μPD424190A/L, 42S4190A/L
262,144 x 18-Bit
Dynamic CMOS RAM

T-46-23-17

Description

The μPD424190A/L and μPD42S4190A/L are fast-page dynamic RAMs organized as 262,144 words by 18 bits and designed to operate from a single power supply.

Optional features are power supply voltage (+5 V or +3.3 V) and a new refresh mode called "self-refresh."

μPD	Options
424190A	+5 V
424190L	+3.3 V
42S4190A	+5 V; self-refresh mode
42S4190L	+3.3 V; self-refresh mode

Advanced polycide technology using stacked capacitors minimizes silicon area and provides high storage cell capacity, high performance, and high reliability. A single-transistor dynamic storage cell and CMOS circuitry throughout ensure minimum power dissipation, while an on-chip circuit internally generates the negative-voltage substrate bias—automatically and transparently.

Word writing (I/O_1 - I/O_{18}), upper byte writing (I/O_{10} - I/O_{18}), and lower byte writing (I/O_1 - I/O_9) are all possible using $\overline{UWE}$ and $\overline{LWE}$. If $\overline{UWE}$ or $\overline{LWE}$ goes low during an early write cycle, all data outputs remain in high impedance. Either going low causes a byte write cycle, while bringing both low at the same time results in a word write cycle. $\overline{UWE}$ and $\overline{LWE}$ cannot be staggered within the same write cycle.

Refreshing may be accomplished by a $\overline{CAS}$ before $\overline{RAS}$ refresh cycle (CBR) that internally generates the refresh address. $\overline{RAS}$-only refresh cycles will also refresh all memory locations.

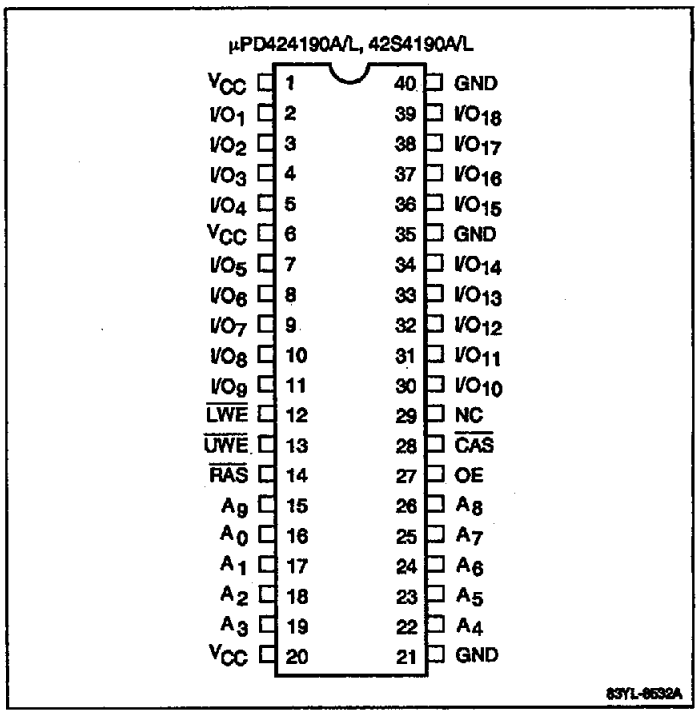
The self-refresh mode is entered by holding $\overline{RAS}$ low for longer than 100 μs during a CBR cycle. Detection of this long $\overline{RAS}$ time starts an internal oscillator that maintains data integrity without external clocking. The slow refresh reduces the data hold current to less than 200 microamperes. Self-refresh mode is used with microprocessors that have a "sleep mode" for low-power applications such as notebook PCs.

Features

- 262,144 by 18-bit organization
- Single power supply (+5-volt or +3.3-volt)
- Self-refresh option (slow internal automatic refresh)
- Fast-page option
- Byte write control with $\overline{UWE}$ and $\overline{LWE}$
- Low power dissipation
- $\overline{CAS}$ before $\overline{RAS}$ refreshing
- On-chip substrate bias generator
- TTL-compatible inputs and outputs
- Nonlatched, three-state outputs
- Low input capacitance
- Multiplexed row and column addresses
- 1024 refresh cycles every 16 ms
- 40-pin SOJ, 40-pin ZIP, and 44/40-pin TSOP plastic packaging

