

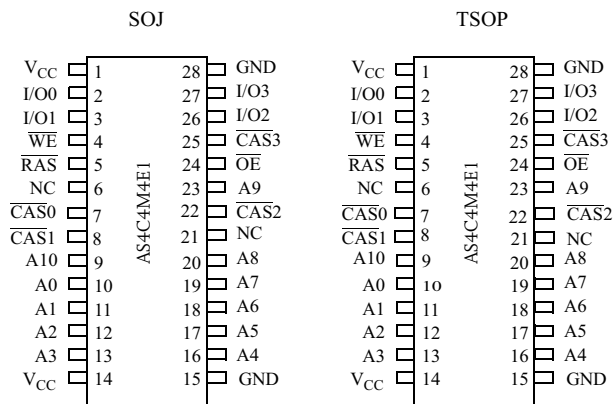


## 4M x 4 CMOS QuadCAS DRAM (EDO) family

### Features

- Organization: 4,194,304 words × 4 bits
- High speed
  - 50/60 ns  $\overline{\text{RAS}}$  access time
  - 25/30 ns column address access time
  - 12/15 ns  $\overline{\text{CAS}}$  access time
- Low power consumption
  - Active: 495 mW max
  - Standby: 5.5 mW max, CMOS I/O
- Extended data out
- Refresh
  - 2048 refresh cycles, 32 ms refresh interval for AS4C4M4E1Q
  - $\overline{\text{RAS}}$ -only and hidden refresh or  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh
- 4 separate  $\overline{\text{CAS}}$  pins allow for separate I/O operation
- JEDEC standard package
  - 300 mil, 28-pin SOJ
  - 300 mil, 28-pin TSOP
- 5V power supply
- Latch-up current  $\geq 200$  mA
- ESD protection  $\geq 2000$  V

### Pin arrangement



### Pin designation

Pin(s)	Description
A0 to A11	Address inputs
$\overline{\text{RAS}}$	Row address strobe
$\overline{\text{CAS}}$	Column address strobe
$\overline{\text{WE}}$	Write enable
I/O0 to I/O3	Input/output
$\overline{\text{OE}}$	Output enable
V <sub>CC</sub>	Power
GND	Ground
NC	No Connection

### Selection guide

	Symbol	AS4C4M4E1Q-50	AS4C4M4E1Q-60	Unit
Maximum $\overline{\text{RAS}}$ access time	$t_{\text{RAC}}$	50	60	ns
Maximum column address access time	$t_{\text{CAA}}$	25	30	ns
Maximum $\overline{\text{CAS}}$ access time	$t_{\text{CAC}}$	12	15	ns
Maximum output enable ( $\overline{\text{OE}}$ ) access time	$t_{\text{OEA}}$	13	15	ns
Minimum read or write cycle time	$t_{\text{RC}}$	85	100	ns
Minimum hyper page mode cycle time	$t_{\text{PC}}$	20	24	ns
Maximum operating current	$I_{\text{CC1}}$	135	120	mA
Maximum CMOS standby current	$I_{\text{CC5}}$	2.0	2.0	mA



## Functional description

The AS4C4M4E1Q is a high performance 16-megabit CMOS Quad  $\overline{\text{CAS}}$  Dynamic Random Access Memories (DRAM) organized as 4,194,304 words  $\times$  4 bits. The devices are fabricated using advanced CMOS technology and innovative design techniques resulting in high speed, extremely low power and wide operating margins at component and system levels. The Alliance 16Mb DRAM family is optimized for use as main memory in PC, workstation, router and switch applications.

This product features a high speed page mode operation where read and write operations within a single row (or page) can be executed at very high speed by toggling column addresses within that row. Row and column addresses are alternately latched into input buffers using the falling edge of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  inputs respectively. Also,  $\overline{\text{RAS}}$  is used to make the column address latch transparent, enabling application of column addresses prior to  $\overline{\text{CAS}}$  assertion.

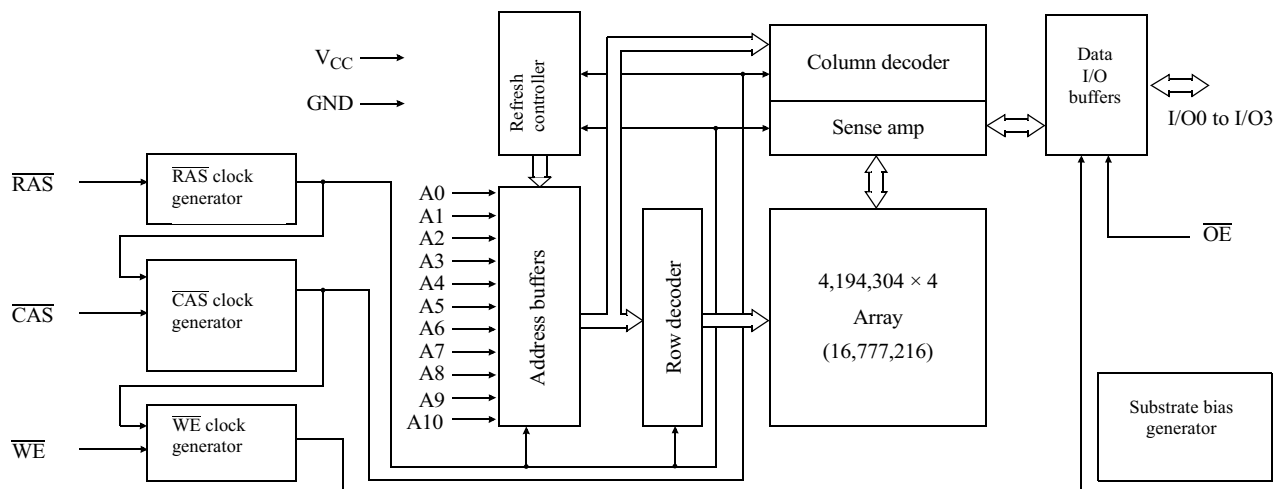
Extended data out (EDO) read mode enables 50 MHz operation using 50 ns devices. Four individual  $\overline{\text{CAS}}$  pins allow for separate I/O operation which enables the device to operate in parity mode. In contrast to 'fast page mode' devices, data remains active on outputs after  $\overline{\text{CAS}}$  is de-asserted high, giving system logic more time to latch the data. Use  $\overline{\text{OE}}$  and  $\overline{\text{WE}}$  to control output impedance and prevent bus contention during read-modify-write and shared bus applications. Outputs also go to high impedance at the last occurrence of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  going high.

