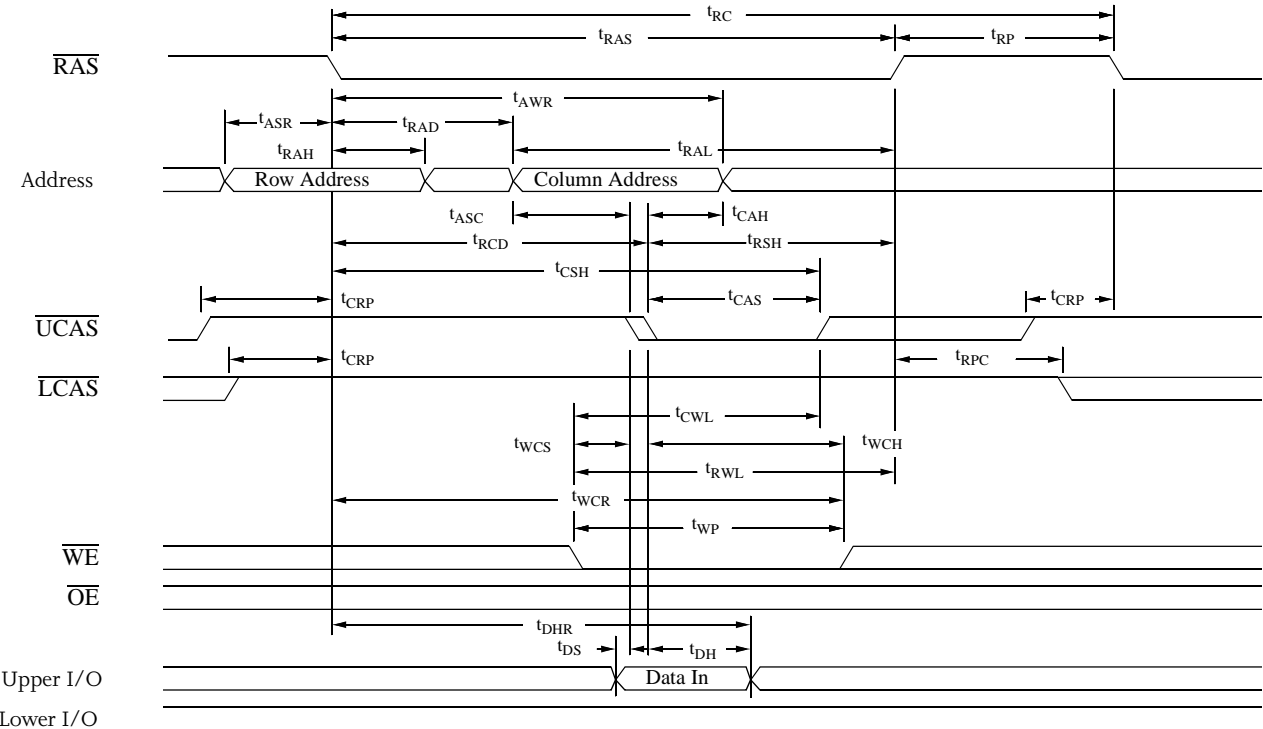




Early write cycle waveform

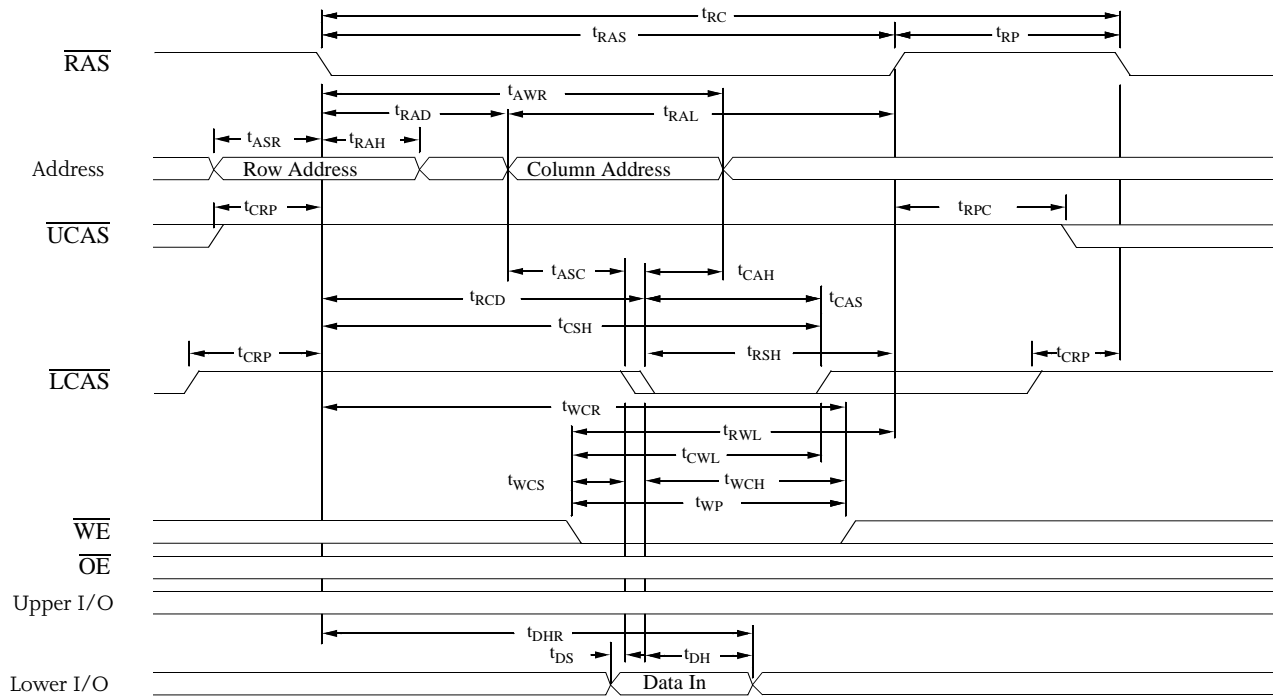


Upper byte early write cycle waveform

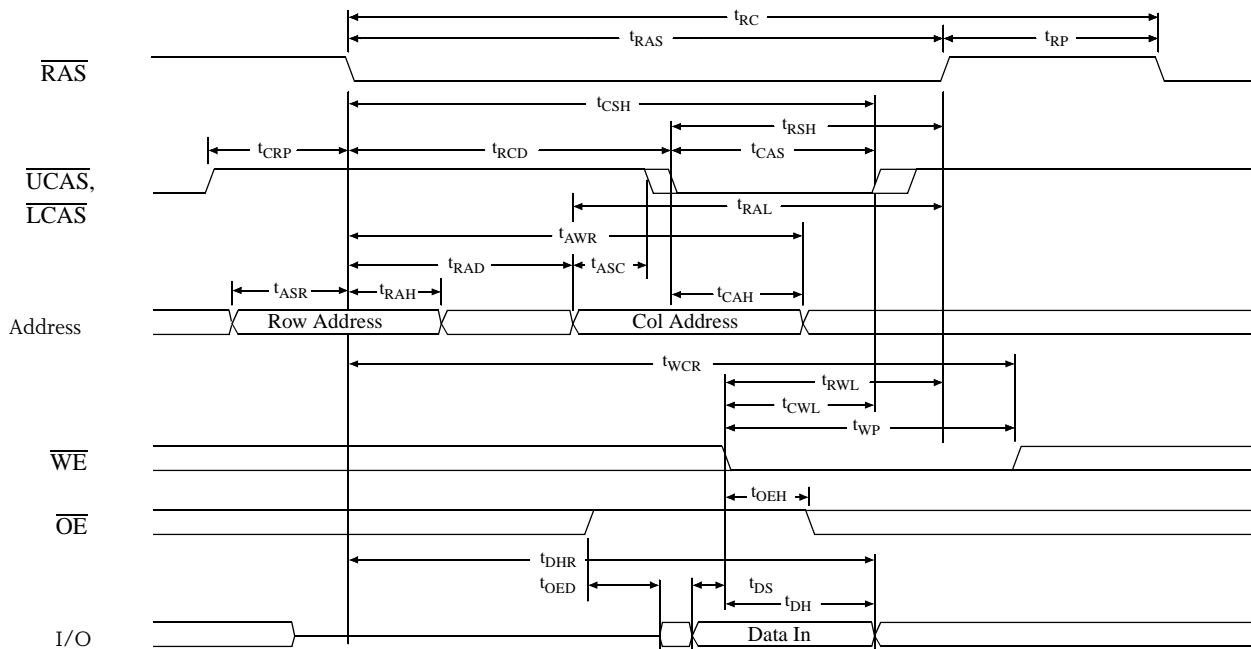