Pin Configurations

40-Pin Plastic SOJ



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Pin Configurations (cont)

40-Pin Plastic ZIP

μPD424190A/L, 42S4190A/L

I/O11	1	2	I/O12
I/O13	3	4	I/O14
GND	5	6	I/O15
I/O16	7	8	I/O17
I/O18	9	10	GND
VCC	11	12	I/O1
I/O2	13	14	I/O3
I/O4	15	16	VCC
I/O5	17	18	I/O6
I/O7	19	20	I/O8
I/O9	21	22	$\overline{LWE}$
$\overline{UWE}$	23	24	$\overline{RAS}$
A9	25	26	A0
A1	27	28	A2
A3	29	30	VCC
GND	31	32	A4
A5	33	34	A6
A7	35	36	A8
$\overline{OE}$	37	38	$\overline{CAS}$
NC	39	40	I/O10

83YL-8533A

44/40-Pin Plastic TSOP (Normal Pinouts)

μPD424190A/L, 42S4190A/L

VCC	1	44	GND
I/O1	2	43	I/O18
I/O2	3	42	I/O17
I/O3	4	41	I/O16
I/O4	5	40	I/O15
VCC	6	39	GND
I/O5	7	38	I/O14
I/O6	8	37	I/O13
I/O7	9	36	I/O12
I/O8	10	35	I/O11
	–7KF		
I/O9	13	32	I/O10
$\overline{LWE}$	14	31	NC
$\overline{UWE}$	15	30	$\overline{CAS}$
$\overline{RAS}$	16	29	$\overline{OE}$
A9	17	28	A8
A0	18	27	A7
A1	19	26	A6
A2	20	25	A5
A3	21	24	A4
VCC	22	23	GND

Suffix –7KF in the package identifier denotes normal pinout sequence.

83YL-8534A

44/40-Pin Plastic TSOP (Reverse Pinouts)

μPD424190A/L, 42S4190A/L

GND	1	44	VCC
I/O18	2	43	I/O1
I/O17	3	42	I/O2
I/O16	4	41	I/O3
I/O15	5	40	I/O4
GND	6	39	VCC
I/O14	7	38	I/O5
I/O13	8	37	I/O6
I/O12	9	36	I/O7
I/O11	10	35	I/O8
	–7JF		
I/O10	13	32	I/O9
NC	14	31	$\overline{LWE}$
$\overline{CAS}$	15	30	$\overline{UWE}$
$\overline{OE}$	16	29	$\overline{RAS}$
A8	17	28	A9
A7	18	27	A0
A6	19	26	A1
A5	20	25	A2
A4	21	24	A3
GND	22	23	VCC

Suffix –7JF in the package identifier denotes reverse pinout sequence.

83YL-8536A

Pin Identification

Name	Function
A0 - A9	Address inputs
$\overline{CAS}$	Column address strobe
I/O1 - I/O18	Data inputs and outputs
$\overline{OE}$	Output enable
$\overline{RAS}$	Row address strobe
$\overline{UWE}$ and $\overline{LWE}$	Byte write enable
GND	Ground
VCC	+5-volt or +3.3-volt power supply
NC	No connection

Ordering Information, μPD424190A (+ 5-volt power)

Part Number	$\overline{RAS}$ Access Time (max)	Fast-Page Cycle Time (max)	$\overline{CAS}$ Access Time (max)	Package
μPD424190ALE-60	60 ns	40 ns	20 ns	40-pin plastic SOJ
LE-70	70 ns	45 ns		
LE-80	80 ns	50 ns		
μPD424190AV-60	60 ns	40 ns	20 ns	40-pin plastic ZIP
V-70	70 ns	45 ns		
V-80	80 ns	50 ns		
μPD424190AG5-60	60 ns	40 ns	20 ns	44/40-pin plastic TSOP (normal pinouts)
G5-70	70 ns	45 ns		
G5-80	80 ns	50 ns		
μPD424190AG5M-60	60 ns	40 ns	20 ns	44/40-pin plastic TSOP (reverse pinouts)
G5M-70	70 ns	45 ns		
G5M-80	80 ns	50 ns		

Ordering Information, μPD424190L (+ 3.3-volt power)