Refresh on the 2048 address combinations of A0 to A10 must be performed every 32 ms using:

- $\overline{\text{RAS}}$ -only refresh:  $\overline{\text{RAS}}$  is asserted while  $\overline{\text{CAS}}$  is held high. Each of the 2048 rows must be strobed. Outputs remain high impedance.
- Hidden refresh:  $\overline{\text{CAS}}$  is held low while  $\overline{\text{RAS}}$  is toggled. Refresh address is generated internally. Outputs remain low impedance with previous valid data.
- $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh (CBR): At least one  $\overline{\text{CAS}}$  is asserted prior to  $\overline{\text{RAS}}$ . Refresh address is generated internally. Outputs are high-impedance ( $\overline{\text{OE}}$  and  $\overline{\text{WE}}$  are don't care).
- Normal read or write cycles refresh the row being accessed.

The AS4C4M4E1Q is available in the standard 28-pin plastic SOJ and 28-pin plastic TSOP packages. The AS4C4M4E1Q operates with a single power supply of  $5\text{V} \pm 0.5\text{V}$ . All provide TTL compatible inputs and outputs.

## Logic block diagram for 2K refresh



## Recommended operating conditions

Parameter	Symbol	Min	Nominal	Max	Unit
Supply voltage	$V_{CC}$	4.5	5.0	5.5	V
	GND	0.0	0.0	0.0	V
Input voltage	$V_{IH}$	2.4	—	$V_{CC}$	V
	$V_{IL}$	$-0.5^{\dagger}$	—	0.8	V
Ambient operating temperature	$T_A$	0		70	$^{\circ}\text{C}$

$^{\dagger}V_{IL}$  min -3.0V for pulse widths less than 5 ns. Recommended operating conditions apply throughout this document unless otherwise specified.



### Absolute maximum ratings

Parameter	Symbol	Min	Max	Unit
Input voltage	$V_{in}$	-1.0	+7.0	V
Input voltage (DQs)	$V_{DQ}$	-1.0	$V_{CC} + 0.5$	V
Power supply voltage	$V_{CC}$	-1.0	+7.0	V
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

### DC electrical characteristics (AS4C4M4E1)

Parameter	Symbol	Test conditions	-50		-60		Unit	Notes
			Min	Max	Min	Max		
Input leakage current	$I_{IL}$	$0V \leq V_{in} \leq +5.5V$ , Pins not under test = 0V	-5	+5	-5	+5	μA	
Output leakage current	$I_{OL}$	$D_{OUT}$ disabled, $0V \leq V_{out} \leq +5.5V$	-5	+5	-5	+5	μA	
Operating power supply current	$I_{CC1}$	$\overline{RAS}$ , $\overline{UCAS}$ , $\overline{LCAS}$ , Address cycling; $t_{RC} = \min$	—	135	—	120	mA	1,2
TTL standby power supply current	$I_{CC2}$	$\overline{RAS} = \overline{UCAS} = \overline{LCAS} \geq V_{IH}$	—	2.0	—	2.0	mA	
Average power supply current, $\overline{RAS}$ refresh mode or CBR	$I_{CC3}$	$\overline{RAS}$ cycling, $\overline{UCAS} = \overline{LCAS} \geq V_{IH}$ , $t_{RC} = \min$ of $\overline{RAS}$ low after $\overline{XCAS}$ low.	—	120	—	110	mA	1
EDO page mode average power supply current	$I_{CC4}$	$\overline{RAS} = V_{IL}$ , $\overline{UCAS}$ or $\overline{LCAS}$ , address cycling: $t_{HPC} = \min$	—	130	—	120	mA	1, 2
CMOS standby power supply current	$I_{CC5}$	$\overline{RAS} = \overline{UCAS} = \overline{LCAS} = V_{CC} - 0.2V$	—	2.0	—	2.0	mA	
Output voltage	$V_{OH}$	$I_{OUT} = -5.0 \text{ mA}$	2.4	—	2.4	—	V	
	$V_{OL}$	$I_{OUT} = 4.2 \text{ mA}$	—	0.4	—	0.4	V	
CAS before $\overline{RAS}$ refresh current	$I_{CC6}$	$\overline{RAS}$ , $\overline{UCAS}$ or $\overline{LCAS}$ cycling, $t_{RC} = \min$	—	120	—	110	mA	



## AC parameters common to all waveforms

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
$t_{RC}$	Random read or write cycle time	80	—	100	—	ns	
$t_{RP}$	$\overline{RAS}$ precharge time	30	—	40	—	ns	
$t_{RAS}$	$\overline{RAS}$ pulse width	50	10K	60	10K	ns	
$t_{CAS}$	$\overline{CAS}$ pulse width	8	10K	10	10K	ns	
$t_{RCD}$	$\overline{RAS}$ to $\overline{CAS}$ delay time	15	35	15	43	ns	6
$t_{RAD}$	$\overline{RAS}$ to column address delay time	12	25	12	30	ns	7
$t_{RSH}$	$\overline{CAS}$ to $\overline{RAS}$ hold time	10	—	10	—	ns	
$t_{CSH}$	$\overline{RAS}$ to $\overline{CAS}$ hold time	40	—	50	—	ns	
$t_{CRP}$	$\overline{CAS}$ to $\overline{RAS}$ precharge time	5	—	5	—	ns	
$t_{ASR}$	Row address setup time	0	—	0	—	ns	
$t_{RAH}$	Row address hold time	8	—	10	—	ns	
$t_T$	Transition time (rise and fall)	1	50	1	50	ns	4,5
$t_{REF}$	Refresh period	—	32	—	32	ms	16
$t_{CP}$	$\overline{CAS}$ precharge time	8	—	10	—	ns	
$t_{RAL}$	Column address to $\overline{RAS}$ lead time	25	—	30	—	ns	
$t_{ASC}$	Column address setup time	0	—	0	—	ns	
$t_{CAH}$	Column address hold time	8	—	10	—	ns	

## Read cycle

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
$t_{RAC}$	Access time from $\overline{RAS}$	—	50	—	60	ns	6
$t_{CAC}$	Access time from $\overline{CAS}$	—	12	—	15	ns	6,13
$t_{AA}$	Access time from address	—	25	—	30	ns	7,13
$t_{RCS}$	Read command setup time	0	—	0	—	ns	
$t_{RCH}$	Read command hold time to $\overline{CAS}$	0	—	0	—	ns	9
$t_{RRH}$	Read command hold time to $\overline{RAS}$	0	—	0	—	ns	9



### Write cycle

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
$t_{WCS}$	Write command setup time	0	—	0	—	ns	11
$t_{WCH}$	Write command hold time	10	—	10	—	ns	11
$t_{WP}$	Write command pulse width	10	—	10	—	ns	
$t_{RWL}$	Write command to $\overline{RAS}$ lead time	10	—	10	—	ns	
$t_{CWL}$	Write command to $\overline{CAS}$ lead time	8	—	10	—	ns	
$t_{DS}$	Data-in setup time	0	—	0	—	ns	12
$t_{DH}$	Data-in hold time	8	—	10	—	ns	12

