

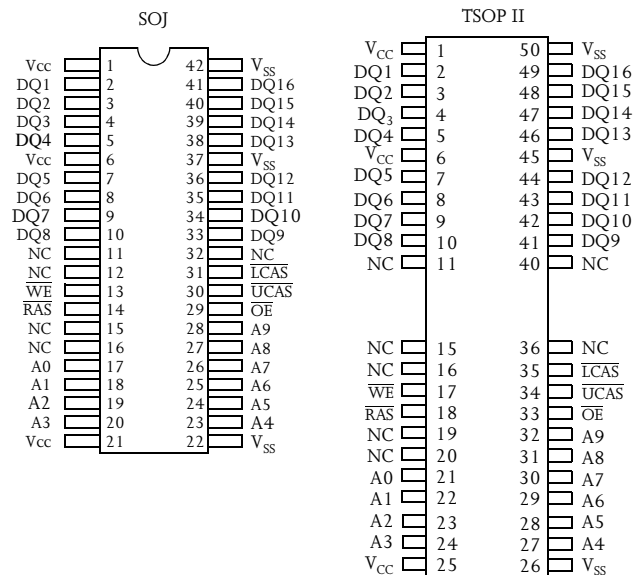


5V 1M×16 CMOS DRAM (fast-page mode)

Features

- Organization: 1,048,576 words × 16 bits
- High speed
  - 50/60 ns  $\overline{\text{RAS}}$  access time
  - 20/25 ns fast page cycle time
  - 13/17 ns  $\overline{\text{CAS}}$  access time
- Low power consumption
  - Active: 880 mW max (AS4C1M16E0-60)
  - Standby: 11 mW max, CMOS DQ
- Fast page mode
- 1024 refresh cycles, 16 ms refresh interval
  - $\overline{\text{RAS}}$ -only or  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh
- Read-modify-write
- TTL-compatible, three-state DQ
- JEDEC standard package and pinout
  - 400 mil, 42-pin SOJ
  - 400 mil, 44/50-pin TSOP II
- 5V power supply
- Industrial and commercial temperature available

Pin arrangement



Pin designation

Pin(s)	Description
A0 to A9	Address inputs
$\overline{\text{RAS}}$	Row address strobe
DQ1 to DQ16	Input/output
$\overline{\text{OE}}$	Output enable
$\overline{\text{WE}}$	Write enable
$\overline{\text{UCAS}}$	Column address strobe, upper byte
$\overline{\text{LCAS}}$	Column address strobe, lower byte
$V_{\text{CC}}$	Power
$V_{\text{SS}}$	Ground

Selection guide

	Symbol	AS4C1M16F5-50	AS4C1M16F5-60	Unit
Maximum $\overline{\text{RAS}}$ access time	$t_{\text{RAC}}$	50	60	ns
Maximum column address access time	$t_{\text{AA}}$	25	30	ns
Maximum $\overline{\text{CAS}}$ access time	$t_{\text{CAC}}$	13	17	ns
Maximum output enable ( $\overline{\text{OE}}$ ) access time	$t_{\text{OEA}}$	13	15	ns
Minimum read or write cycle time	$t_{\text{RC}}$	84	104	ns
Minimum fast page mode cycle time	$t_{\text{PC}}$	20	25	ns
Maximum operating current	$I_{\text{CC1}}$	170	160	mA
Maximum CMOS standby current	$I_{\text{CC5}}$	2.0	2.0	mA



## Functional description

The AS4C1M16F5 is a high performance 16-megabit CMOS Dynamic Random Access Memory (DRAM) organized as 1,048,576 words  $\times$  16 bits. The AS4C1M16F5 is 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 personal and portable PCs, workstations, and multimedia and router switch applications.

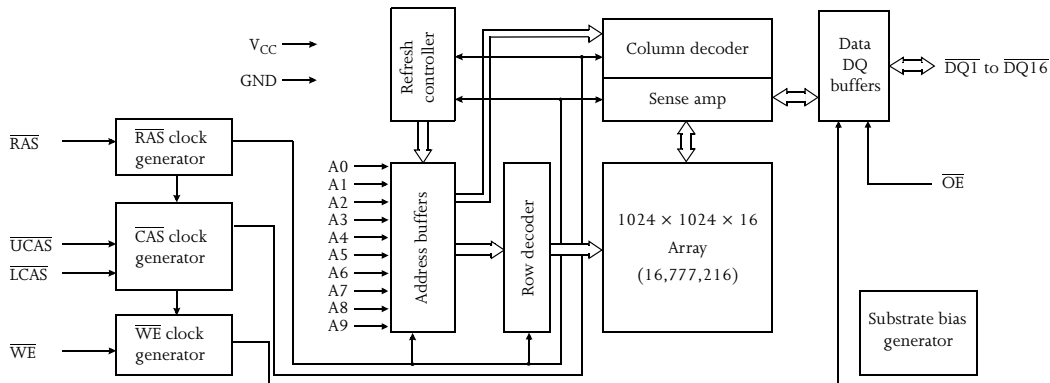
The AS4C1M16F5 features high speed page mode operation where read and write operations within a single row (or page) can be executed at very high speed (15 ns from  $\overline{\text{XCAS}}$ ) by toggling column addresses within that row. Row and column addresses are alternately latched into input buffers using the falling edge of  $\overline{\text{RAS}}$  and  $\overline{\text{XCAS}}$  inputs respectively. Also,  $\overline{\text{RAS}}$  is used to make the column address latch transparent, enabling application of column addresses prior to  $\overline{\text{XCAS}}$  assertion. The AS4C1M16F5 provides dual  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$  for independent byte control of read and write access.

Refresh on the 1024 address combinations of A0 to A9 must be performed every 16 ms using:

- $\overline{\text{RAS}}$ -only refresh:  $\overline{\text{RAS}}$  is asserted while  $\overline{\text{XCAS}}$  is held high. Each of the 1024 rows must be strobed. Outputs remain high impedance.
- Hidden refresh:  $\overline{\text{XCAS}}$  is held low while  $\overline{\text{RAS}}$  is toggled. Outputs remain low impedance with previous valid data.
- $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh (CBR): At least one  $\overline{\text{XCAS}}$  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 AS4C1M16F5 is available in the standard 42-pin plastic SOJ and the 44/50-pin TSOP II packages, respectively. It operates with a single power supply of  $5V \pm 0.5V$ . The device provides TTL compatible inputs and outputs.

## Logic block diagram



## Recommended operating conditions

Parameter		Symbol	Min	Nominal	Max	Unit
Supply voltage	AS4C1M16F5	$V_{CC}$	4.5	5.0	5.5	V
		GND	0.0	0.0	0.0	V
Input voltage	AS4C1M16F5	$V_{IH}$	2.4	—	$V_{CC}$	V
		$V_{IL}$	-0.5 <sup>†</sup>	—	0.8	V
Ambient operating temperature	Commercial	$T_A$	0	—	70	°C
	Industrial		-40	—	85	

<sup>†</sup> $V_{IL}$  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 × 10	°C × sec
Power dissipation	$P_D$	–	1	W
Short circuit output current	$I_{out}$	–	50	mA

## DC electrical characteristics

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; $t_{RC} = \text{min}$	–	170	–	160	mA	1,2
TTL standby power supply current	$I_{CC2}$	$\overline{RAS} = \overline{UCAS} = \overline{LCAS} \geq V_{IH}$	–	2.5	–	2.5	mA	
Average power supply current, $\overline{RAS}$ refresh mode or CBR	$I_{CC3}$	$\overline{RAS}$ cycling, $\overline{UCAS} = \overline{LCAS} \geq V_{IH}$ , $t_{RC} = \text{min of } \overline{RAS} \text{ low after } \overline{XCAS} \text{ low.}$	–	170	–	160	mA	1
Fast page mode average power supply current	$I_{CC4}$	$\overline{RAS} = V_{IL}$ , $\overline{UCAS}$ or $\overline{LCAS}$ , address cycling: $t_{PC} = \text{min}$	–	120	–	110	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	
$\overline{CAS}$ before $\overline{RAS}$ refresh current	$I_{CC6}$	$\overline{RAS}$ , $\overline{UCAS}$ or $\overline{LCAS}$ cycling, $t_{RC} = \text{min}$	–	170	–	160	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	84	–	104	–	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	–	16	–	16	ms	3
$t_{CP}$	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 $\overline{CAS}$	–	13	–	17	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	



## Fast page mode cycle

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
t <sub>CPA</sub>	Access time from $\overline{\text{CAS}}$ precharge	–	28	–	35	ns	13
t <sub>RASP</sub>	$\overline{\text{RAS}}$ pulse width	50	100K	60	100K	ns	
t <sub>PC</sub>	Read-write cycle time	30	–	35	–	ns	
t <sub>CP</sub>	$\overline{\text{CAS}}$ precharge time (fast page)	10	–	10	–	ns	
t <sub>PCM</sub>	Fast page mode RMW cycle	80	–	85	–	ns	
t <sub>CRW</sub>	Page mode $\overline{\text{CAS}}$ pulse width (RMW)	54	–	60	–	ns	

## Output enable

Symbol	Parameter	-50		-60		Unit	Notes
		Min	Max	Min	Max		
t <sub>CLZ</sub>	$\overline{\text{CAS}}$ to output in Low Z	0	–	0	–	ns	8
t <sub>ROH</sub>	$\overline{\text{RAS}}$ hold time referenced to $\overline{\text{OE}}$	8	–	10	–	ns	
t <sub>OEa</sub>	$\overline{\text{OE}}$ access time	–	13	–	15	ns	
t <sub>OED</sub>	$\overline{\text{OE}}$ to data delay	13	–	15	–	ns	
t <sub>OEZ</sub>	Output buffer turnoff delay from $\overline{\text{OE}}$	0	13	0	15	ns	8
t <sub>OEh</sub>	$\overline{\text{OE}}$ command hold time	10	–	10	–	ns	
t <sub>OLZ</sub>	$\overline{\text{OE}}$ to output in Low Z	0	–	0	–	ns	
t <sub>OFF</sub>	Output buffer turn-off time	0	13	0	15	ns	8,10