## Lower byte early write cycle waveform

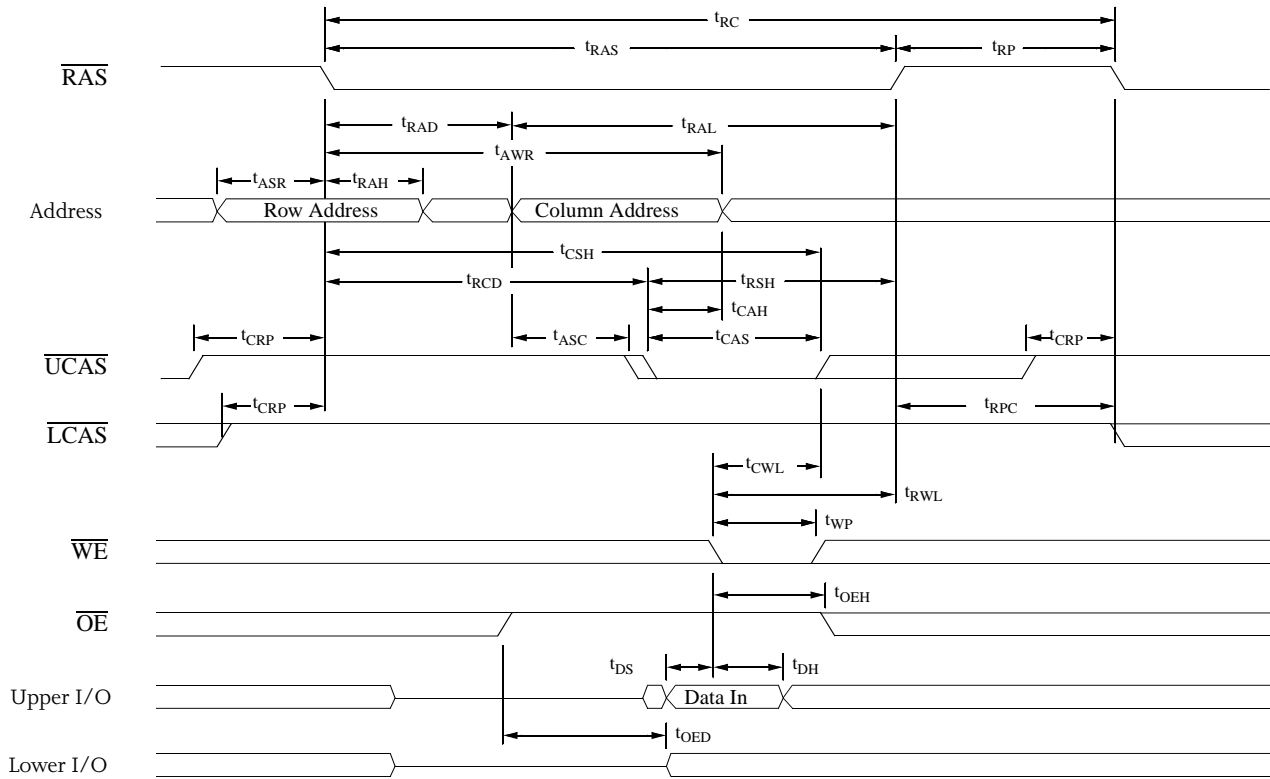


## Write cycle waveform

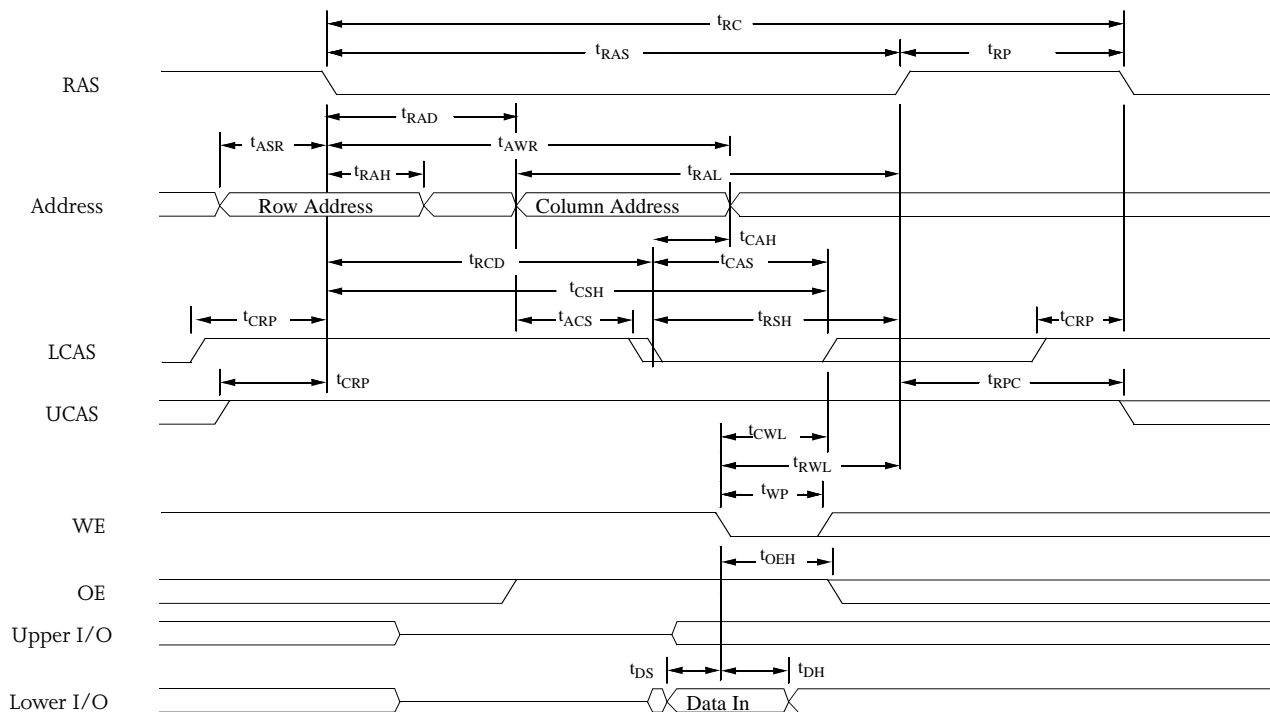
( $\overline{OE}$  controlled)