Part Number	$\overline{RAS}$ Access Time (max)	Fast-Page Cycle Time (max)	$\overline{CAS}$ Access Time (max)	Package
μPD424190LLE-A60	60 ns	40 ns	20 ns	40-pin plastic SOJ
LE-A70	70 ns	45 ns		
LE-A80	80 ns	50 ns		
μPD424190LV-A60	60 ns	40 ns	20 ns	40-pin plastic ZIP
V-A70	70 ns	45 ns		
V-A80	80 ns	50 ns		
μPD424190LG5-A60	60 ns	40 ns	20 ns	44/40-pin plastic TSOP (normal pinouts)
G5-A70	70 ns	45 ns		
G5-A80	80 ns	50 ns		
μPD424190LG5M-A60	60 ns	40 ns	20 ns	44/40-pin plastic TSOP (reverse pinouts)
G5M-A70	70 ns	45 ns		
G5M-A80	80 ns	50 ns		

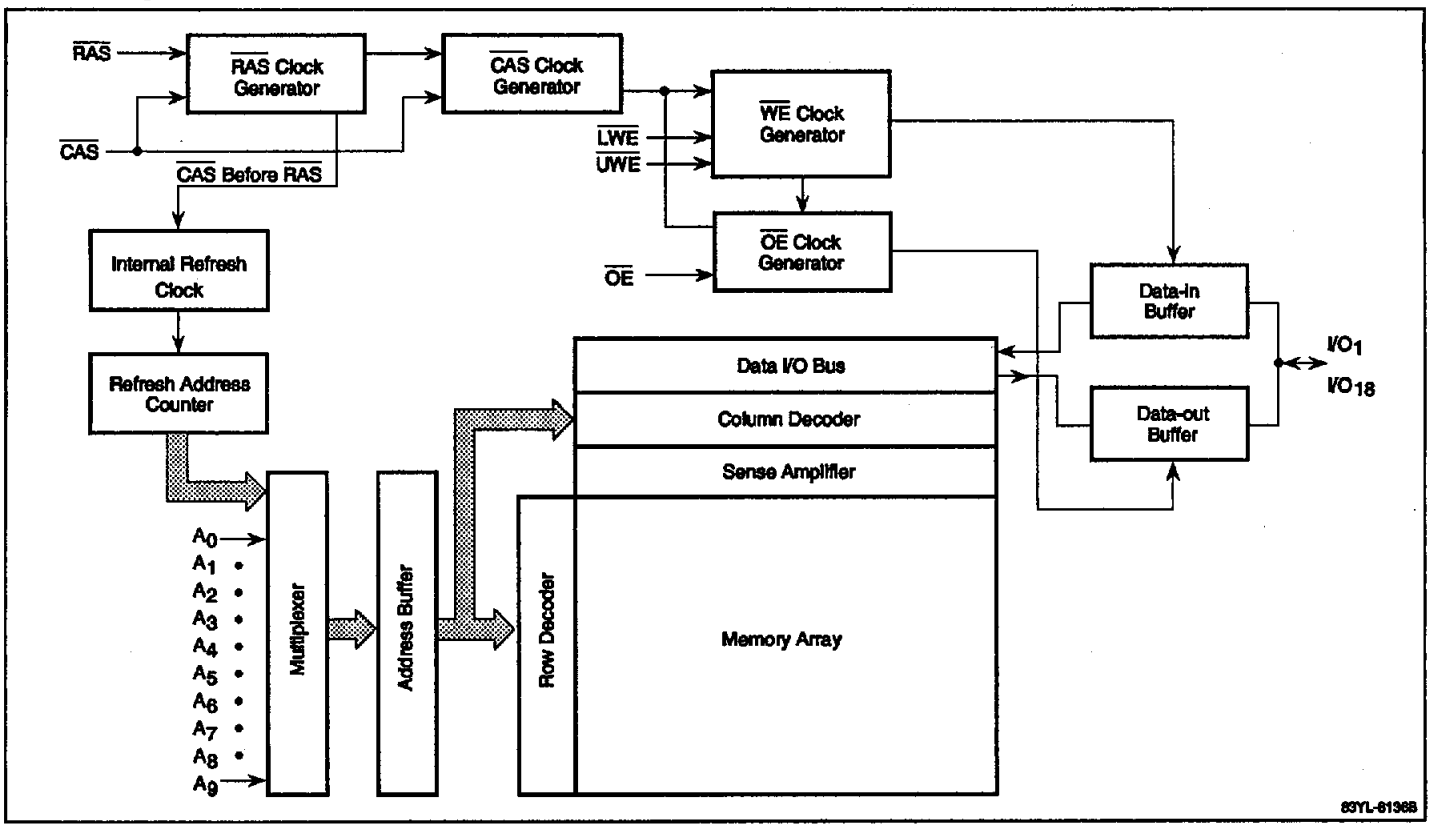
Ordering Information, μPD42S4190A (+ 5-volt power; self-refresh mode)