### Read-modify-write cycle

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
$t_{RWC}$	Read-write cycle time	113	—	135	—	ns	
$t_{RWD}$	$\overline{RAS}$ to $\overline{WE}$ delay time	67	—	77	—	ns	11
$t_{CWD}$	$\overline{CAS}$ to $\overline{WE}$ delay time	32	—	35	—	ns	11
$t_{AWD}$	Column address to $\overline{WE}$ delay time	42	—	47	—	ns	11

### Refresh cycle

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
$t_{CSR}$	$\overline{CAS}$ setup time ( $\overline{CAS}$ -before- $\overline{RAS}$ )	5	—	5	—	ns	3
$t_{CHR}$	$\overline{CAS}$ hold time ( $\overline{CAS}$ -before- $\overline{RAS}$ )	8	—	10	—	ns	3
$t_{RPC}$	$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	0	—	0	—	ns	
$t_{CPT}$	$\overline{CAS}$ precharge time (CBR counter test)	10		10	—	ns	



### Hyper page mode cycle

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
$t_{CPWD}$	$\overline{CAS}$ precharge to $\overline{WE}$ delay time	45	—	52	—	ns	
$t_{CPA}$	Access time from $\overline{CAS}$ precharge	—	28	—	35	ns	13
$t_{RASP}$	$\overline{RAS}$ pulse width	50	100K	60	100K	ns	
$t_{DOH}$	Previous data hold time from $\overline{CAS}$	5	—	5	—	ns	
$t_{REZ}$	Output buffer turn off delay from $\overline{RAS}$	0	13	0	15	ns	
$t_{WEZ}$	Output buffer turn off delay from $\overline{WE}$	0	13	0	15	ns	
$t_{OEZ}$	Output buffer turn off delay from $\overline{OE}$	0	13	0	15	ns	
$t_{HPC}$	Hyper page mode cycle time	20	—	25	—	ns	
$t_{HPRWC}$	Hyper page mode RMW cycle	47	—	56	—	ns	
$t_{RHCP}$	$\overline{RAS}$ hold time from $\overline{CAS}$	30	—	35	—	ns	

### Output enable

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
$t_{CLZ}$	$\overline{CAS}$ to output in Low Z	0	—	0	—	ns	8
$t_{ROH}$	$\overline{RAS}$ hold time referenced to $\overline{OE}$	8	—	10	—	ns	
$t_{OEA}$	$\overline{OE}$ access time	—	13	—	15	ns	
$t_{OED}$	$\overline{OE}$ to data delay	13	—	15	—	ns	
$t_{OEZ}$	Output buffer turnoff delay from $\overline{OE}$	0	13	0	15	ns	8
$t_{OEH}$	$\overline{OE}$ command hold time	10	—	10	—	ns	
$t_{OLZ}$	$\overline{OE}$ to output in Low Z	0	—	0	—	ns	
$t_{OFF}$	Output buffer turn-off time	0	13	0	15	ns	8,10

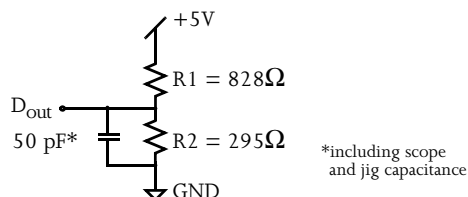


## Notes

- 1  $I_{CC1}$ ,  $I_{CC3}$ ,  $I_{CC4}$ , and  $I_{CC6}$  are dependent on frequency.
- 2  $I_{CC1}$  and  $I_{CC4}$  depend on output loading. Specified values are obtained with the output open.
- 3 An initial pause of 200  $\mu$ s is required after power-up followed by any 8  $\overline{RAS}$  cycles before proper device operation is achieved. In the case of an internal refresh counter, a minimum of 8  $\overline{CAS}$ -before- $\overline{RAS}$  initialization cycles instead of 8  $\overline{RAS}$  cycles are required. 8 initialization cycles are required after extended periods of bias without clocks (greater than 8 ms).
- 4 AC Characteristics assume  $t_T = 2$  ns. All AC parameters are measured with a load equivalent to two TTL loads and 50 pF,  $V_{IL}(\min) \geq GND$  and  $V_{IH}(\max) \leq V_{CC}$ .
- 5  $V_{IH}(\min)$  and  $V_{IL}(\max)$  are reference levels for measuring timing of input signals. Transition times are measured between  $V_{IH}$  and  $V_{IL}$ .
- 6 Operation within the  $t_{RCD}(\max)$  limit insures that  $t_{RAC}(\max)$  can be met.  $t_{RCD}(\max)$  is specified as a reference point only. If  $t_{RCD}$  is greater than the specified  $t_{RCD}(\max)$  limit, then access time is controlled exclusively by  $t_{CAC}$ .
- 7 Operation within the  $t_{RAD}(\max)$  limit insures that  $t_{RAC}(\max)$  can be met.  $t_{RAD}(\max)$  is specified as a reference point only. If  $t_{RAD}$  is greater than the specified  $t_{RAD}(\max)$  limit, then access time is controlled exclusively by  $t_{AA}$ .
- 8 Assumes three state test load (5 pF and a 380  $\Omega$  Thevenin equivalent).
- 9 Either  $t_{RCH}$  or  $t_{RRH}$  must be satisfied for a read cycle.
- 10  $t_{OFF}(\max)$  defines the time at which the output achieves the open circuit condition; it is not referenced to output voltage levels.  $t_{OFF}$  is referenced from rising edge of  $\overline{RAS}$  or  $\overline{CAS}$ , whichever occurs last.
- 11  $t_{WCS}$ ,  $t_{WCH}$ ,  $t_{RWD}$ ,  $t_{CWD}$  and  $t_{AWD}$  are not restrictive operating parameters. They are included in the datasheet as electrical characteristics only.  
If  $t_{WS} \geq t_{WS}(\min)$  and  $t_{WH} \geq t_{WH}(\min)$ , the cycle is an early write cycle and data out pins will remain open circuit, high impedance, throughout the cycle. If  $t_{RWD} \geq t_{RWD}(\min)$ ,  $t_{CWD} \geq t_{CWD}(\min)$  and  $t_{AWD} \geq t_{AWD}(\min)$ , 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.
- 12 These parameters are referenced to  $\overline{CAS}$  leading edge in early write cycles and to  $\overline{WE}$  leading edge in read-write cycles.
- 13 Access time is determined by the longest of  $t_{CAA}$  or  $t_{CAC}$  or  $t_{CPA}$ .
- 14  $t_{ASC} \geq t_{CP}$  to achieve  $t_{PC}(\min)$  and  $t_{CPA}(\max)$  values.
- 15 These parameters are sampled and not 100% tested.
- 16 These characteristics apply to AS4C4M4E1Q 5V devices.