## Upper byte write cycle waveform

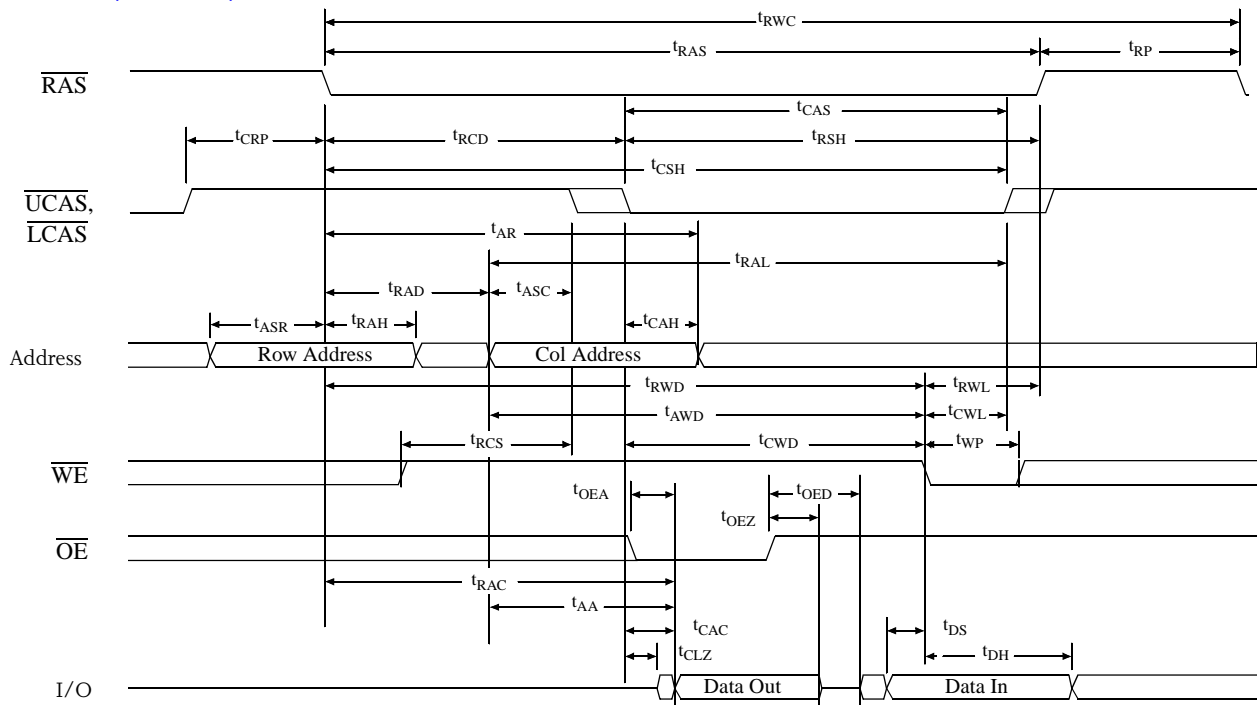
( $\overline{\text{OE}}$  controlled)

## Lower byte write cycle waveform

( $\overline{\text{OE}}$  controlled)