## Notes

- 1  $I_{CC1}$ ,  $I_{CC3}$ , and  $I_{CC4}$  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  $\overline{\text{RAS}}$  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).
- 4 AC Characteristics assume  $t_T = 2$  ns. All AC parameters are measured with a load equivalent to two TTL loads and 100 pF,  $V_{IL}(\text{min}) \geq \text{GND}$  and  $V_{IH}(\text{max}) \leq V_{CC}$ .
- 5  $V_{IH}(\text{min})$  and  $V_{IL}(\text{max})$  are reference levels for measuring timing of input signals. Transition times are measured between  $V_{IH}$  and  $V_{IL}$ .
- 6 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  $t_{\text{CAC}}$ .
- 7 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  $t_{\text{AA}}$ .
- 8 Assumes three state test load (5 pF and a 380  $\Omega$  Thevenin equivalent).
- 9 Either  $t_{\text{RCH}}$  or  $t_{\text{RRH}}$  must be satisfied for a read cycle.
- 10  $t_{\text{OFF}}(\text{max})$  defines the time at which the output achieves the open circuit condition; it is not referenced to output voltage levels.  $t_{\text{OFF}}$  is referenced from rising edge of  $\overline{\text{RAS}}$  or  $\overline{\text{CAS}}$ , whichever occurs last.
- 11  $t_{\text{WCS}}$ ,  $t_{\text{WCH}}$ ,  $t_{\text{RWD}}$ ,  $t_{\text{CWD}}$  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.
- 12 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.
- 13 Access time is determined by the longest of  $t_{\text{CAA}}$  or  $t_{\text{CAC}}$  or  $t_{\text{CPA}}$
- 14  $t_{\text{ASC}} \geq t_{\text{CP}}$  to achieve  $t_{\text{PC}}(\text{min})$  and  $t_{\text{CPA}}(\text{max})$  values.
- 15 These parameters are sampled and not 100% tested.
- 16 These characteristics apply to AS4C1M16F5 5V devices.