## AC test conditions

- Access times are measured with output reference levels of  $V_{OH} = 2.4V$  and  $V_{OL} = 0.4V$ ,  
 $V_{IH} = 2.4V$  and  $V_{IL} = 0.8V$
- Input rise and fall times: 2 ns



\*including scope and jig capacitance

Figure A: Equivalent output load  
(AS4C4M4E1)

## Key to switching waveforms



Rising input



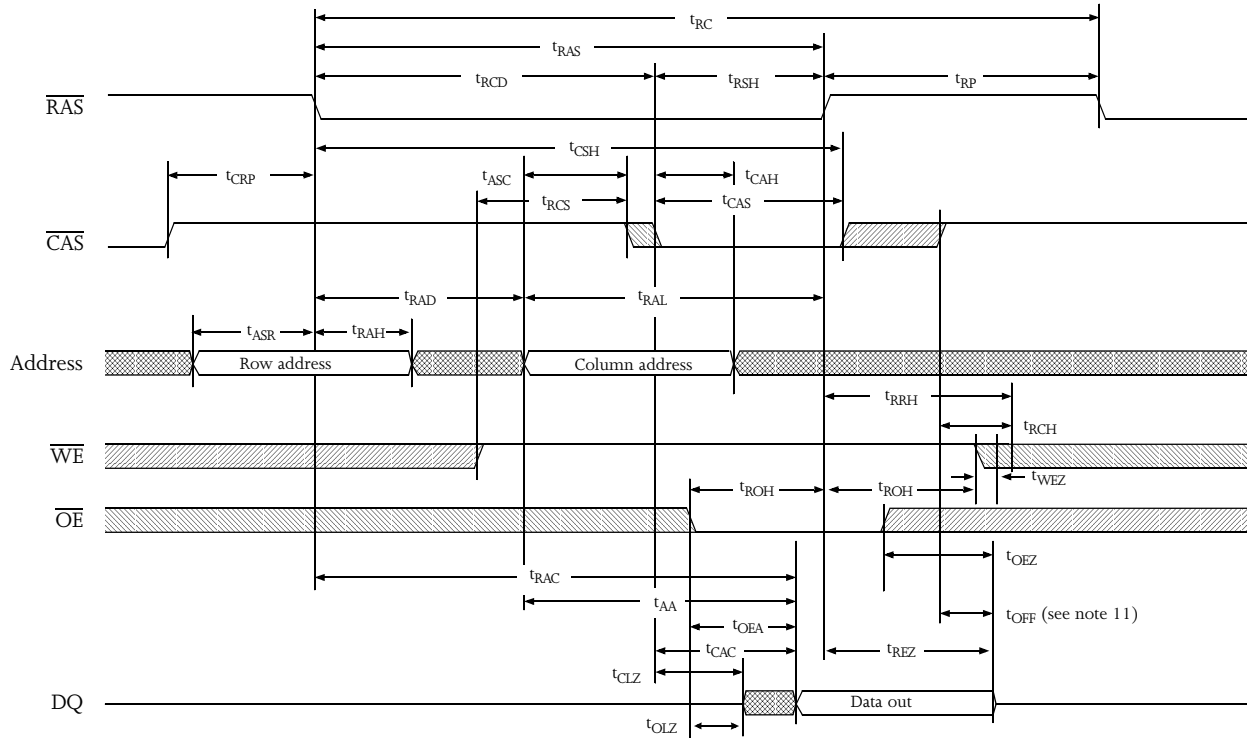
Falling input



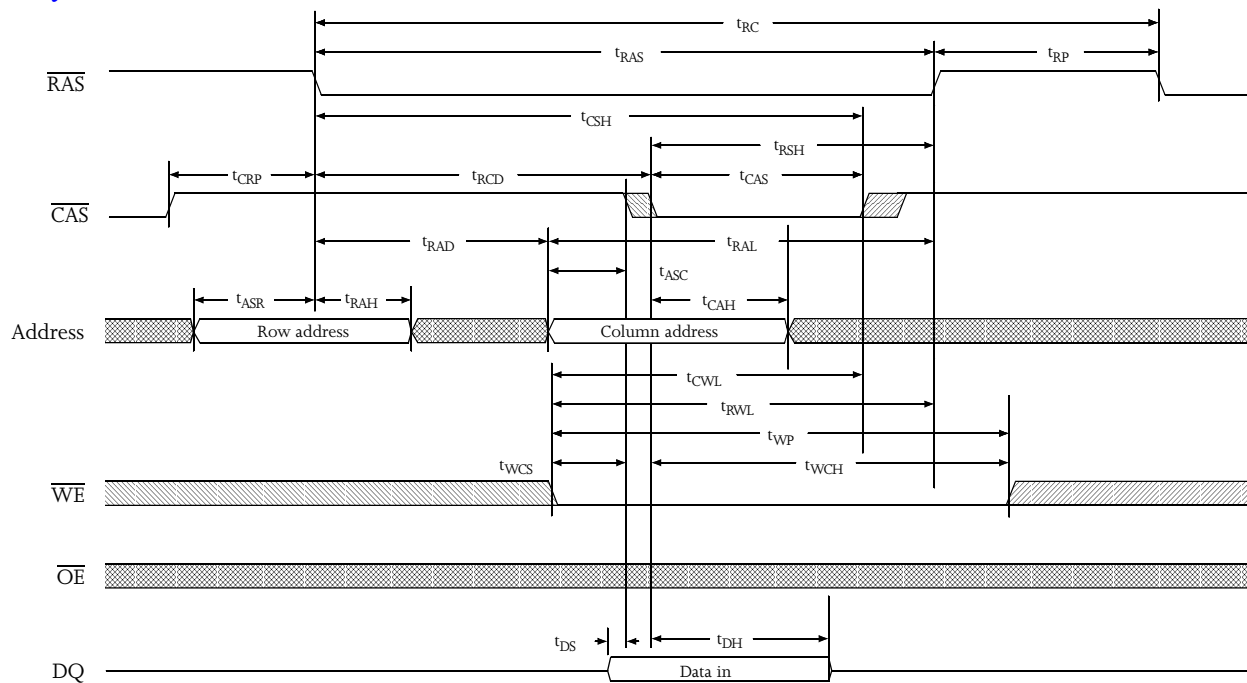
Undefined output/don't care



## Read waveform



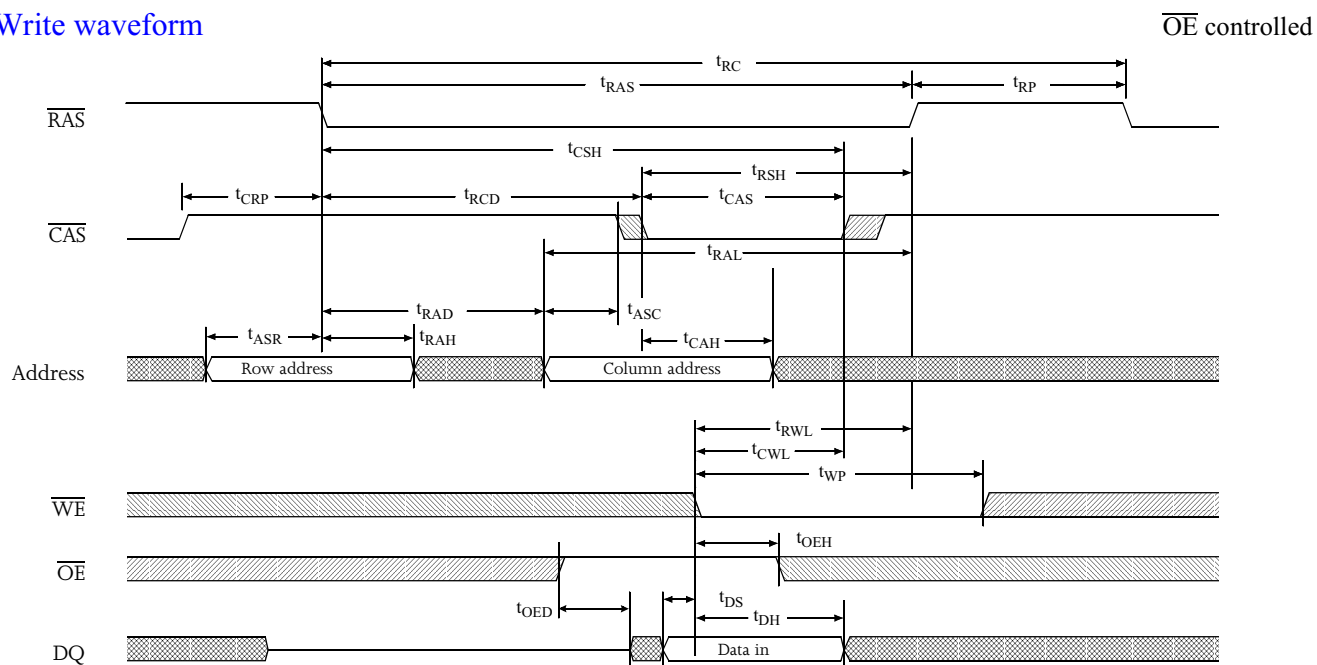
## Early write waveform



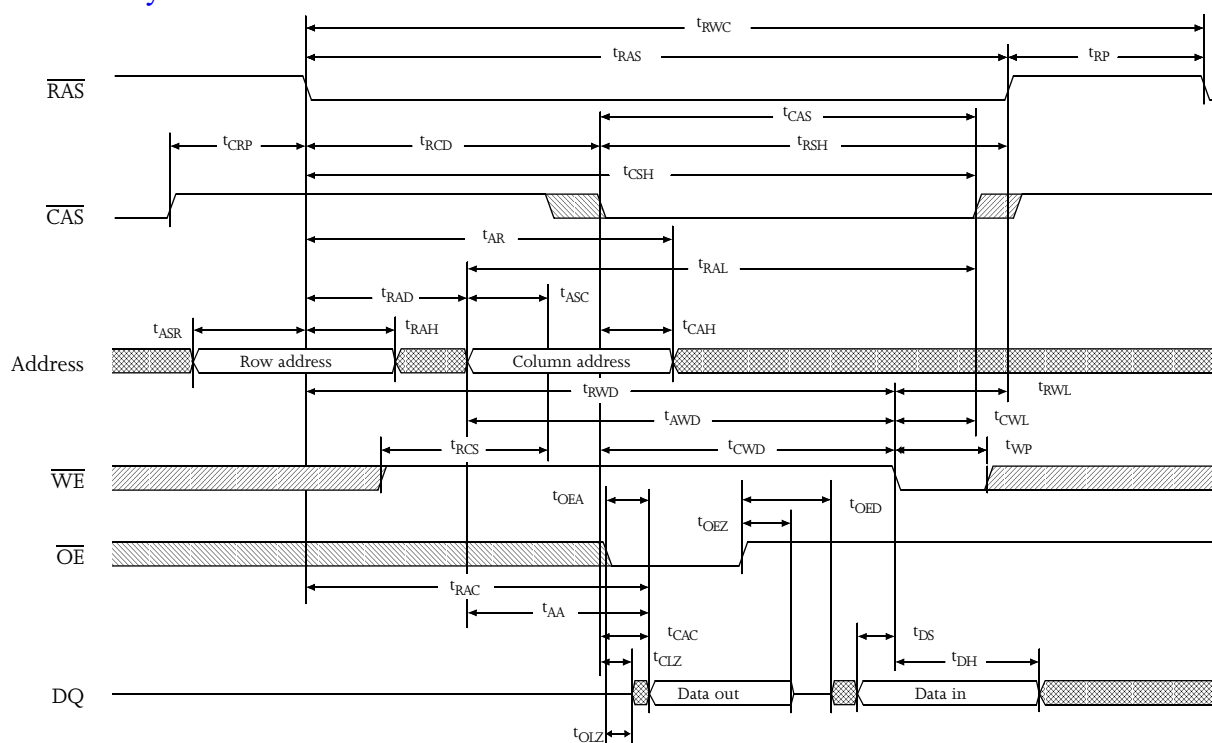