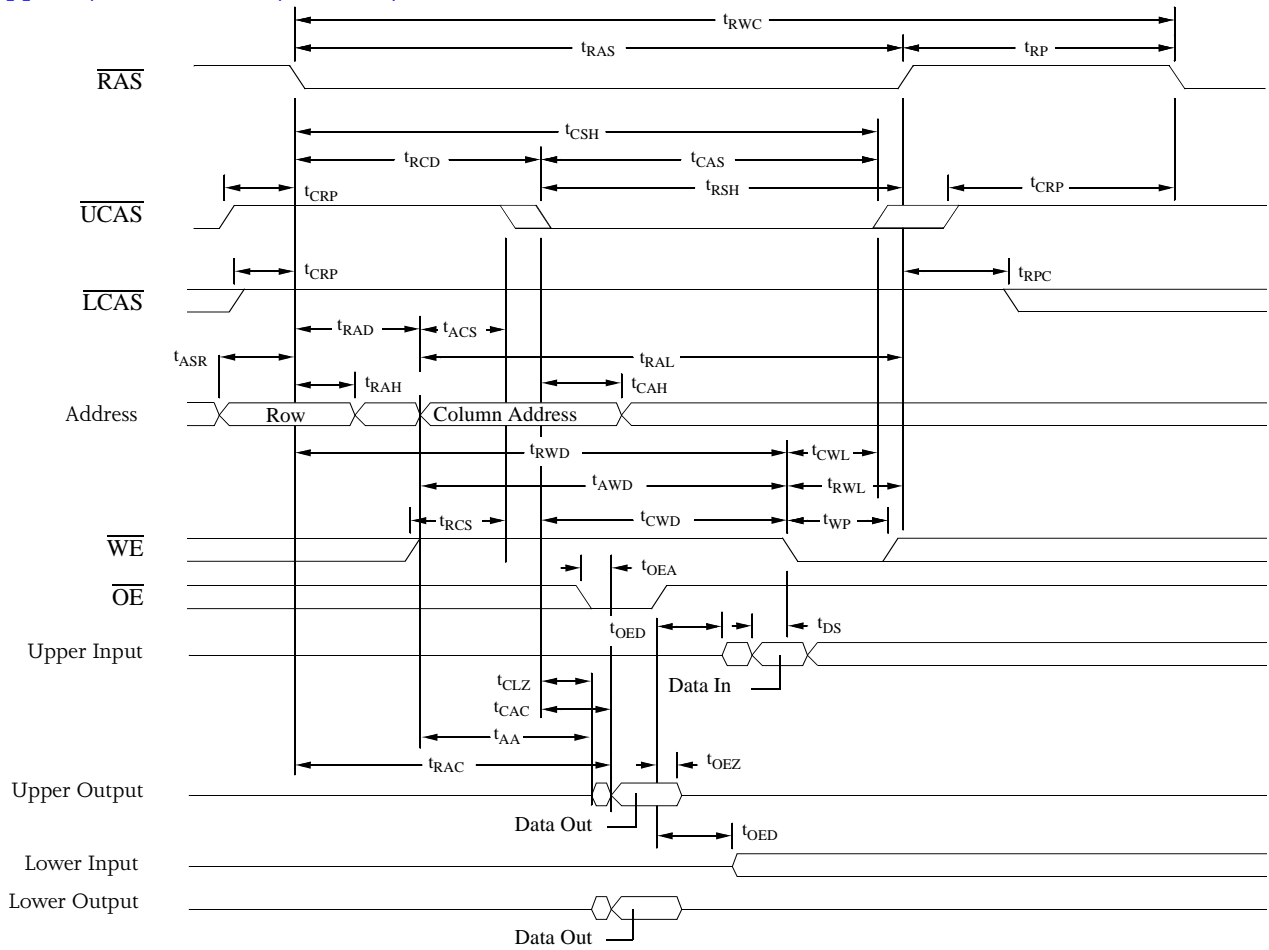


Read-modify-write cycle waveform



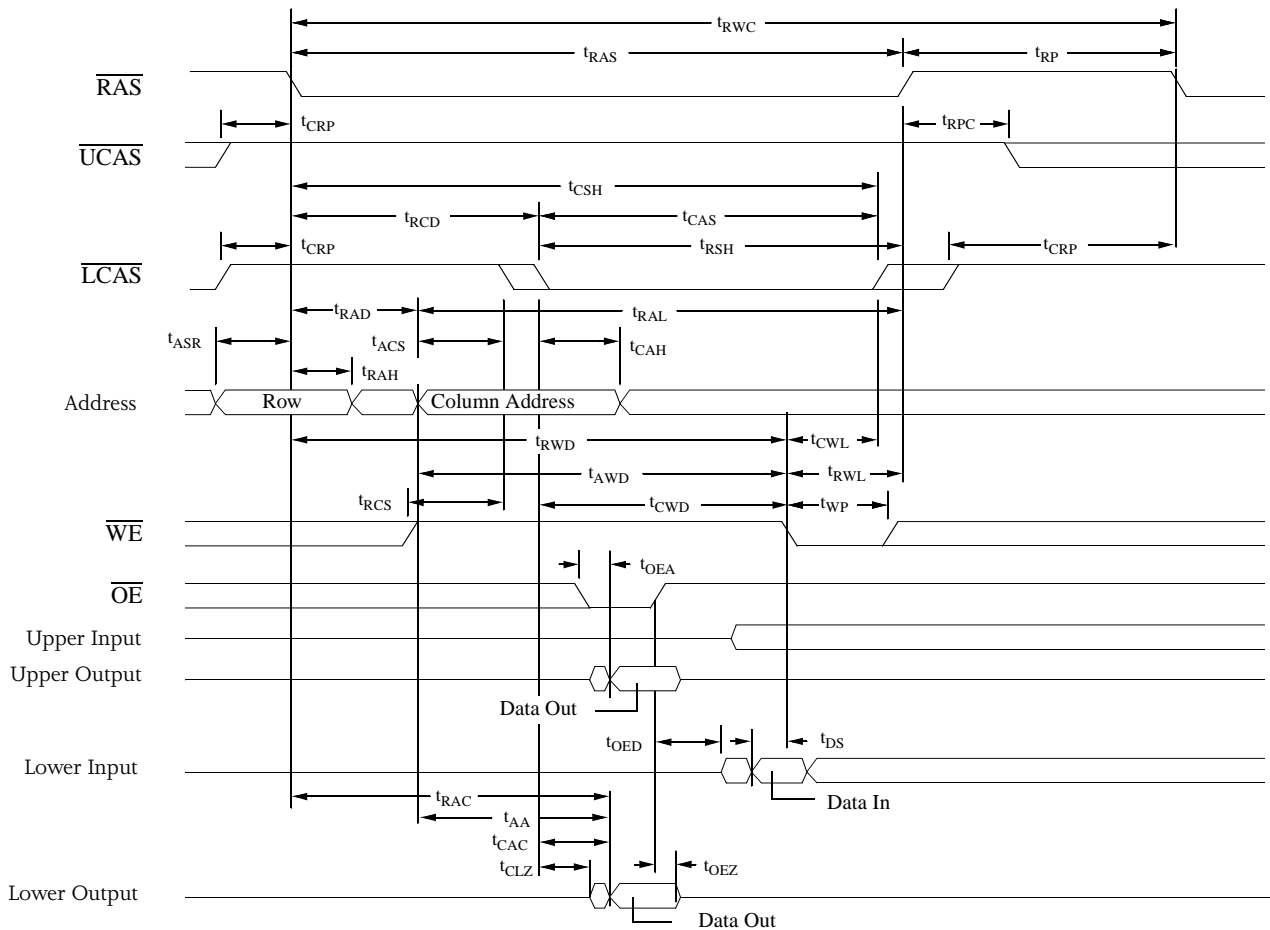


Upper byte read-modify-write cycle waveform



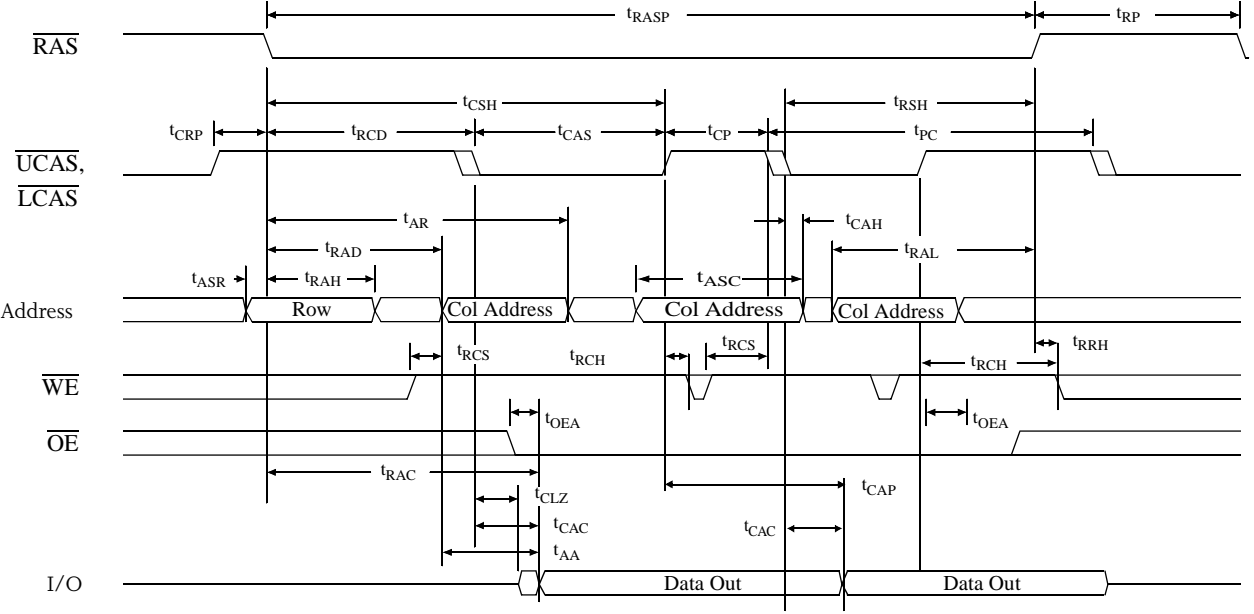


Lower byte read-modify-write cycle waveform

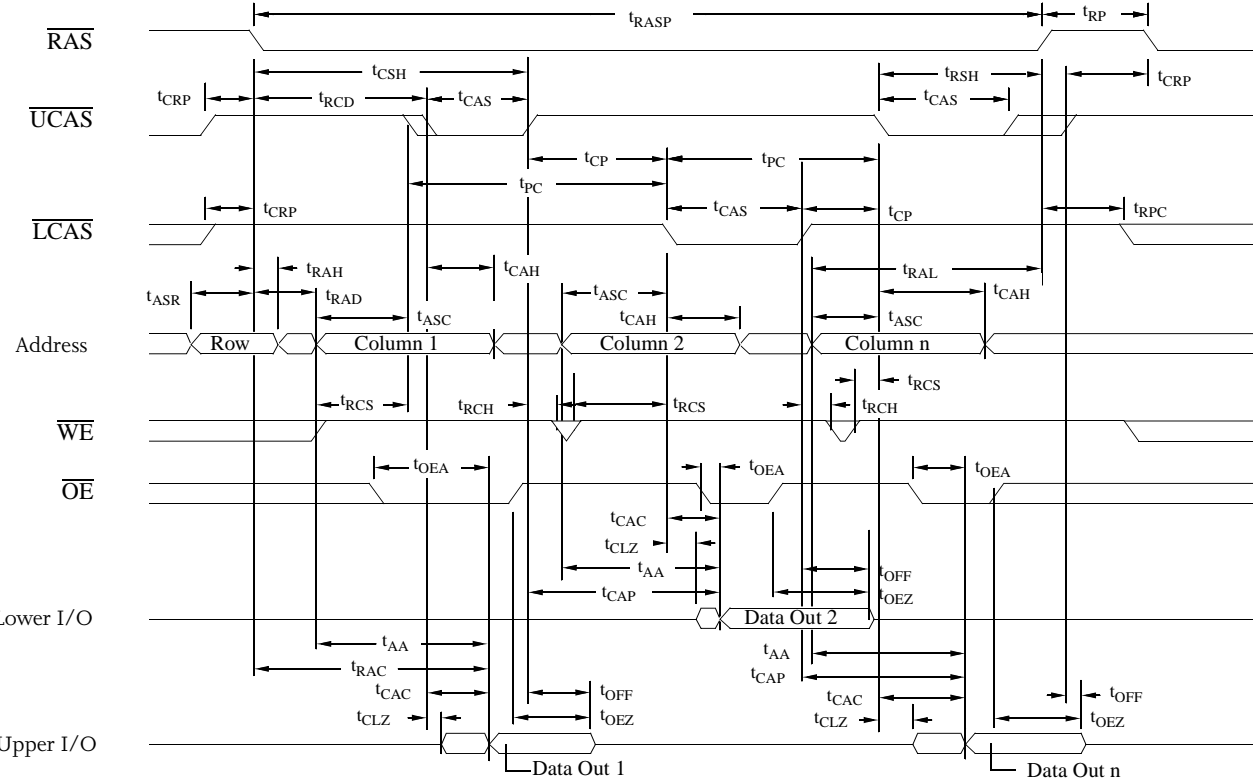




EDO page mode read cycle waveform



EDO page mode byte read cycle waveform