## AC test conditions

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

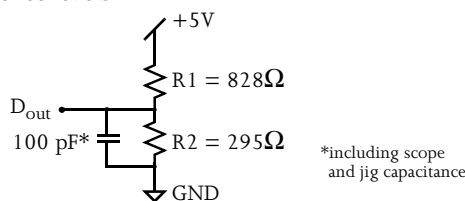


Figure A: Equivalent output load

## Key to switching waveforms



Rising input



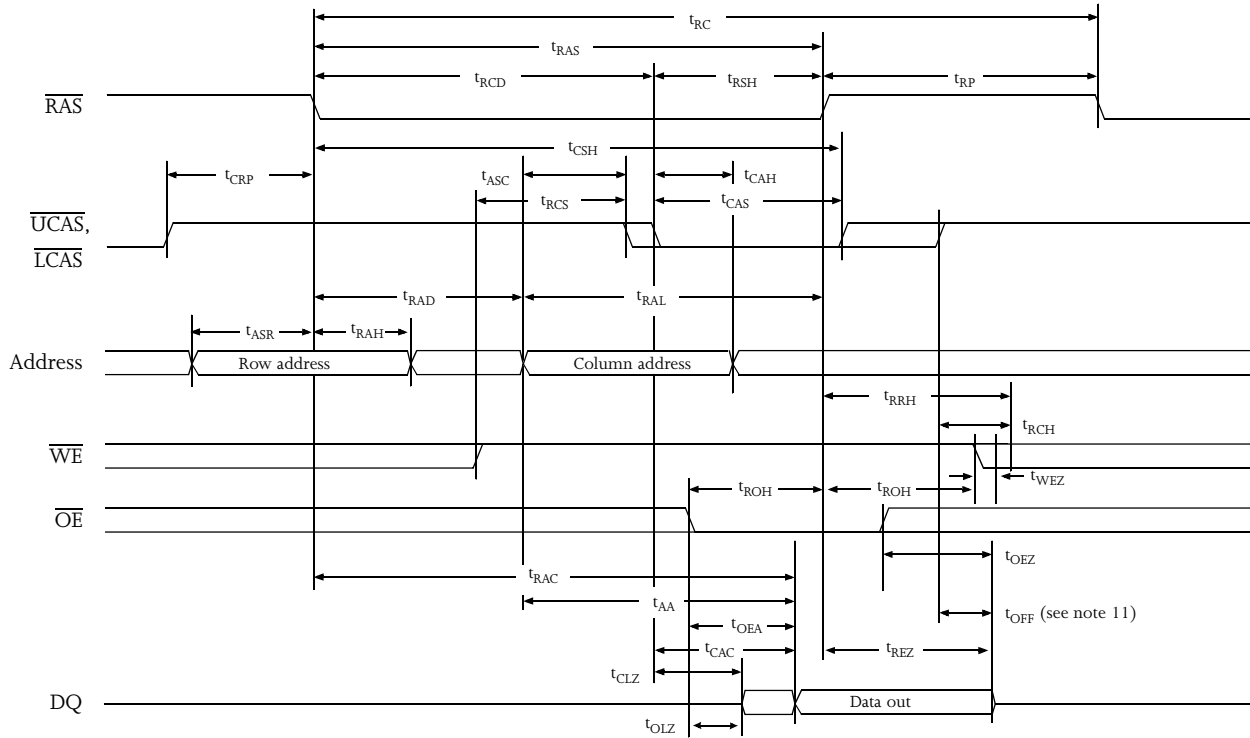
Falling input



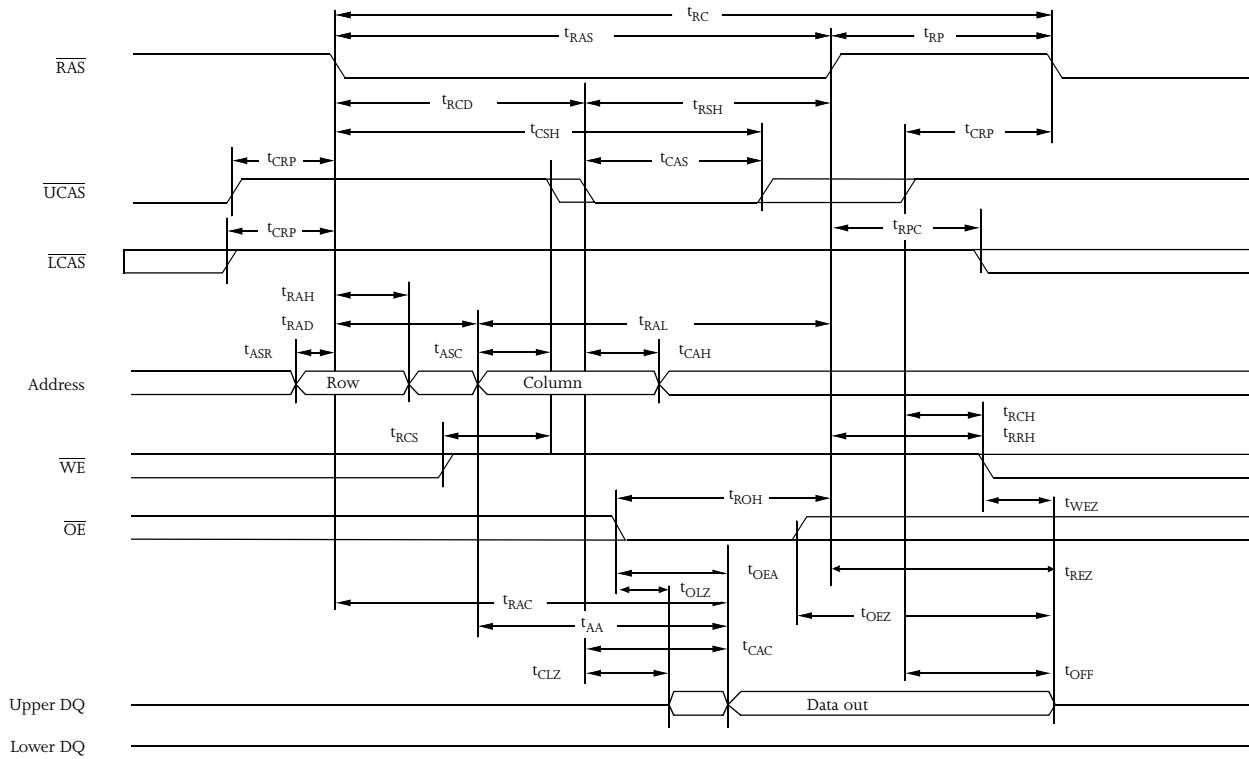
Undefined output/don't care



Read waveform



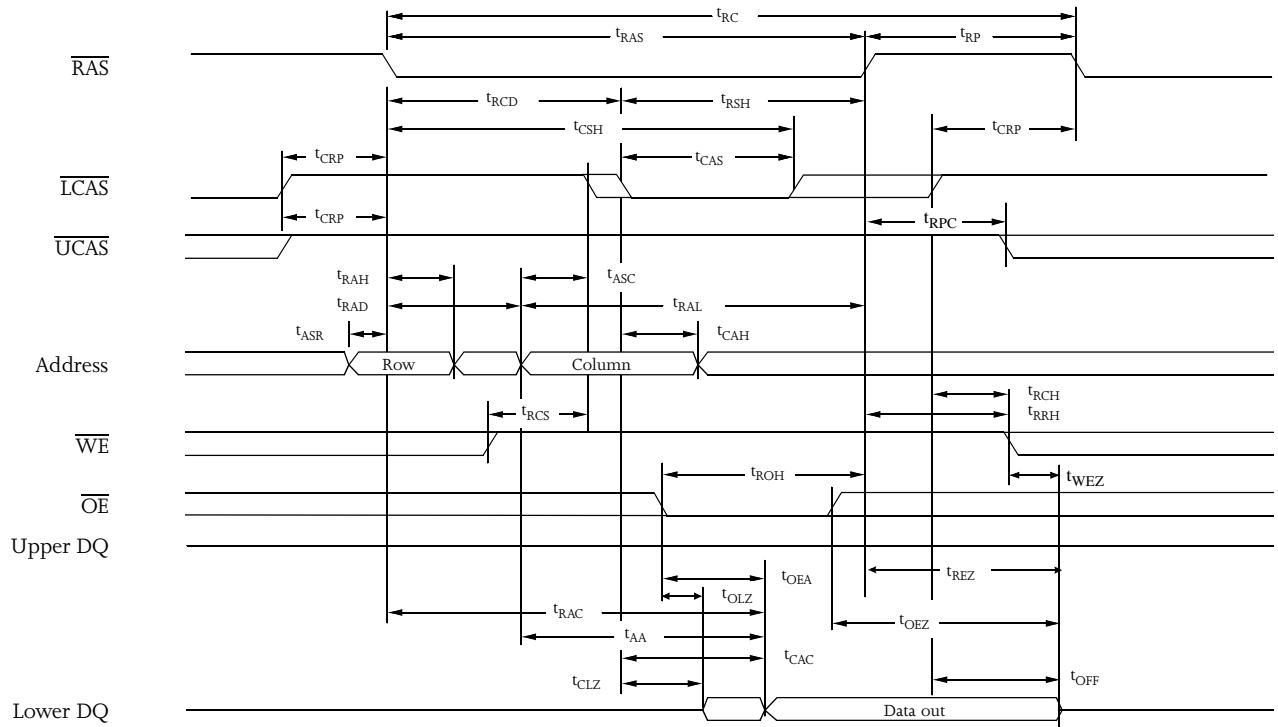
Upper byte read waveform



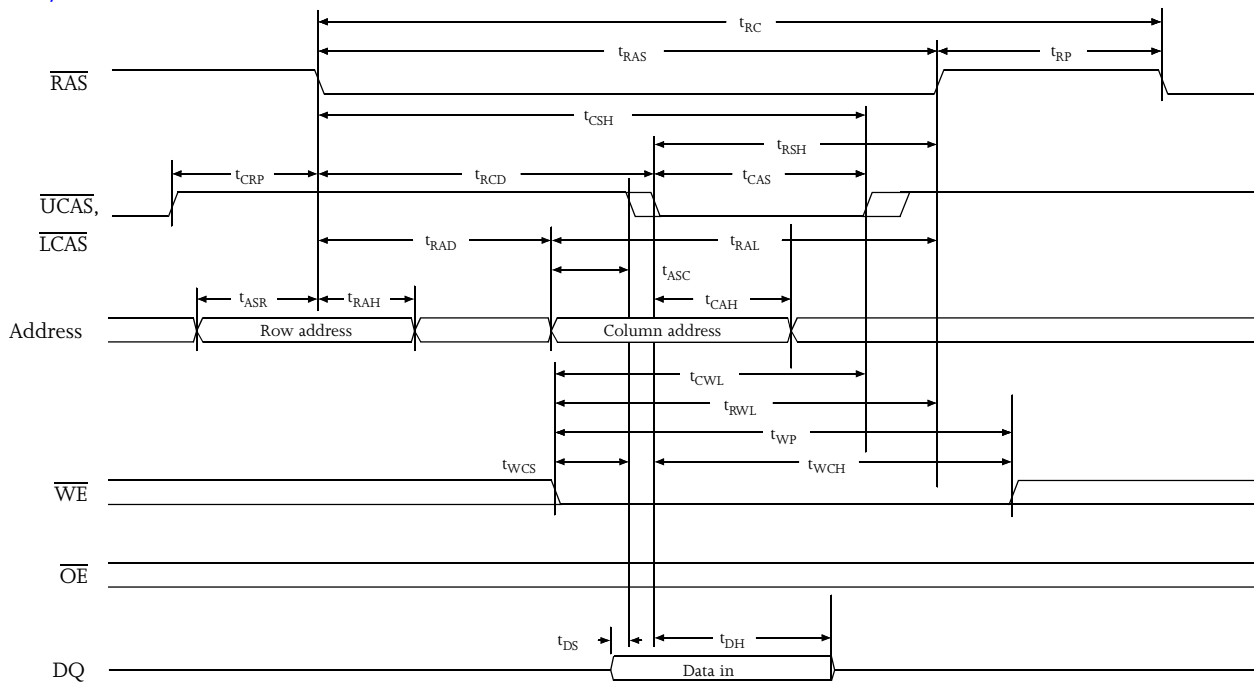