## Write waveform

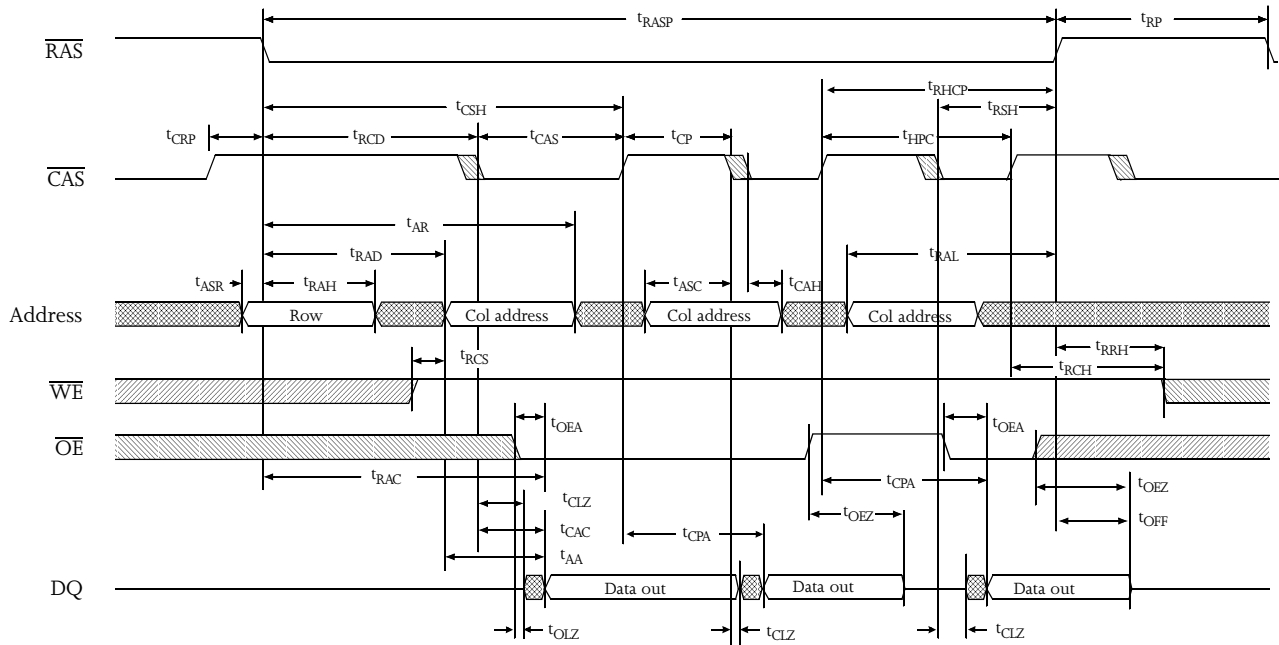


## Read-modify-write waveform

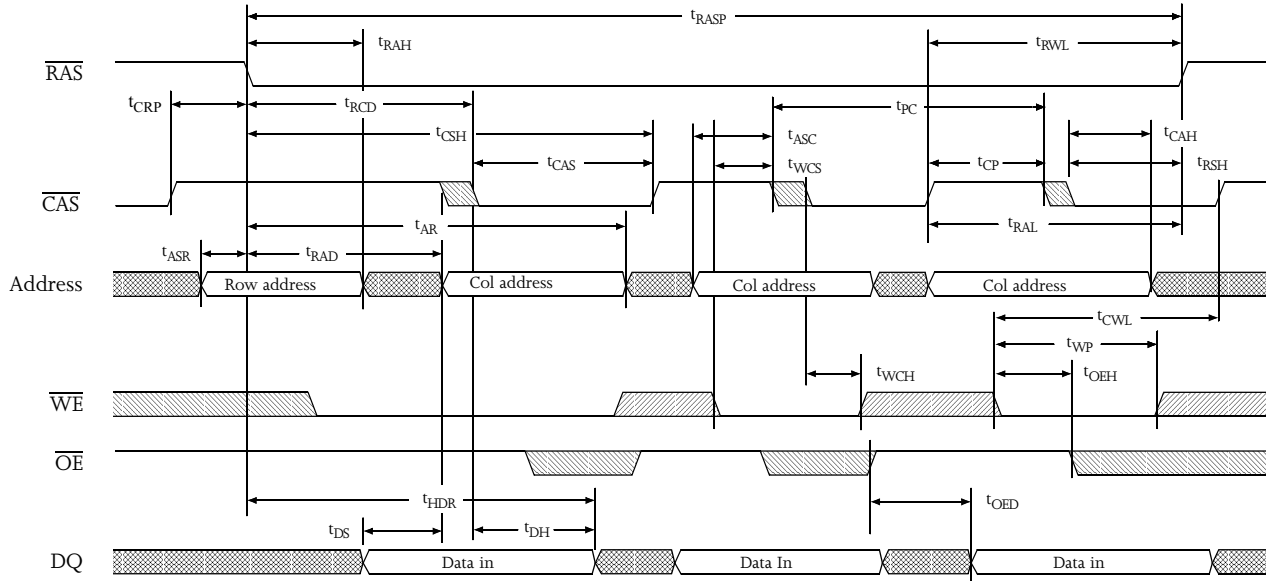




### EDO page mode read waveform

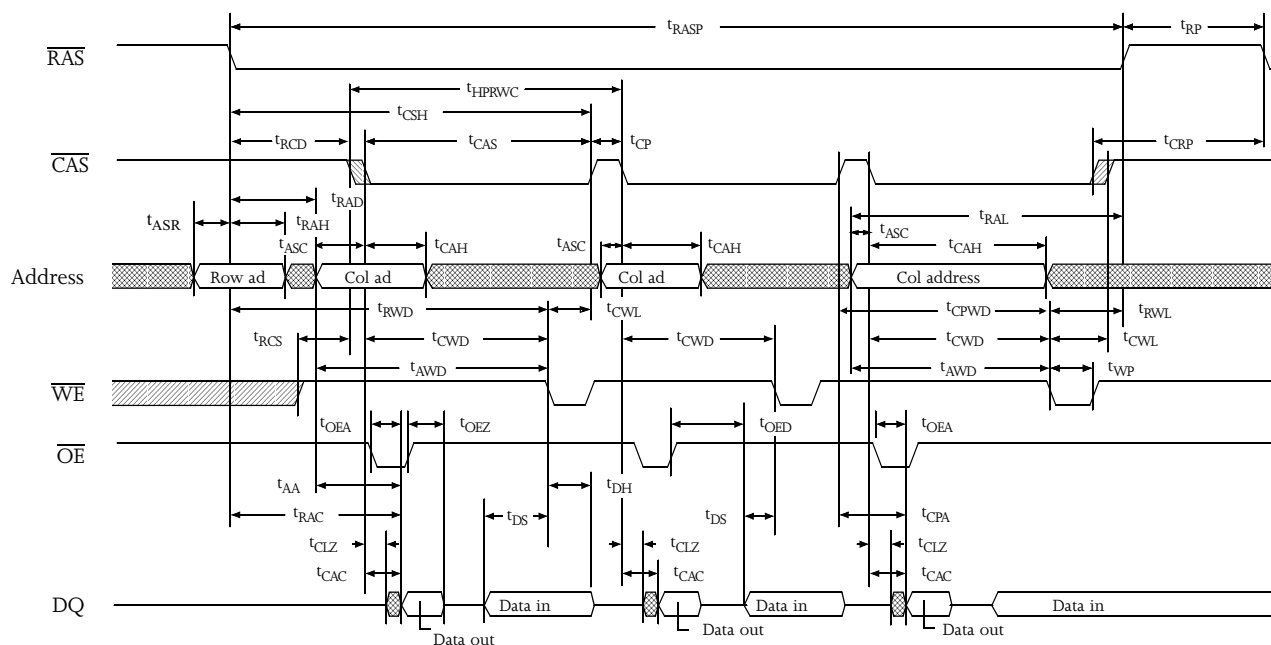
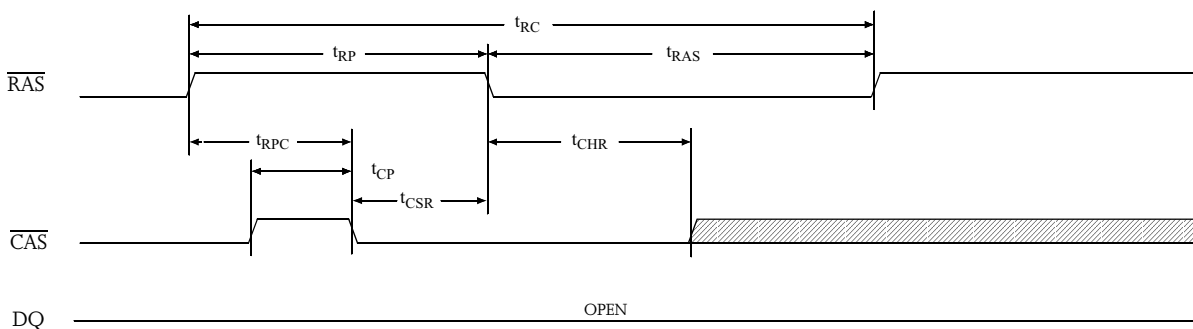
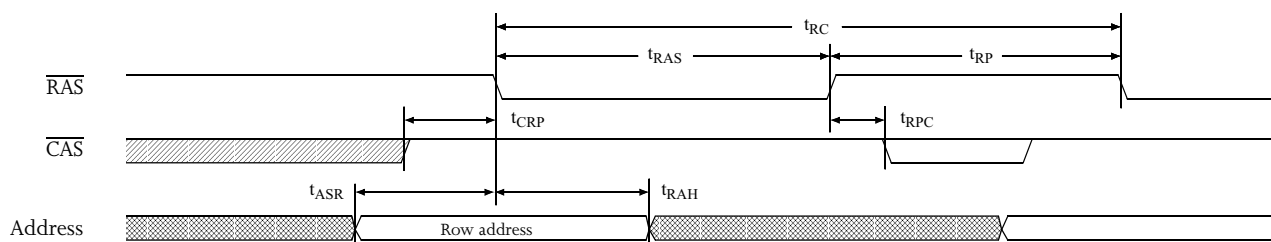


### EDO page mode early write waveform



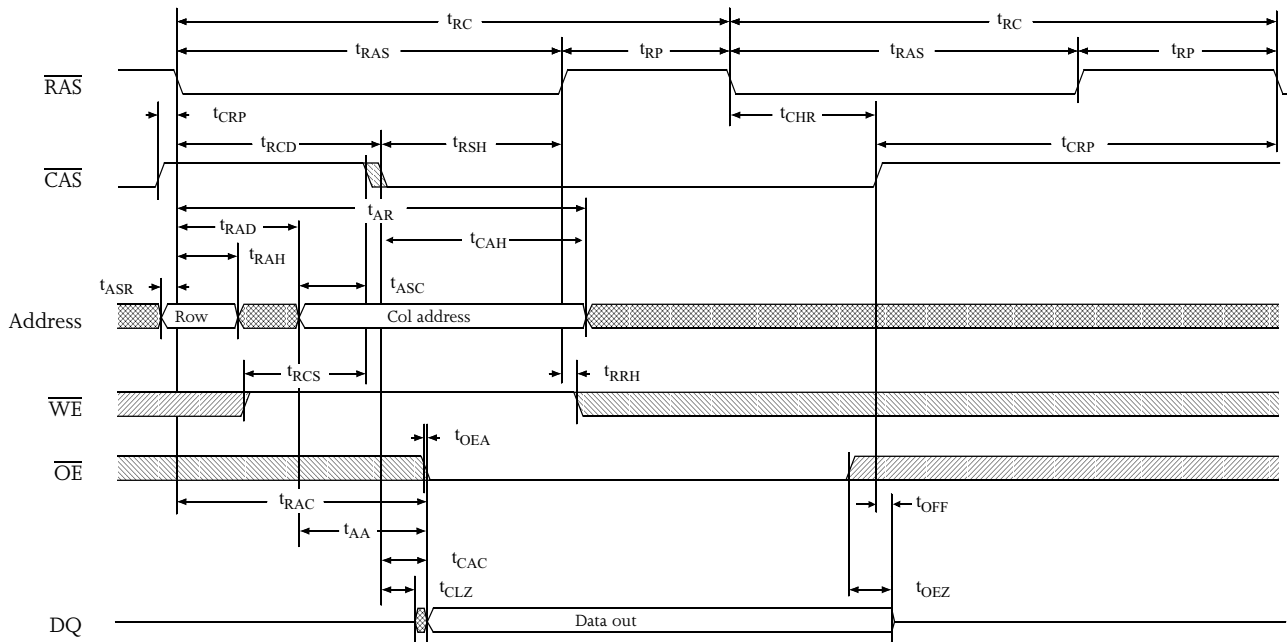