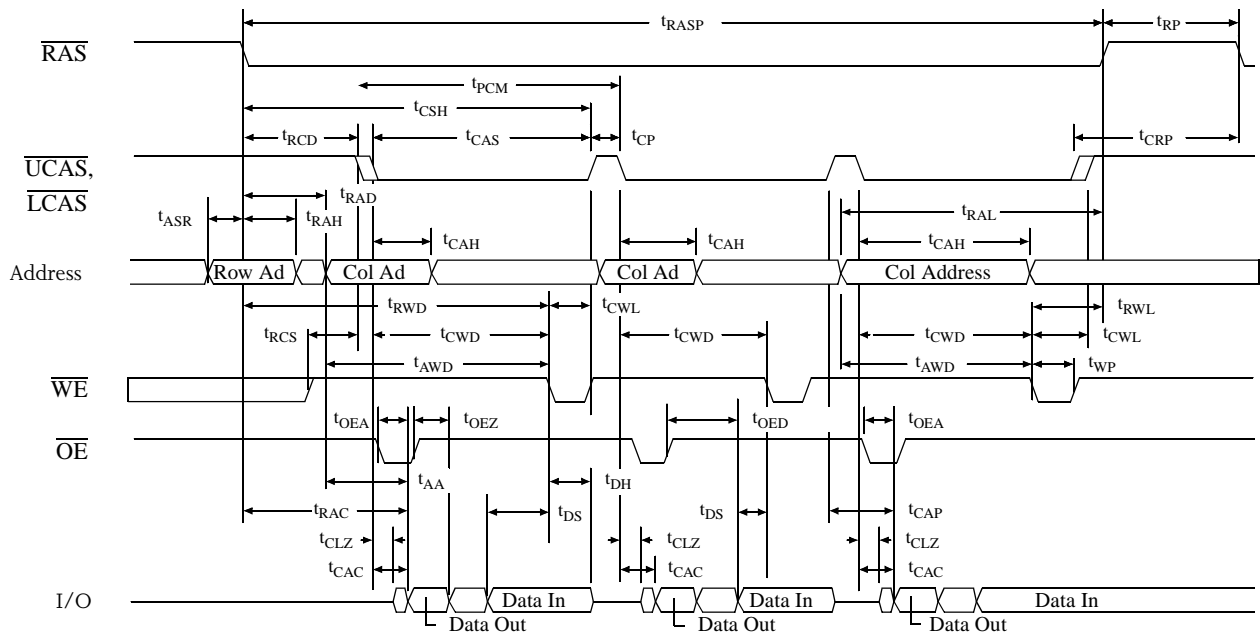






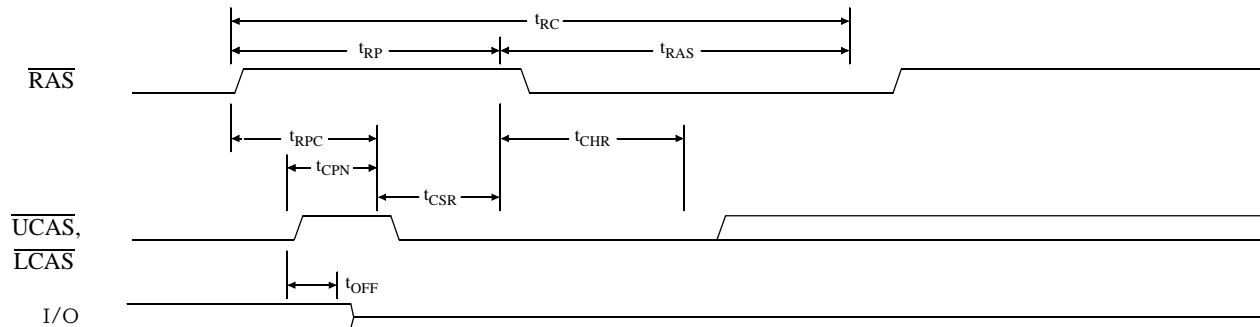


EDO page mode read-modify-write cycle waveform



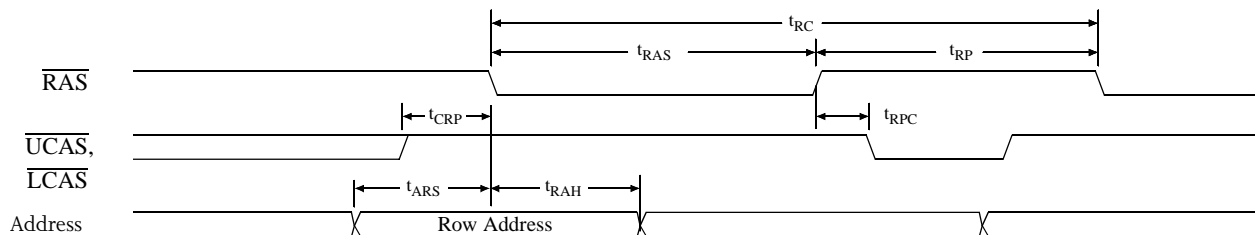
CAS-before-RAS refresh cycle waveform

( $\overline{WE} = V_{IH}$ )



RAS only refresh cycle waveform

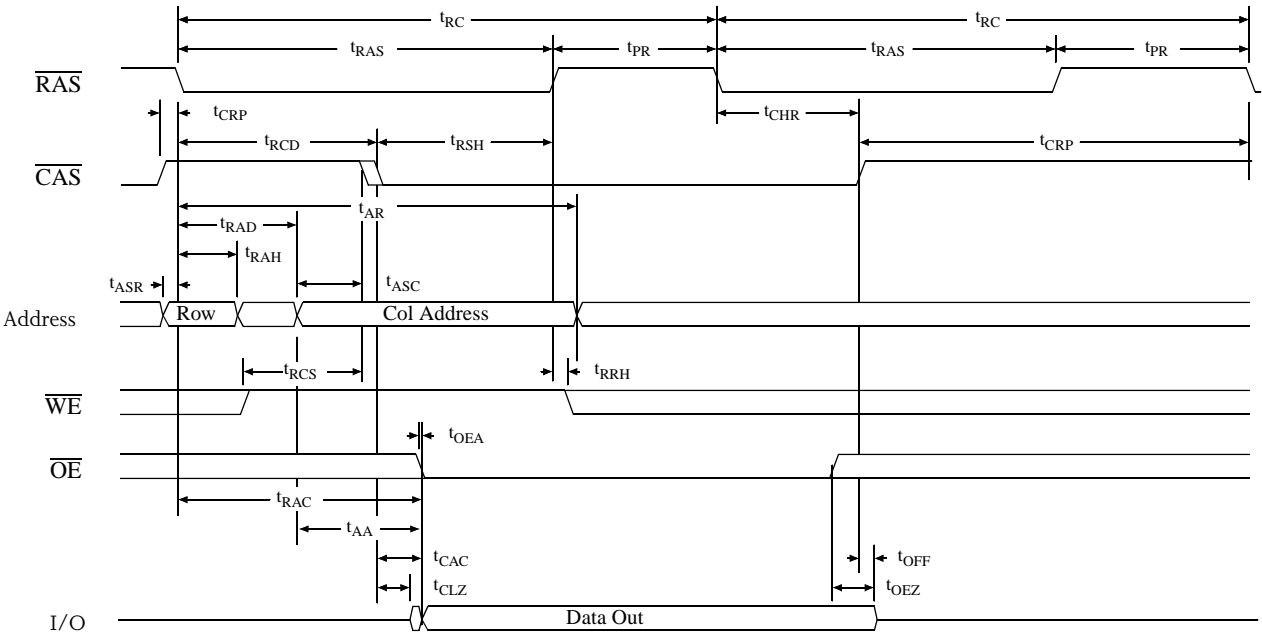
( $\overline{WE} = \overline{OE} = V_{IH}$  or  $V_{IL}$ )