Lower byte read waveform

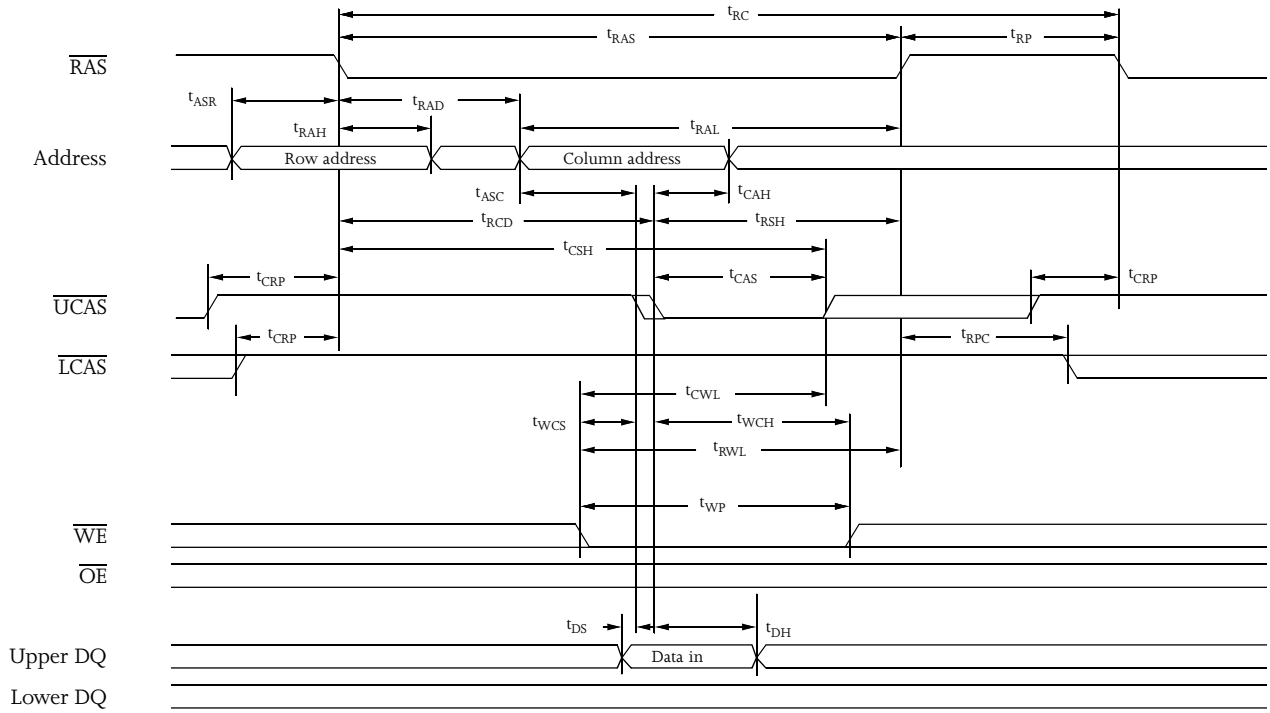


Early write waveform

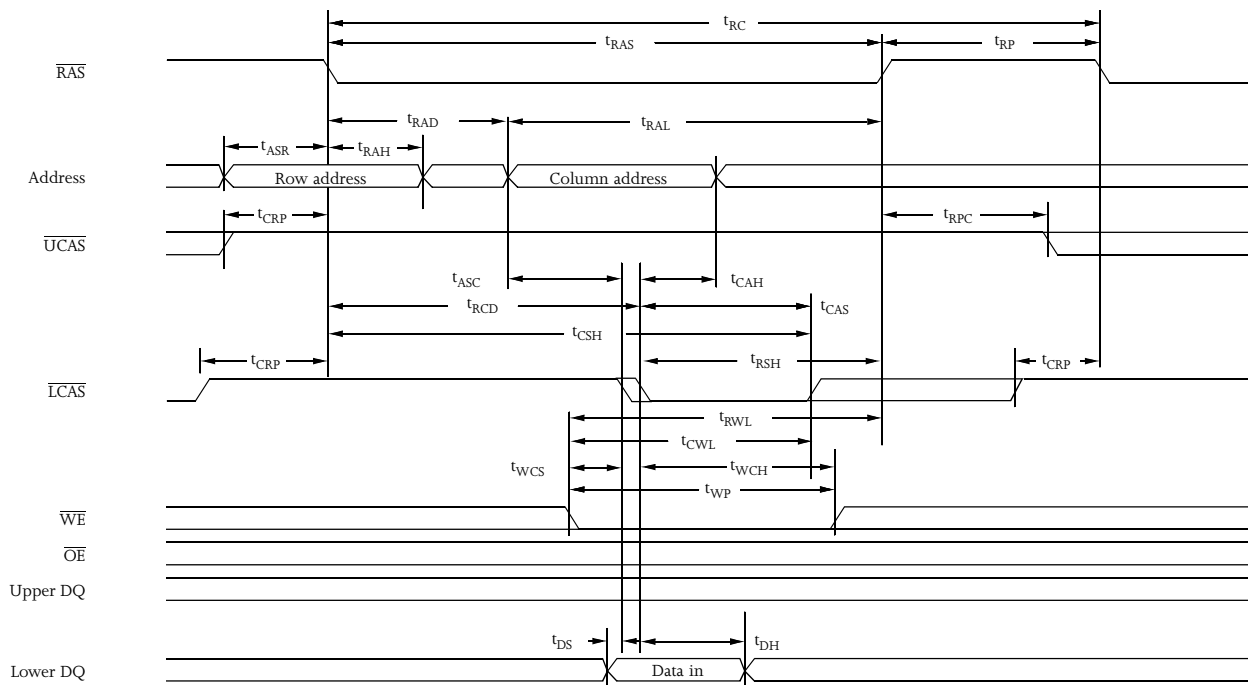




Upper byte early write waveform



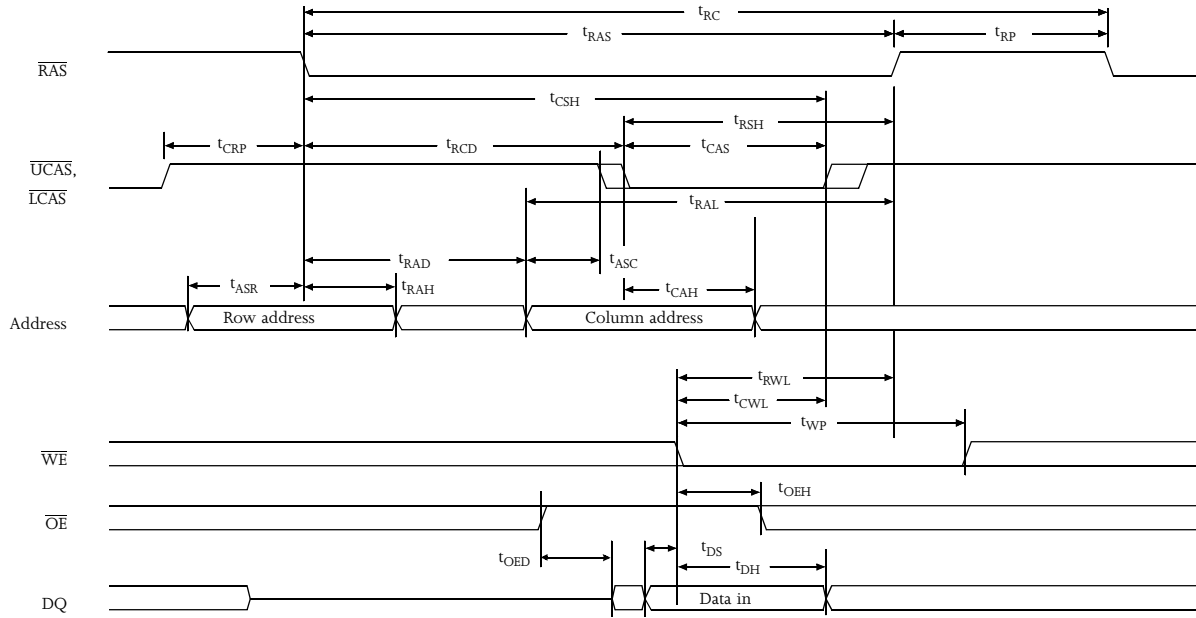
Lower byte early write waveform





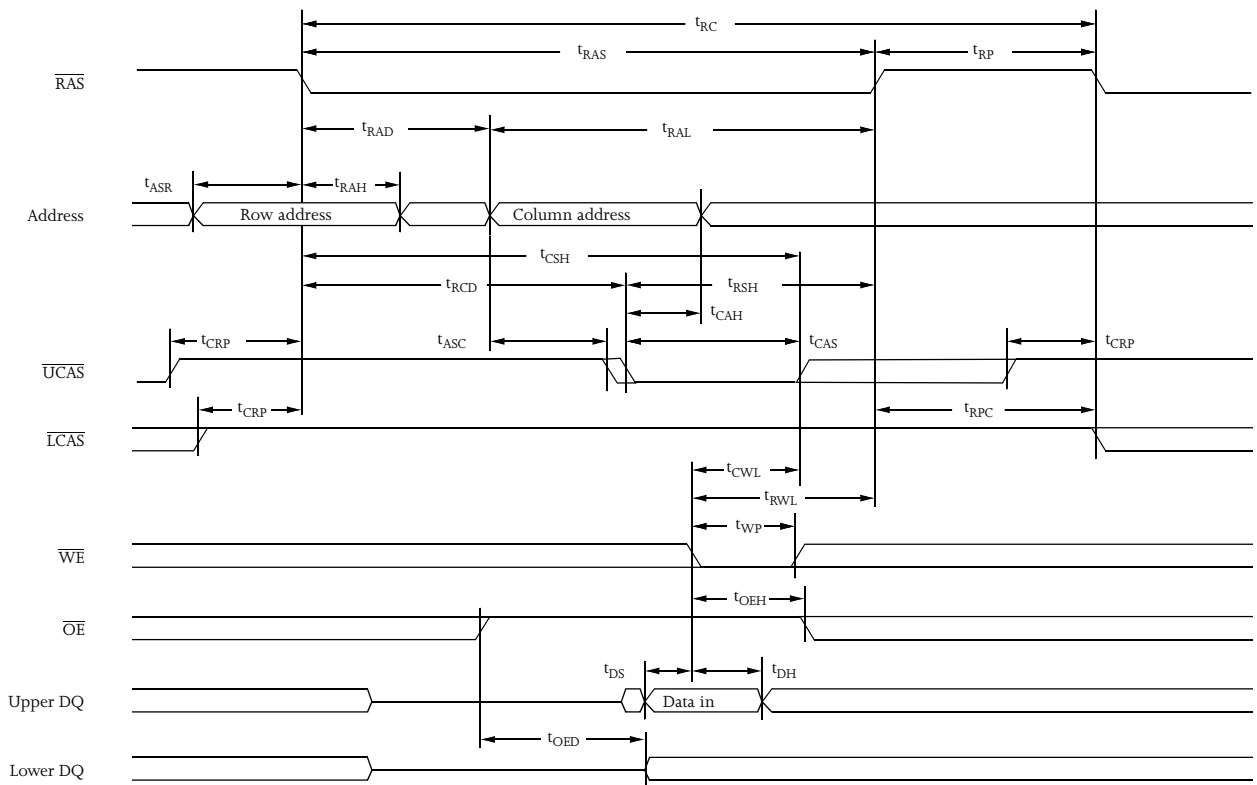
Write waveform

$\overline{OE}$  controlled



Upper byte write waveform

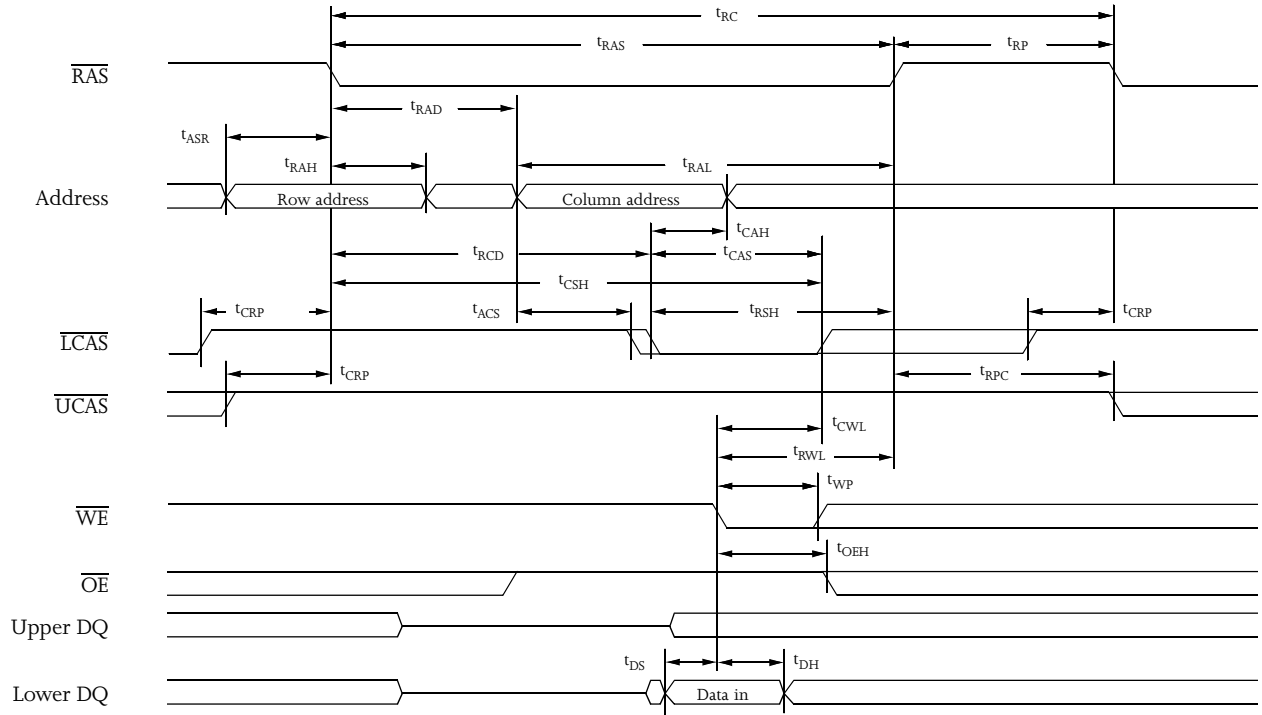
$\overline{OE}$  controlled