## EDO page mode read-modify-write waveform

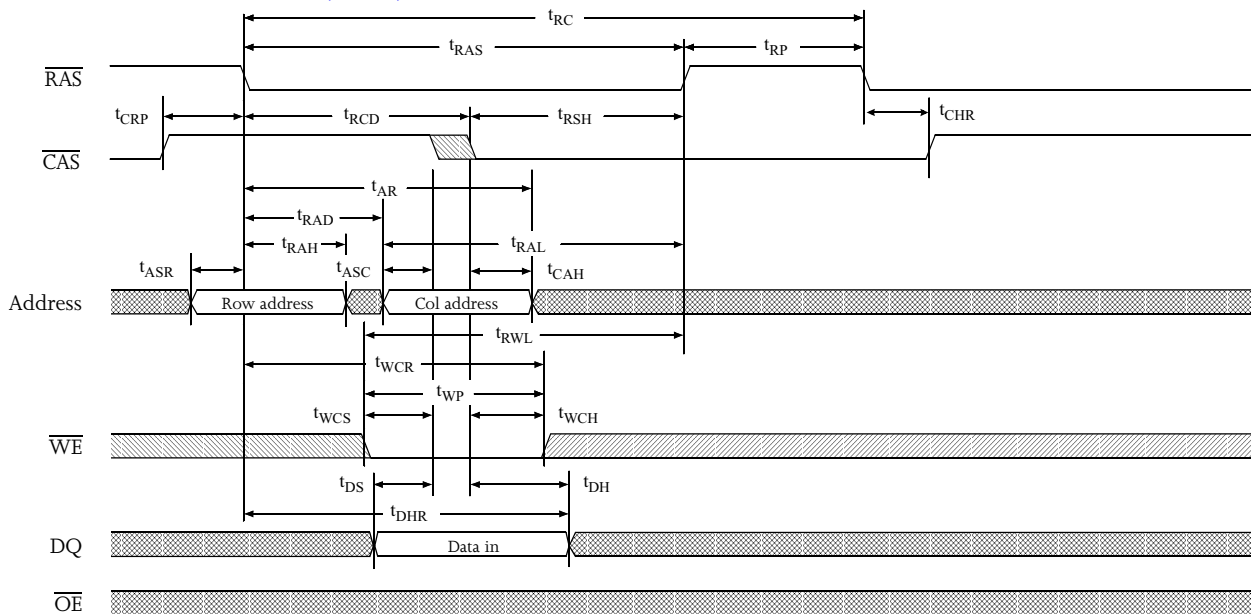
 $\overline{CAS}$  before  $\overline{RAS}$  refresh waveform $\overline{WE} = V_{IH}$  $\overline{RAS}$  only refresh waveform $\overline{WE} = \overline{OE} = V_{IH}$  or  $V_{IL}$ 