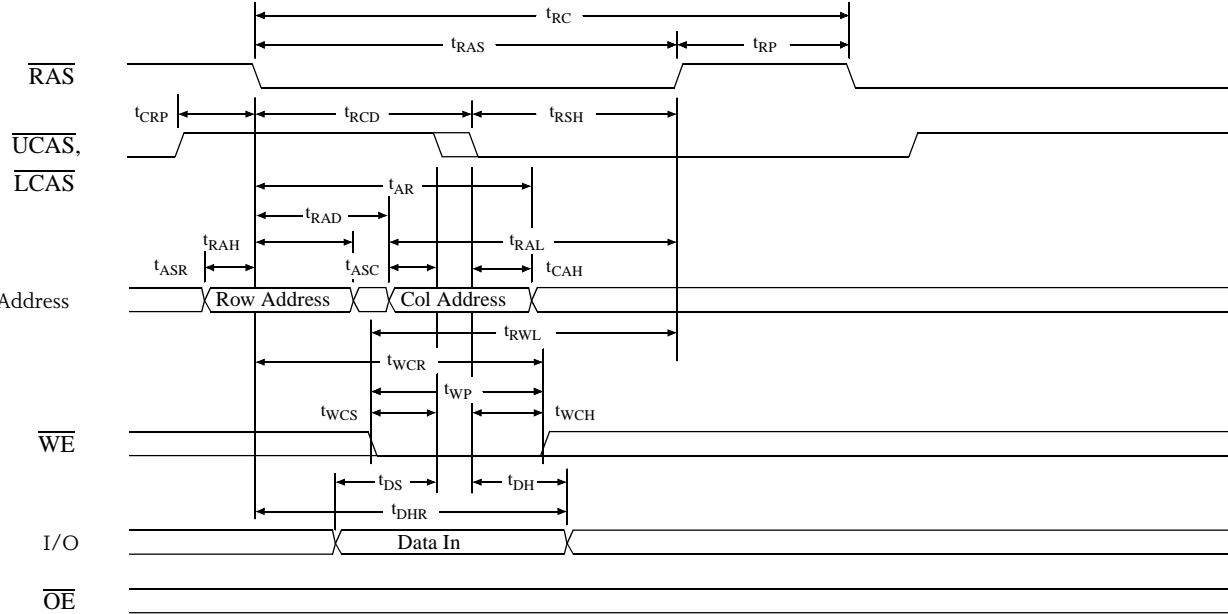




Hidden refresh cycle (read) waveform

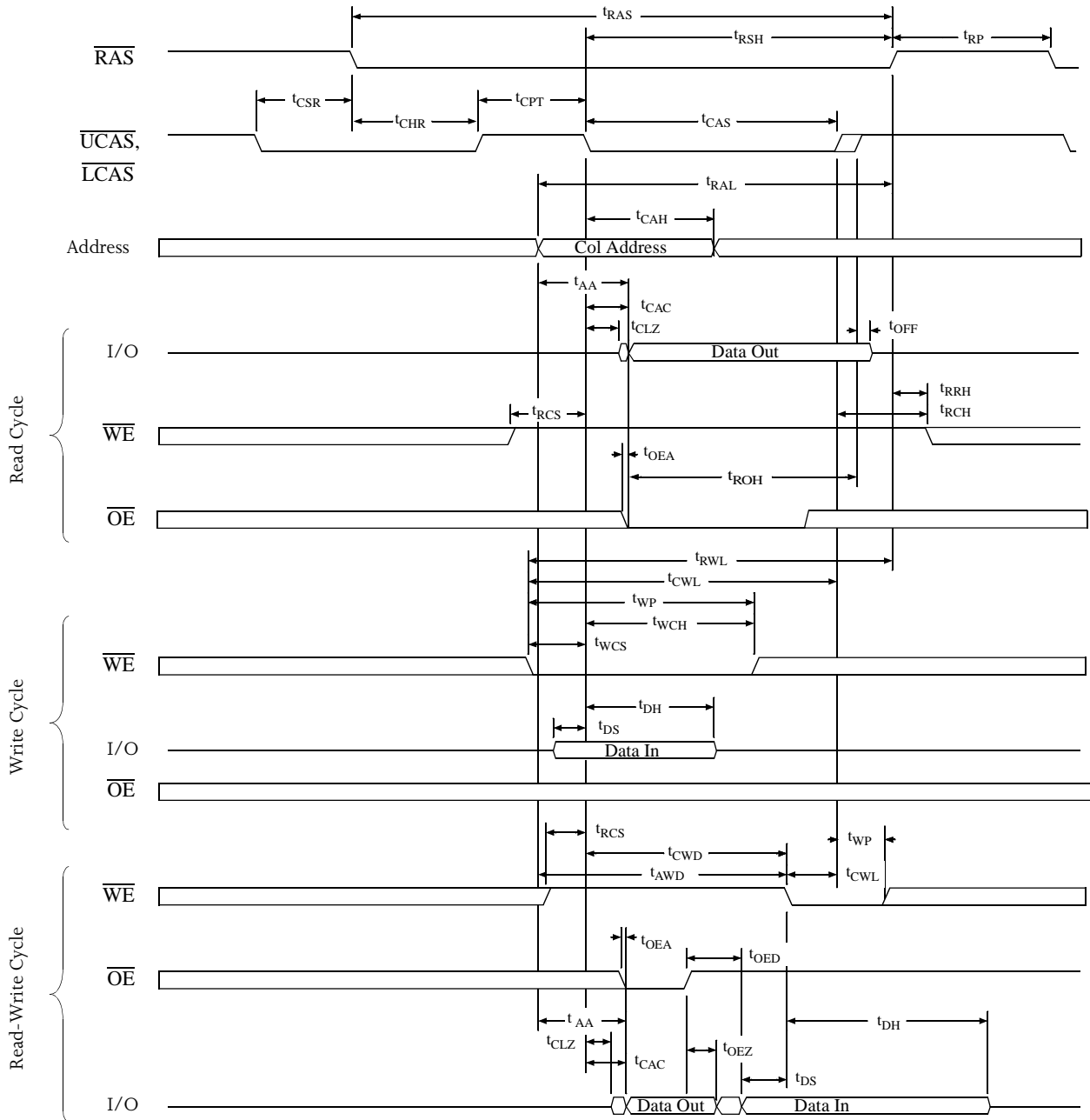


Hidden refresh cycle (write) waveform



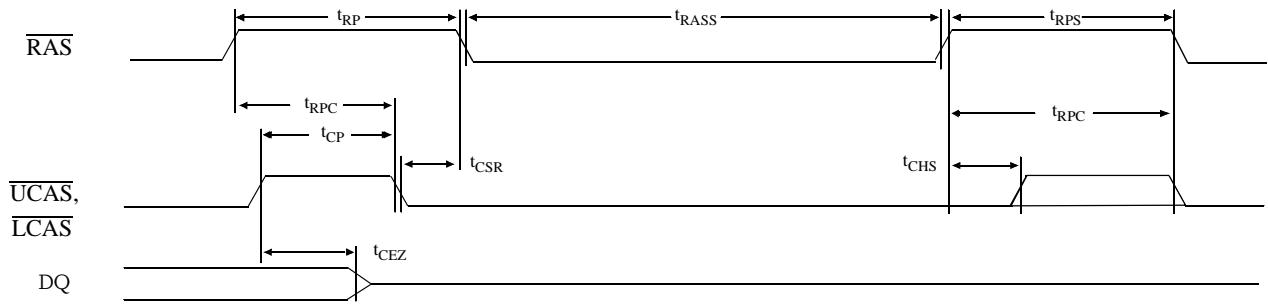


CAS-before-RAS refresh counter test cycle waveform



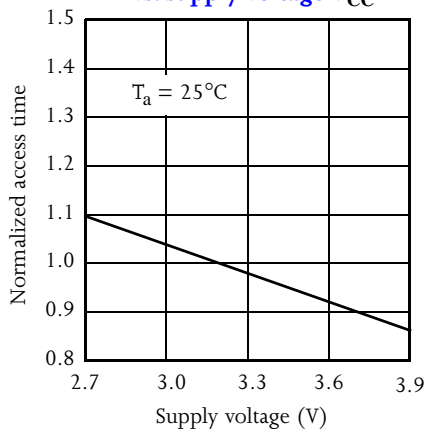


$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  self refresh cycle

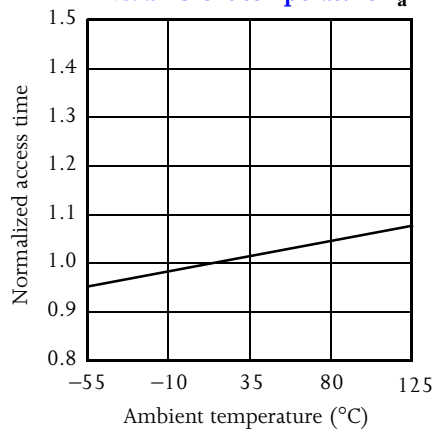


Typical DC and AC characteristics

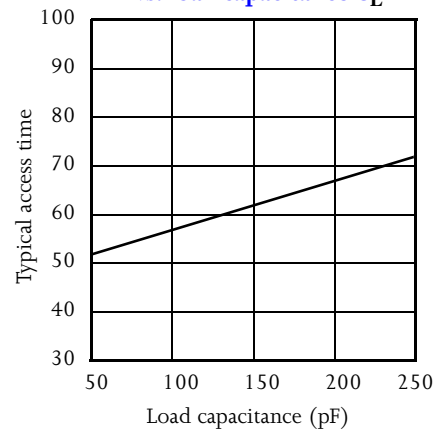
Normalized access time  $t_{RAC}^{RAC}$  vs. supply voltage  $V_{CC}$



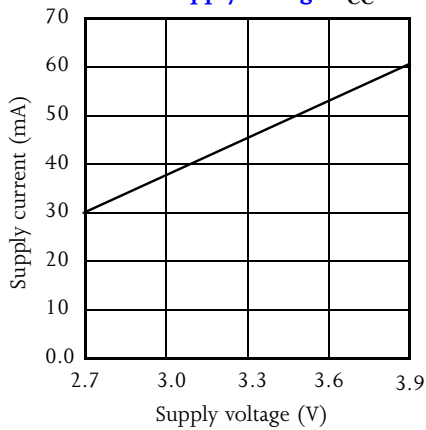