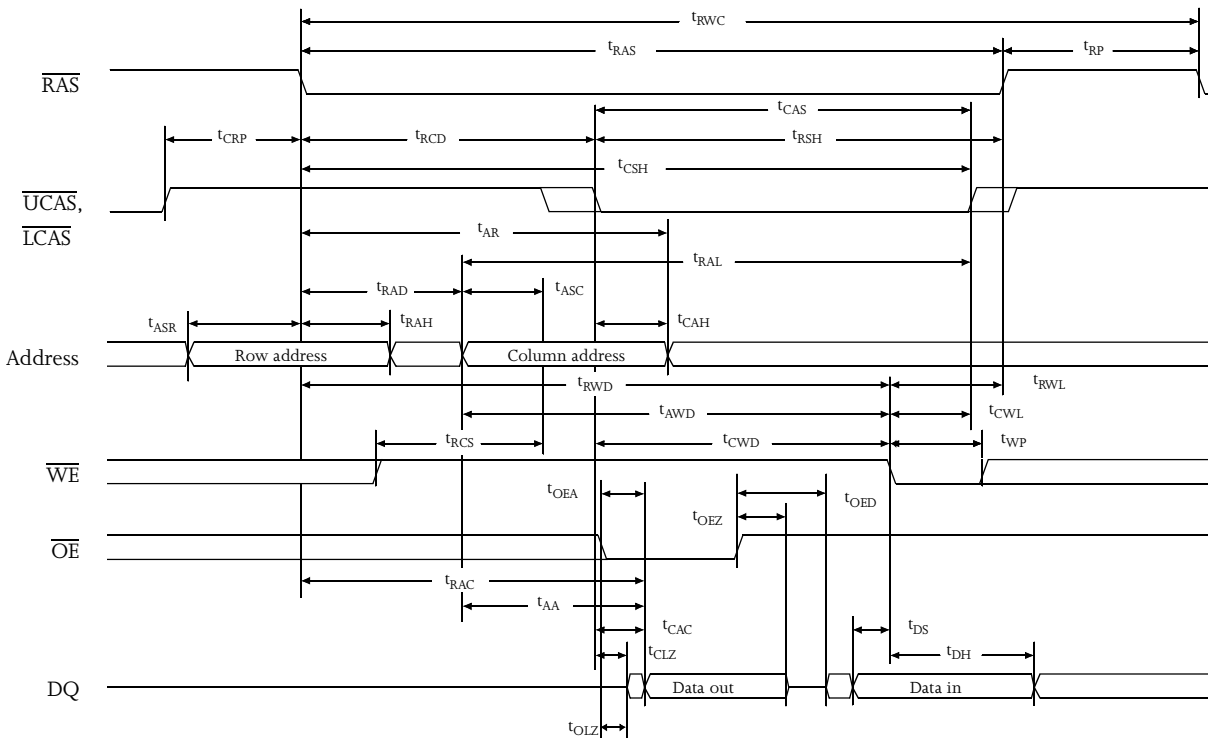


Lower byte write waveform

$\overline{OE}$  controlled

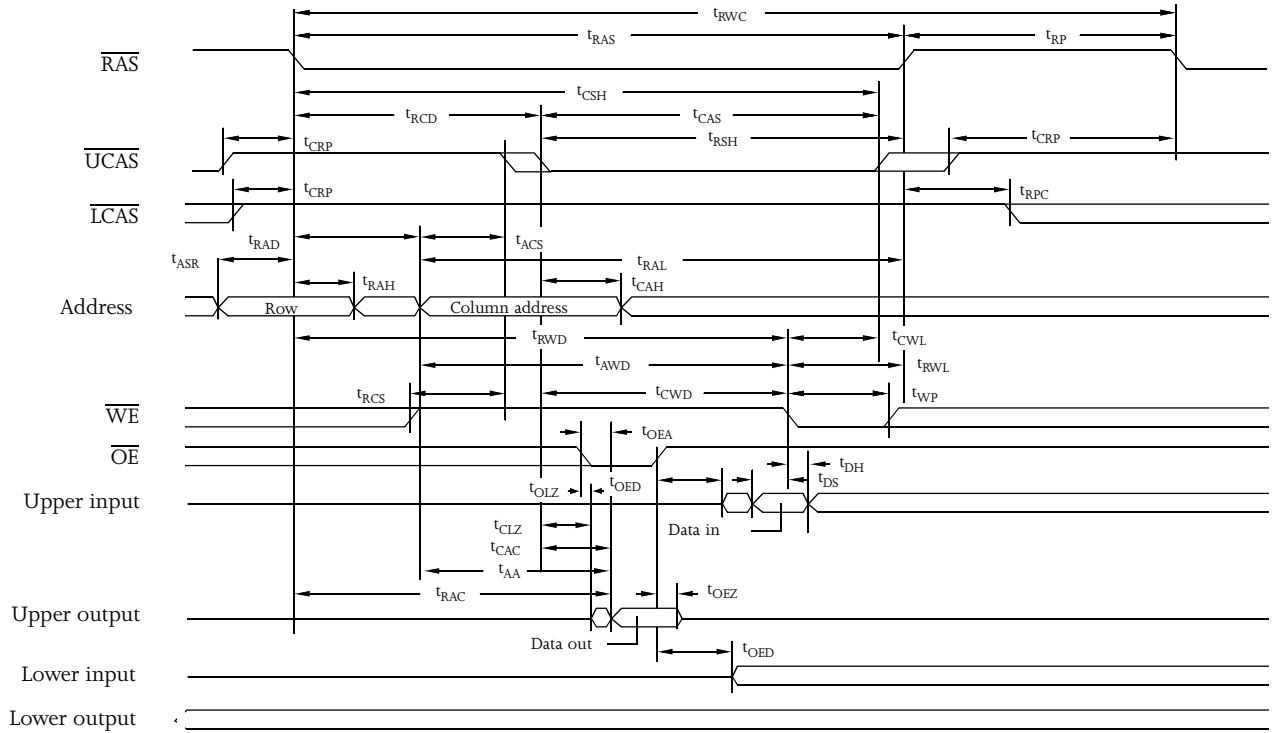


Read-modify-write waveform

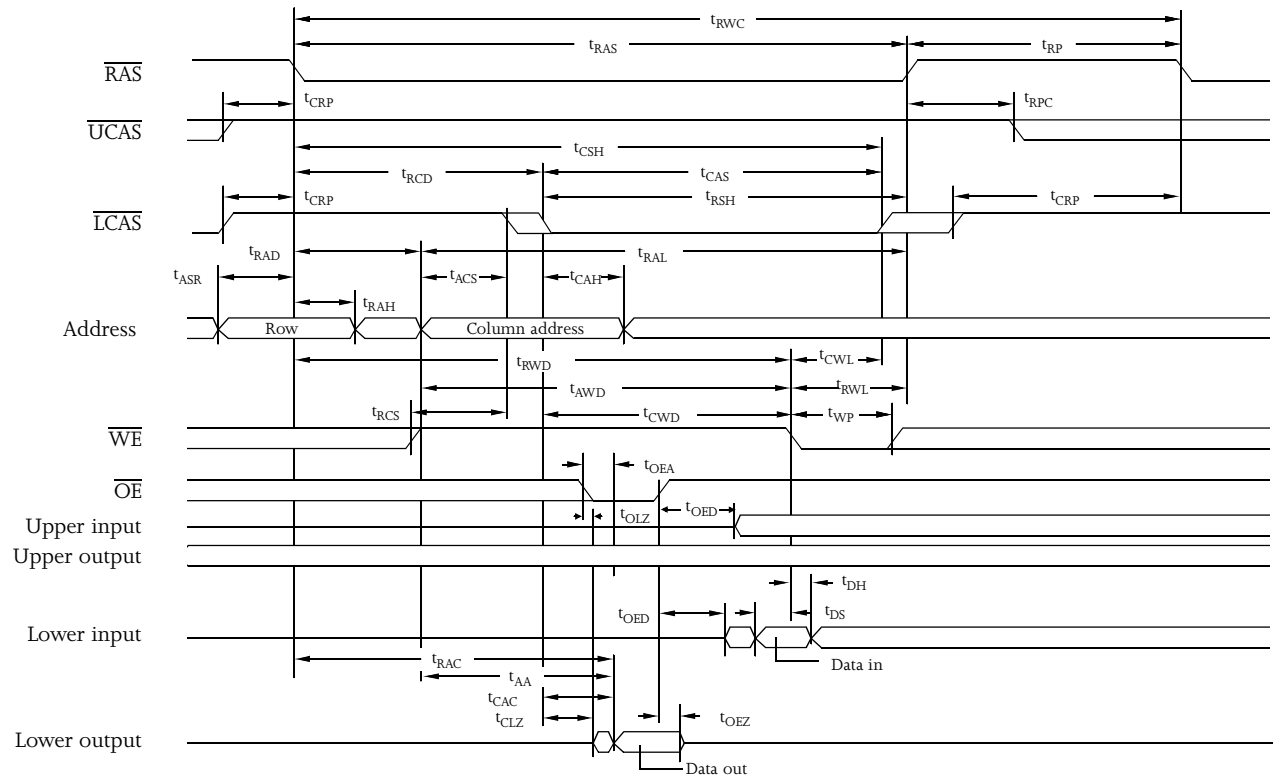




Upper byte read-modify-write waveform

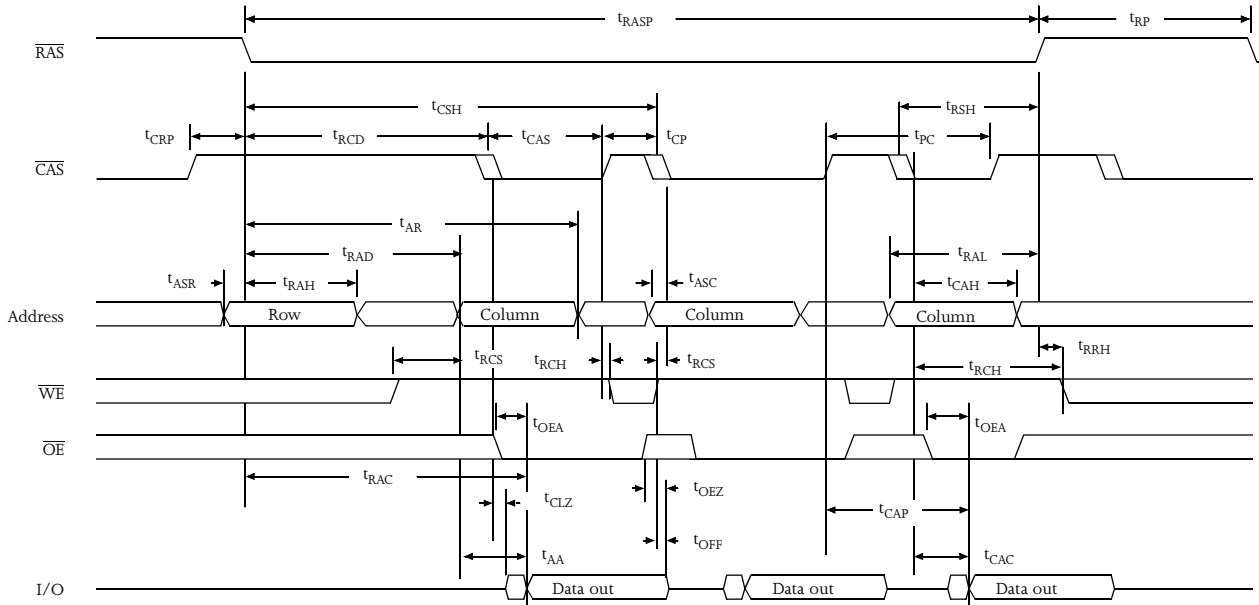


Lower byte read-modify-write waveform

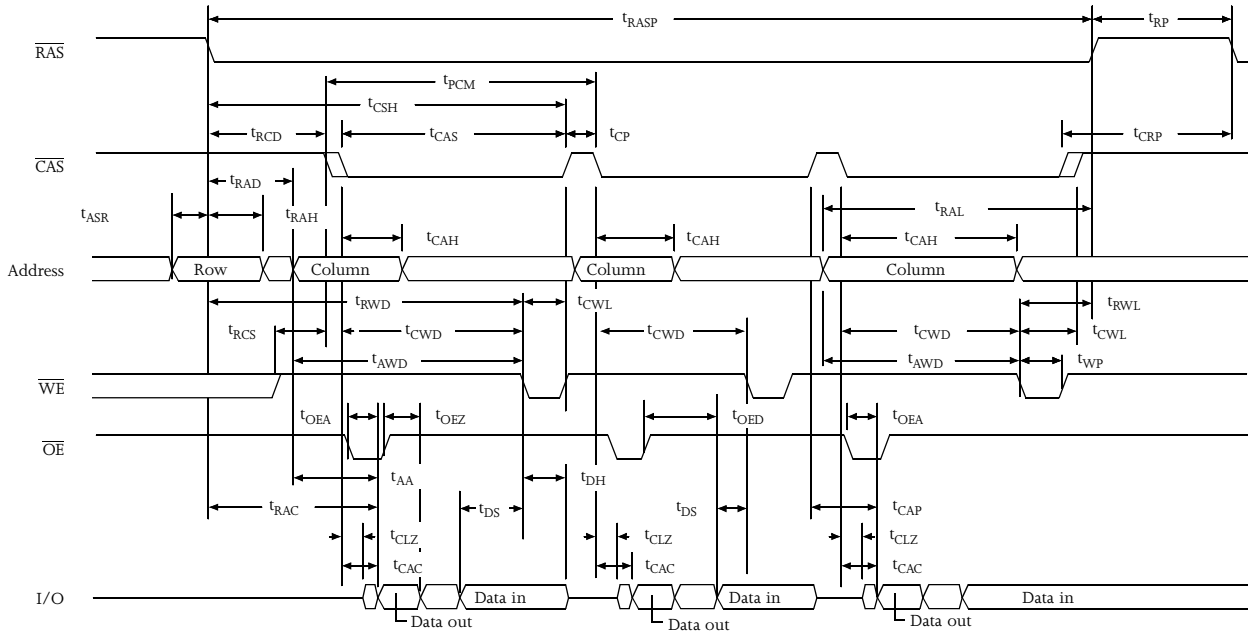




Fast page mode read waveform

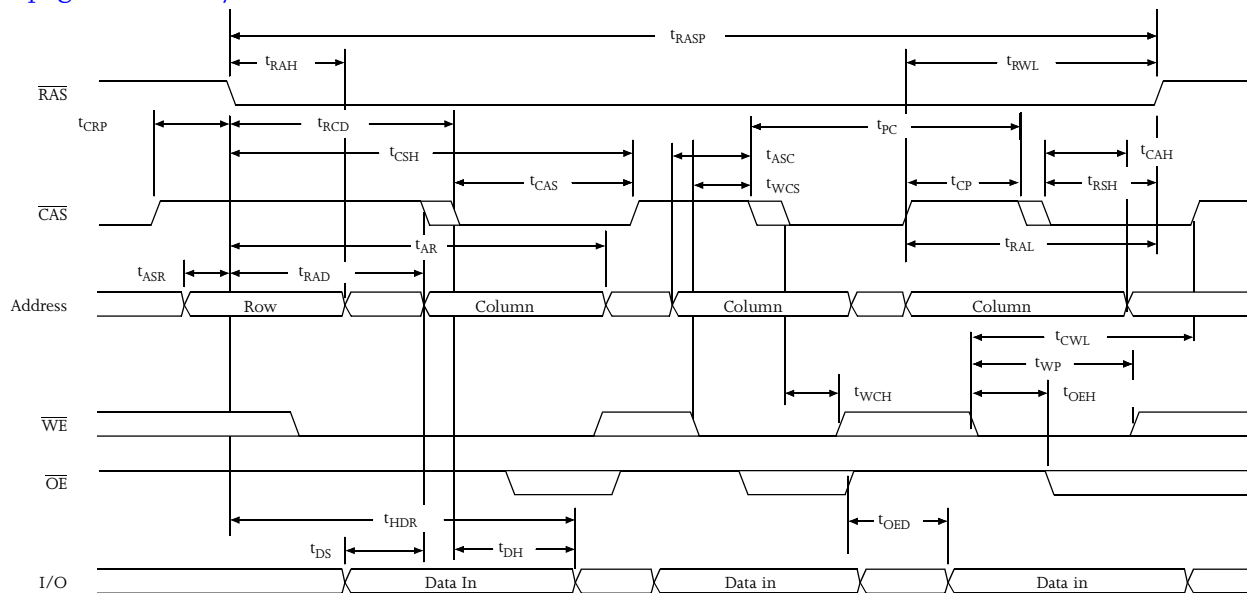