### Hidden refresh waveform (read)

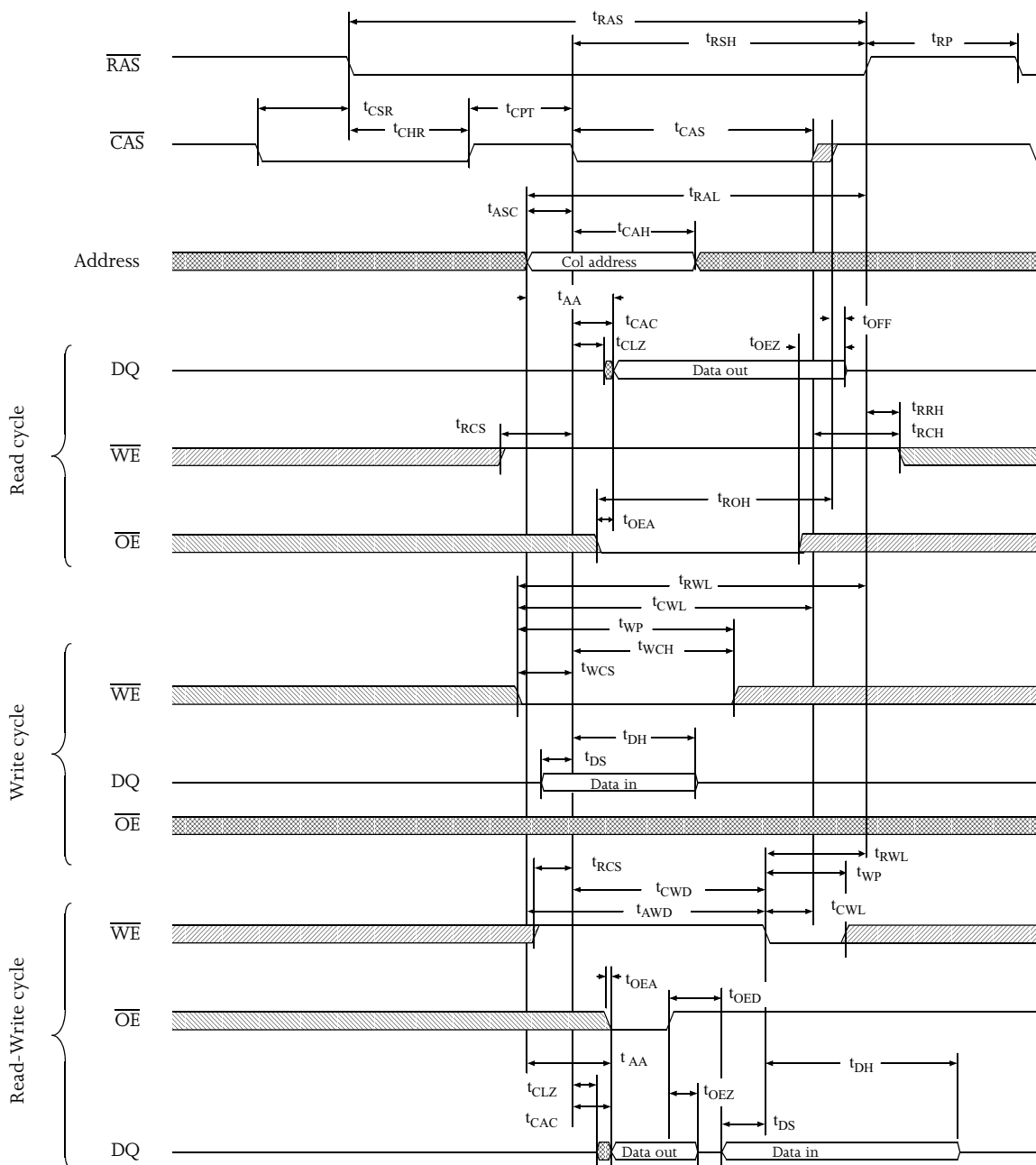


### Hidden refresh waveform (write)





### $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ refresh counter test waveform





### Capacitance <sup>15</sup>

 $f = 1 \text{ MHz}, T_a = \text{Room temperature}$ 

Parameter	Symbol	Signals	Test conditions	Max	Unit
Input capacitance	$C_{IN1}$	A0 to A9	$V_{in} = 0V$	5	pF
	$C_{IN2}$	$\overline{RAS}$ , $\overline{CAS0}$ , $\overline{CAS1}$ , $\overline{CAS2}$ , $\overline{CAS3}$ , $\overline{WE}$ , $\overline{OE}$	$V_{in} = 0V$	7	pF
DQ capacitance	$C_{DQ}$	DQ0 to DQ3	$V_{in} = V_{out} = 0V$	7	pF

### AS4C4M4E1Q ordering information

Package \ $\overline{RAS}$ access time		50 ns	60 ns
Plastic SOJ, 300 mil, 28-pin	5V	AS4C4M4E1Q-50JC	AS4C4M4E1Q-60JC
Plastic TSOP, 300 mil, 28-pin	5V	AS4C4M4E1Q-50TC	AS4C4M4E1Q-60TC

### AS4C4M4E1Q family part numbering system

AS4	C	4M4	E0	-XX	X	C
DRAM prefix	C = 5V CMOS	4M×4	E1=2K refresh	$\overline{RAS}$ access time	Package: J = SOJ 300 mil, 28-pin T = TSOP 300 mil, 28-pin	Commercial temperature range: 0°C to 70 °C