Normalized access time  $t_{RAC}^{RAC}$  vs. ambient temperature  $T_a$



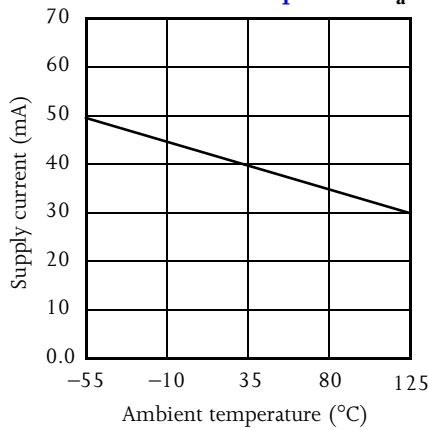
Typical access time  $t_{RAC}^{RAC}$  vs. load capacitance  $C_L$



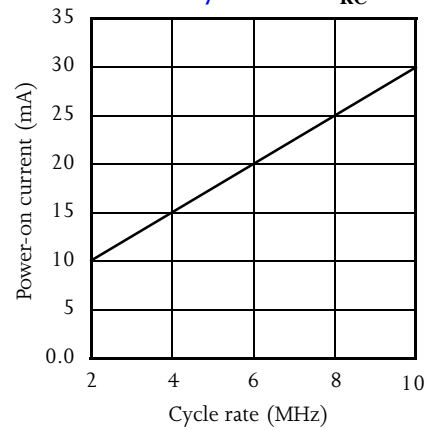
Typical supply current  $I_{CC}$  vs. supply voltage  $V_{CC}$



Typical supply current  $I_{CC}$  vs. ambient temperature  $T_a$

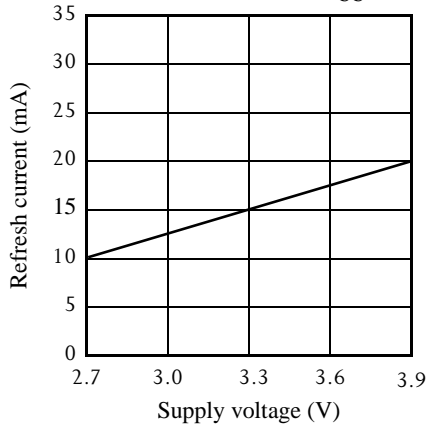


Typical power-on current  $I_{PO}$  vs. cycle rate  $1/t_{RC}$

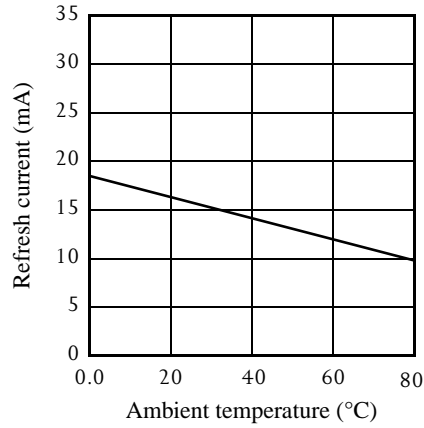




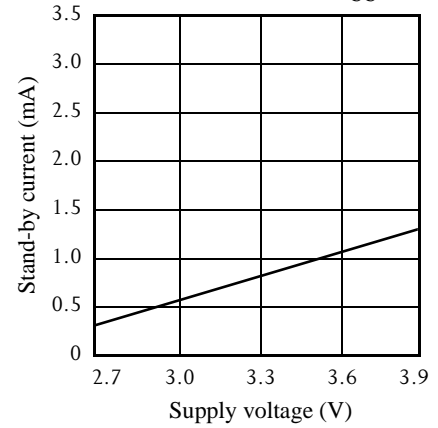
Typical refresh current  $I_{CC3}$   
vs. supply voltage  $V_{CC}$