Fast page mode byte write waveform



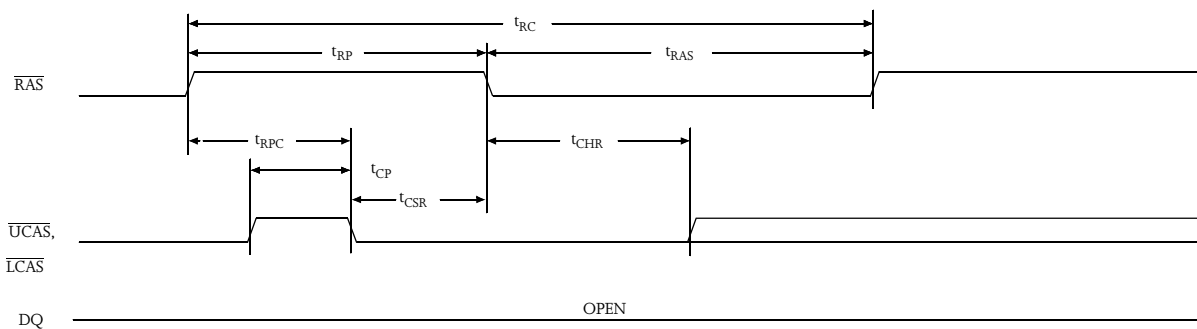


Fast page mode early write waveform



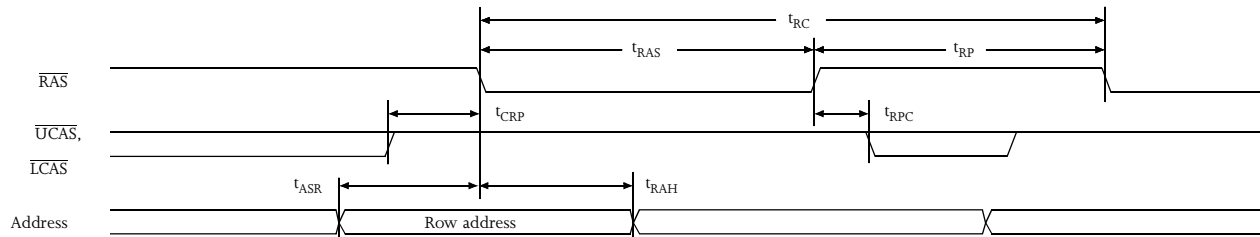
CAS before RAS refresh waveform

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



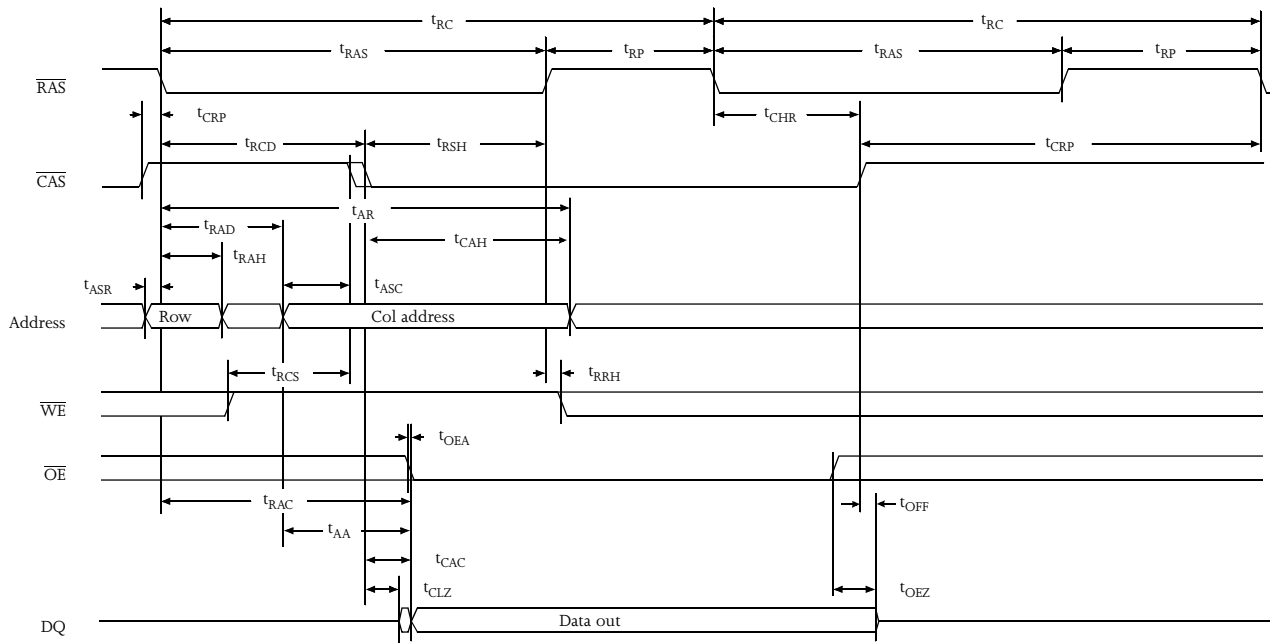
RAS only refresh waveform

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

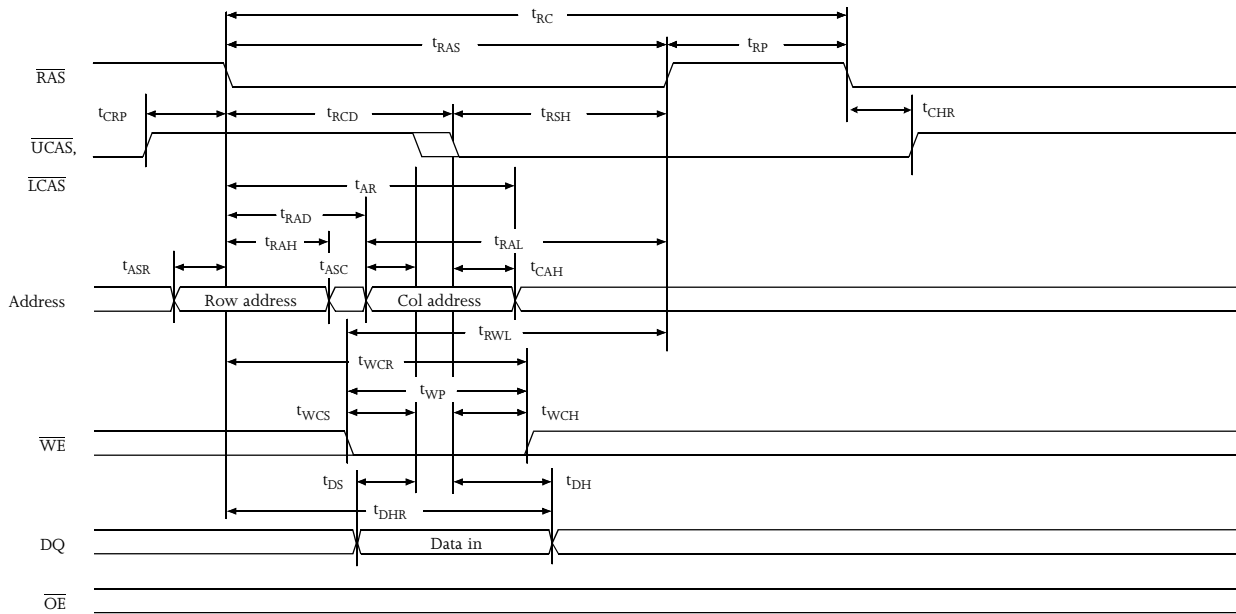




Hidden refresh waveform (read)



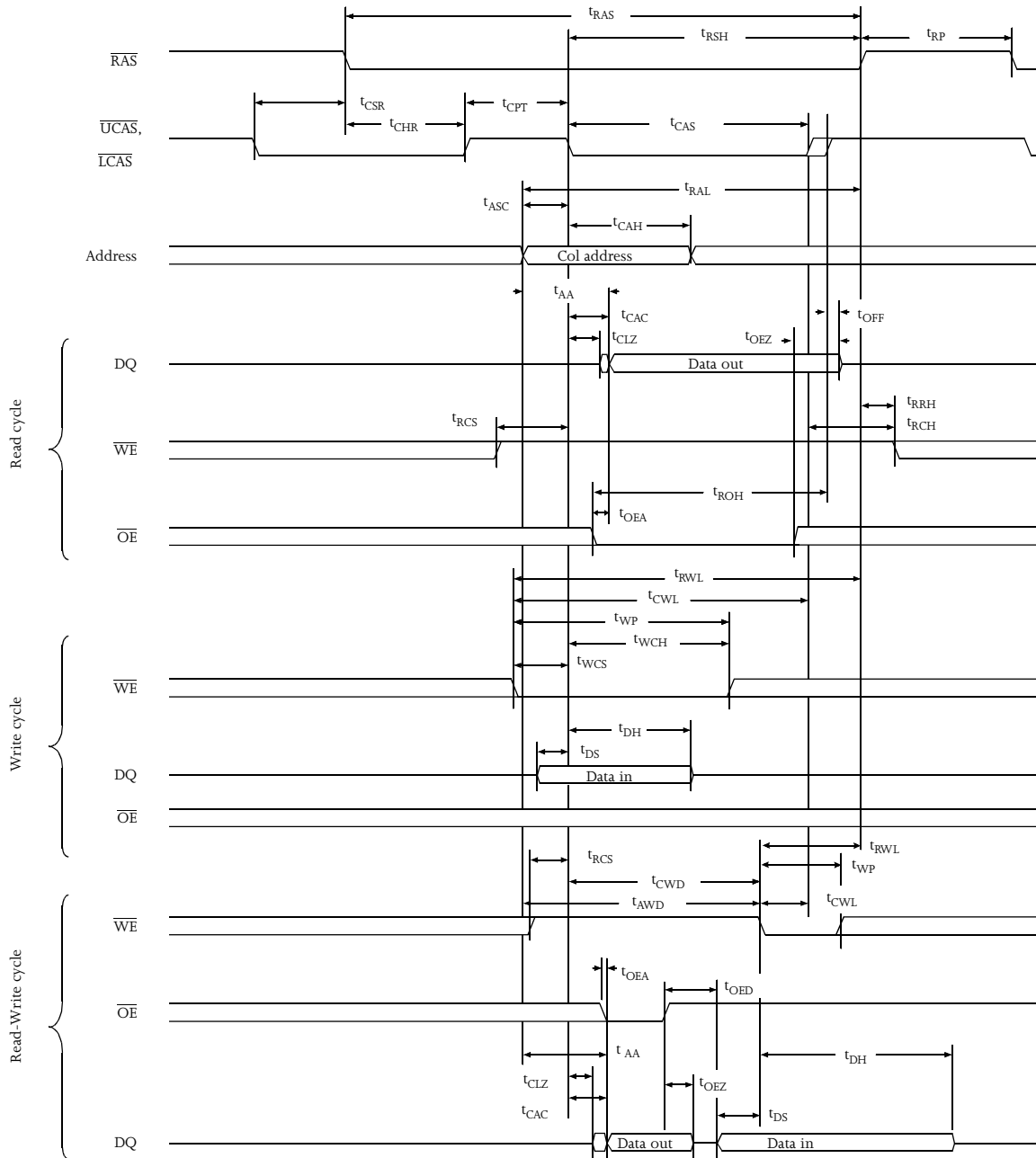
Hidden refresh waveform (write)





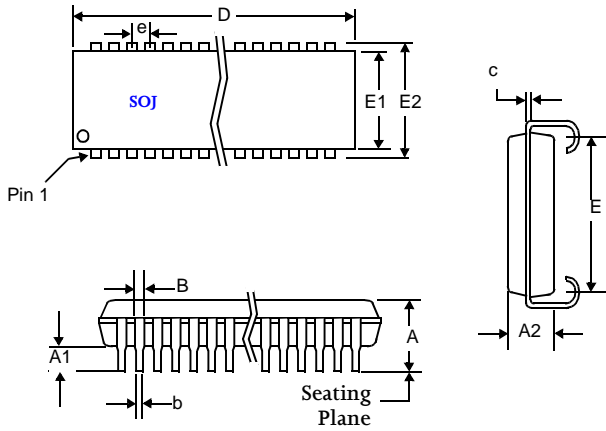


$\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  refresh counter test waveform



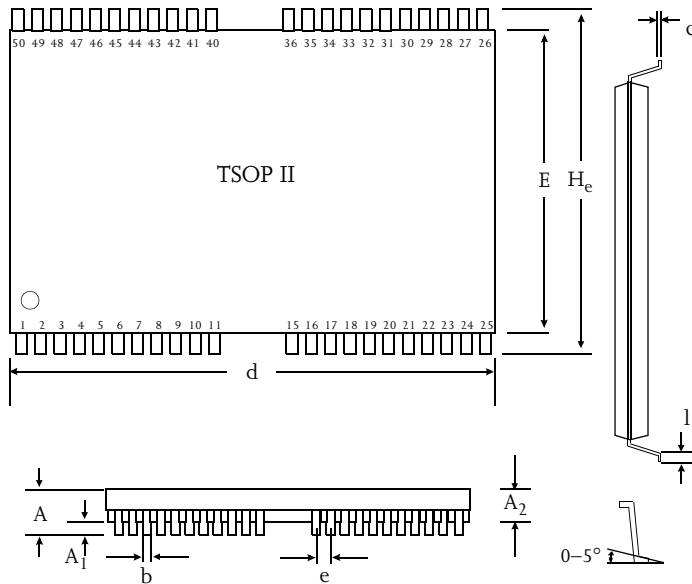


Package dimensions



42-pin SOJ  
400 mil

	Min	Max
A	0.128	0.148
A1	0.025	-
A2	0.105	0.115
B	0.026	0.032
b	0.015	0.020
c	0.007	0.013
D	1.070	1.080
E	0.370	NOM
E1	0.395	0.405
E2	0.435	0.445
e	0.050	NOM