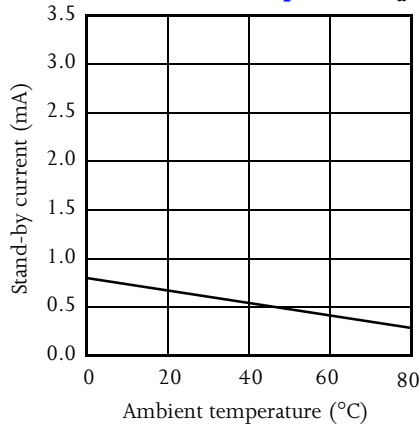
Typical refresh current  $I_{CC3}$   
vs. Ambient temperature  $T_a$



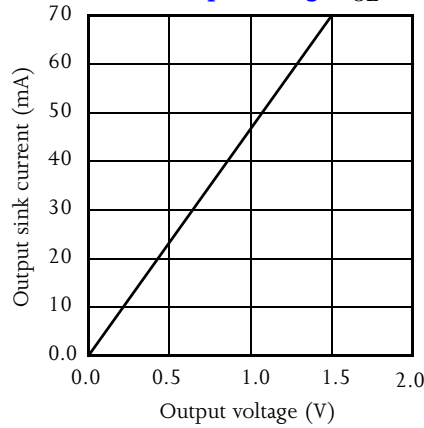
Typical TTL stand-by current  $I_{CC2}$   
vs. supply voltage  $V_{CC}$



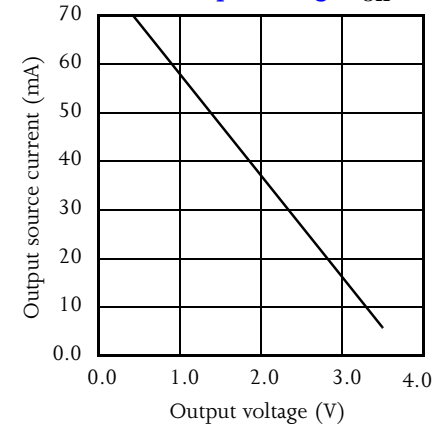
Typical TTL stand-by current  $I_{CC2}$   
vs. ambient temperature  $T_a$



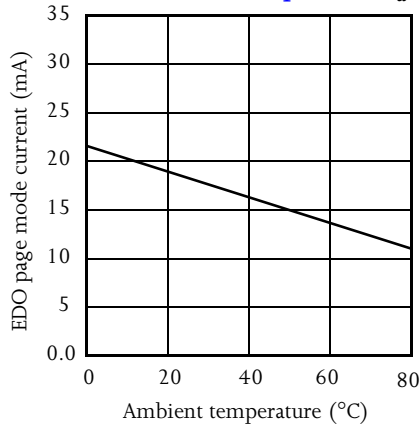
Typical output sink current  $I_{OL}$   
vs. output voltage  $V_{OL}$



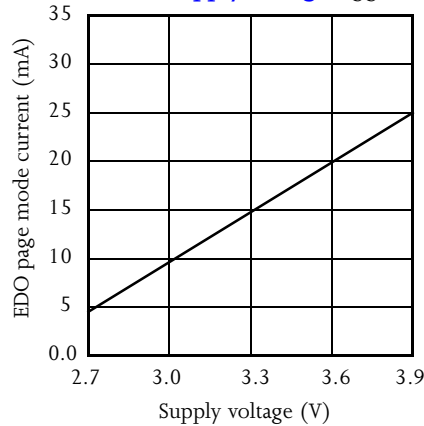
Typical output source current  $I_{OH}$   
vs. output voltage  $V_{OH}$



Typical EDO page mode current  $I_{CC4}$   
vs. ambient temperature  $T_a$

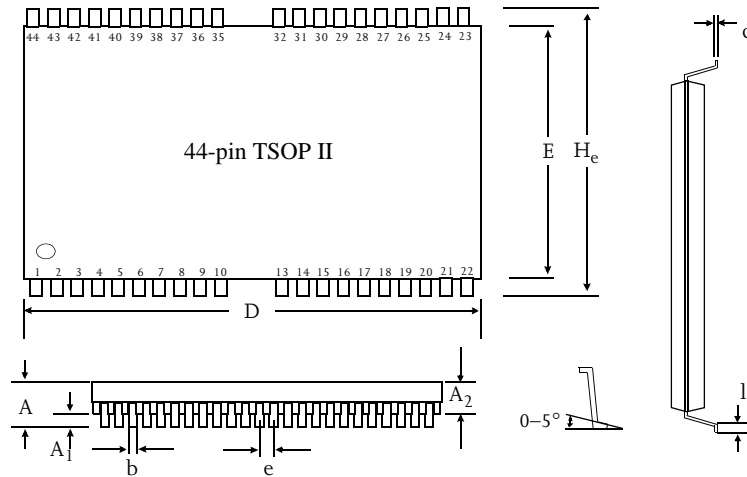


Typical EDO page mode current  $I_{CC4}$   
vs. supply voltage  $V_{CC}$





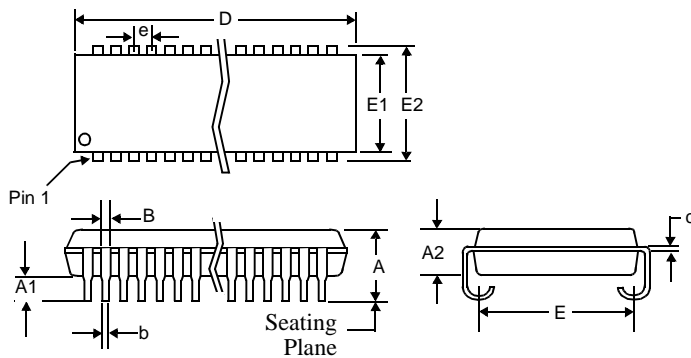
Package dimensions



44-pin TSOP II

	Min (mm)	Max (mm)
A		1.2
A <sub>1</sub>	0.05	
A <sub>2</sub>	0.95	1.05
b	0.30	0.45
c	0.127 (typical)	
D	18.28	18.54
E	10.03	10.29
H <sub>e</sub>	11.56	11.96
e	0.80 (typical)	
l	0.40	0.60

40-pin SOJ



40-pin SOJ  
400 mil

	Min	Max
A	0.128	0.148
A <sub>1</sub>	0.026	-
A <sub>2</sub>	1.105	1.115
B	0.026	0.032
b	0.015	0.020
c	0.007	0.013
D	1.020	1.035
E	0.370 (typical)	
E <sub>1</sub>	0.395	0.405
E <sub>2</sub>	0.435	0.445
e	0.050 (typical)	

Capacitance

f = 1 MHz, T<sub>a</sub> = room temperature, V<sub>CC</sub> = 3.3V ± 0.3V)

Parameter	Symbol	Signals	Test conditions	Max	Unit
Input capacitance	C <sub>IN1</sub>	A0 to A8	V <sub>in</sub> = 0V	5	pF
	C <sub>IN2</sub>	RAS, UCAS, LCAS, WE, OE	V <sub>in</sub> = 0V	7	pF
I/O capacitance	C <sub>I/O</sub>	I/O0 to I/O15	V <sub>in</sub> = V <sub>out</sub> = 0V	7	pF





Ordering codes

Package \ Access time	35 ns	45 ns	60 ns
Plastic SOJ, 400 mil, 40-pin	AS4LC256K16EO-35JC	AS4LC256K16EO-45JC	AS4LC256K16EO-60JC
TSOP II, 400 mil, 40/44-pin	AS4LC256K16EO-35TC	AS4LC256K16EO-45TC	AS4LC256K16EO-60TC

Part numbering system

AS4LC	256K16EO	-XX	X	C
3.3V DRAM prefix	Device number	$\overline{\text{RAS}}$ access time	Package: J = SOJ T = TSOP II	Commercial temperature range, 0°C to 70 °C