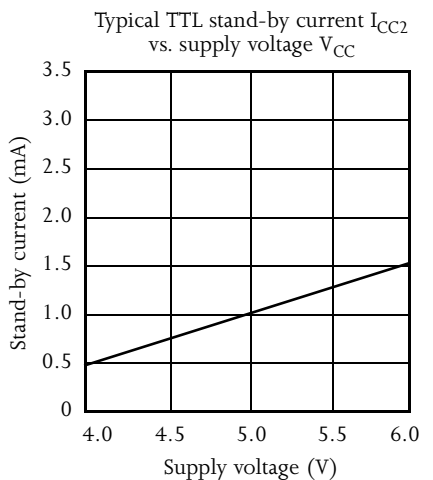
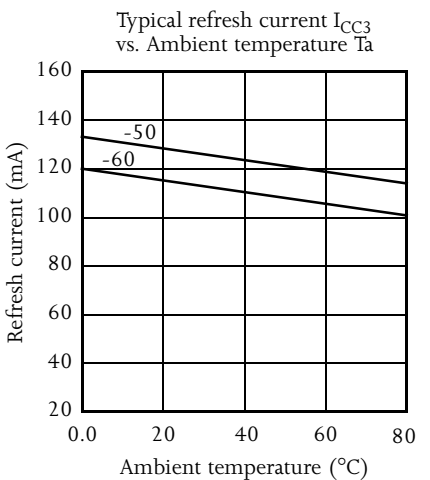
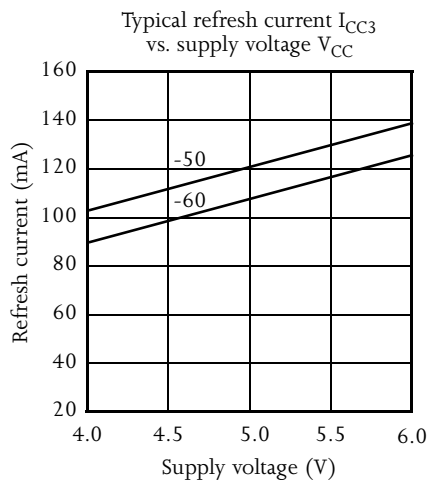
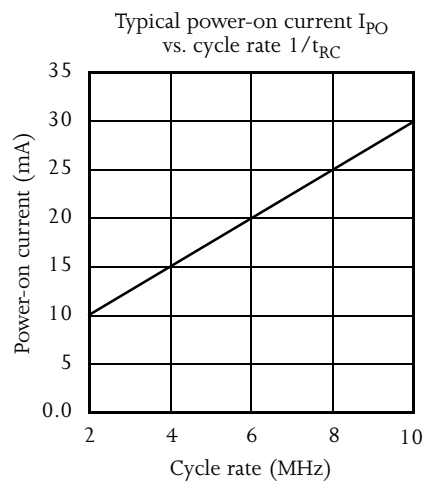
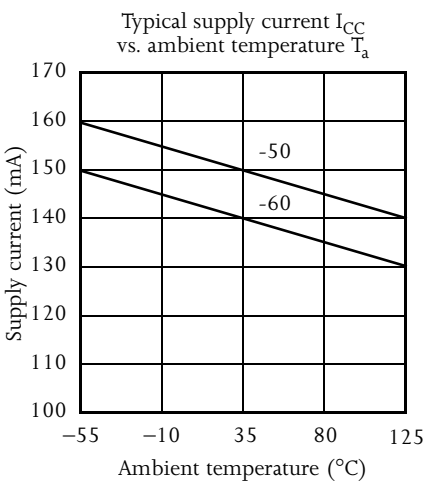
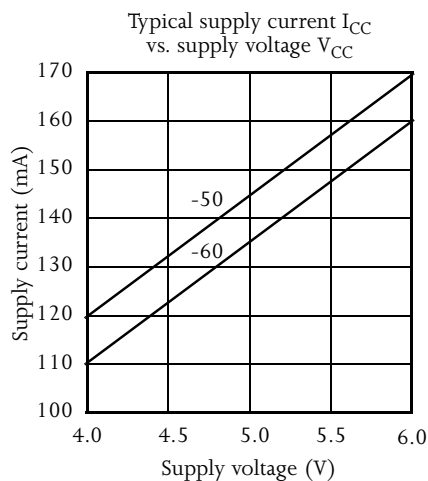
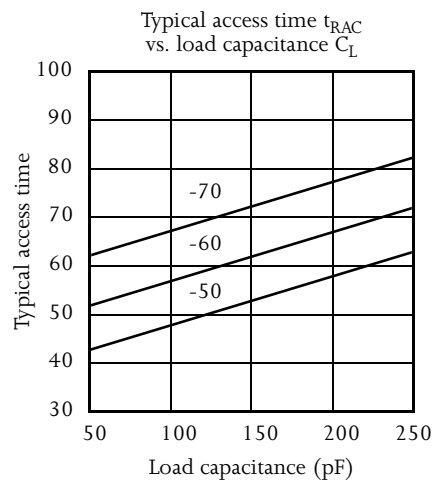
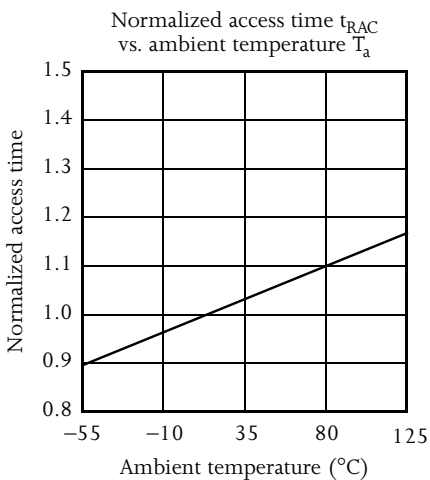
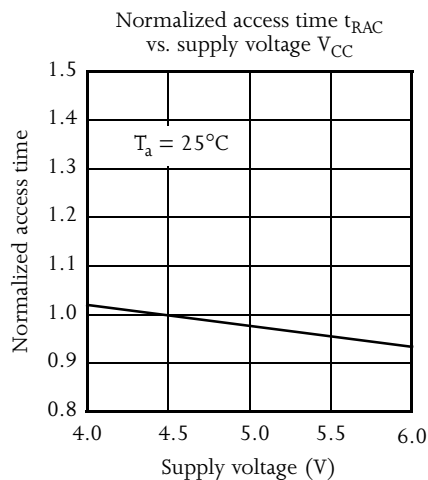


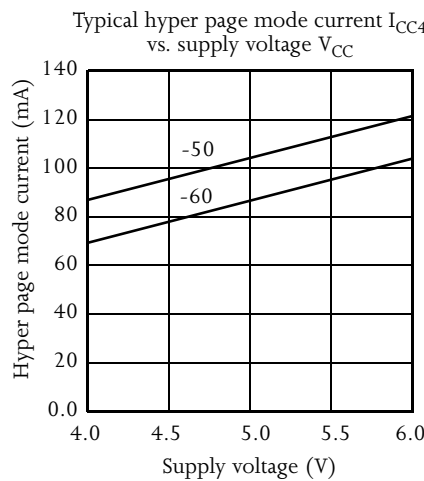
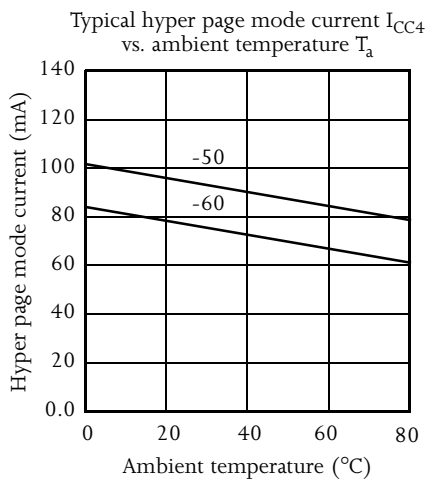
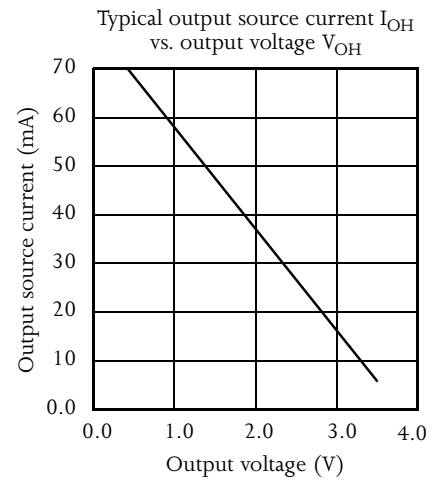
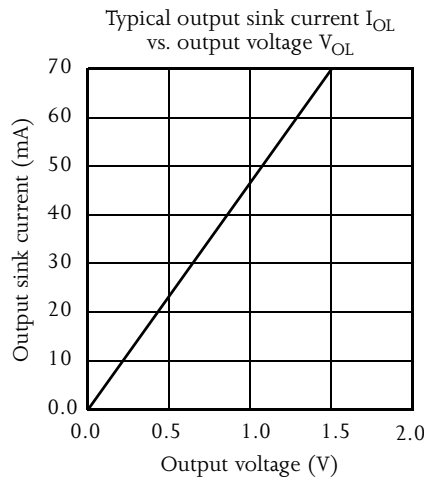
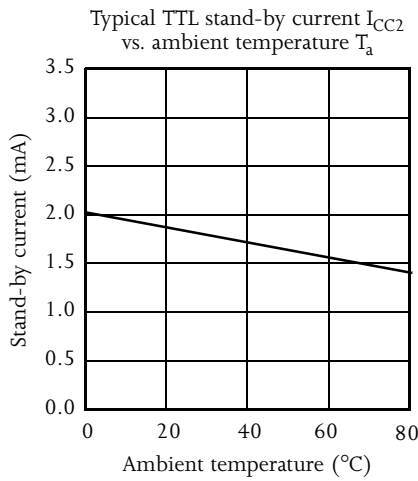
50-pin TSOP II

	Min (mm)	Max (mm)
A		1.2
A1	0.05	
A2	0.95	1.05
b	0.30	0.45
c	0.12	0.21
d	20.85	21.05
E	10.03	10.29
H <sub>c</sub>	11.56	11.96
e	0.80	(typical)
l	0.40	0.60



Typical DC and AC characteristics





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
	$C_{IN2}$	$\overline{RAS}, \overline{UCAS}, \overline{LCAS}, \overline{WE}, \overline{OE}$	$V_{in} = 0V$	7	pF
DQ capacitance	$C_{DQ}$	DQ0 to DQ15	$V_{in} = V_{out} = 0V$	7	pF

AS4C1M16F5 ordering information

Package \ $\overline{RAS}$ access time	50 ns		60 ns
	5V	AS4C1M16F5-50JC AS4C1M16F5-50JI	AS4C1M16F5-60JC AS4C1M16F5-60JI
Plastic SOJ, 400 mil, 42-pin	5V	AS4C1M16F5-50JC AS4C1M16F5-50JI	AS4C1M16F5-60JC AS4C1M16F5-60JI
TSOP II, 400 mil, 44/50-pin	5V	AS4C1M16F5-50TC AS4C1M16F5-50TI	AS4C1M16F5-60TC AS4C1M16F5-60TI



AS4C1M16F5 part numbering system

AS4	C	1M16E0	-XX	X	X
DRAM prefix	C = 5V CMOS	Device number	$\overline{\text{RAS}}$ access time	Package: J = 42-pin SOJ 400 mil T=44/50-pin TSOP II 400 mil	Temperature range C=Commercial, 0°C to 70°C I=Industrial, -40°C to 85°C