Part Number	$\overline{RAS}$ Access Time (max)	Fast-Page Cycle Time (max)	$\overline{CAS}$ Access Time (max)	Self-Refresh Current (max)	Package
μPD42S4190ALE-60	60 ns	40 ns	20 ns	300 μA	40-pin plastic SOJ
LE-70	70 ns	45 ns			
LE-80	80 ns	50 ns			
μPD42S4190AV-60	60 ns	40 ns	20 ns	300 μA	40-pin plastic ZIP
V-70	70 ns	45 ns			
V-80	80 ns	50 ns			
μPD42S4190AG5-60	60 ns	40 ns	20 ns	300 μA	44/40-pin plastic TSOP (normal pinouts)
G5-70	70 ns	45 ns			
G5-80	80 ns	50 ns			
μPD42S4190AG5M-60	60 ns	40 ns	20 ns	300 μA	44/40-pin plastic TSOP (reverse pinouts)
G5M-70	70 ns	45 ns			
G5M-80	80 ns	50 ns			

Ordering Information, μPD42S4190L (+ 3.3-volt power; self-refresh mode)

Part Number	$\overline{RAS}$ Access Time (max)	Fast-Page Cycle Time (max)	$\overline{CAS}$ Access Time (max)	Self-Refresh Current (max)	Package
μPD42S4190LLE-A60	60 ns	40 ns	20 ns	300 μA	40-pin plastic SOJ
LE-A70	70 ns	45 ns			
LE-A80	80 ns	50 ns			
μPD42S4190LV-A60	60 ns	40 ns	20 ns	300 μA	40-pin plastic ZIP
V-A70	70 ns	45 ns			
V-A80	80 ns	50 ns			
μPD42S4190LG5-A60	60 ns	40 ns	20 ns	300 μA	44/40-pin plastic TSOP (normal pinouts)
G5-A70	70 ns	45 ns			
G5-A80	80 ns	50 ns			
μPD42S4190LG5M-A60	60 ns	40 ns	20 ns	300 μA	44/40-pin plastic TSOP (reverse pinouts)
G5M-A70	70 ns	45 ns			
G5M-A80	80 ns	50 ns			

Block Diagram



Truth Table

Function	$\overline{RAS}$	$\overline{LWE}$	$\overline{UWE}$	$\overline{CAS}$	$\overline{OE}$	I/O_1 - I/O_9	I/O_{10} - I/O_{18}
Standby	V_{IH}	X	X	X	X	High-Z	High-Z
Refresh cycle	V_{IL}	X	X	V_{IH}	X	High-Z	High-Z
Byte write cycle	V_{IL}	V_{IL}	V_{IH}	V_{IL}	V_{IH}	Data input	High-Z
	V_{IL}	V_{IH}	V_{IL}	V_{IL}	V_{IH}	High-Z	Data input
Word read cycle	V_{IL}	V_{IH}	V_{IH}	V_{IL}	V_{IL}	Data output	Data output
Word write cycle	V_{IL}	V_{IL}	V_{IL}	V_{IL}	V_{IH}	Data input	Data input
——	V_{IL}	V_{IL}	V_{IL}	V_{IH}	V_{IH}	High-Z	High-Z

X = don't care.

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Absolute Maximum Ratings

Voltage on any pin relative to GND	
5-volt devices	−1.0 to +7.0 V
3.3-volt devices	−0.5 to +4.6 V
Operating temperature, T_{OPR}	0 to +70°C
Storage temperature, T_{STG}	−55 to +125°C
Short-circuit output current, I_{OS}	
5-volt devices	50 mA
3.3-volt devices	20 mA
Power dissipation, P_D	1.0 W

Exposure to Absolute Maximum Ratings for extended periods may affect device reliability; exceeding the ratings could cause permanent damage. The device should be operated within the limits specified under DC and AC Characteristics.

Capacitance

T_A = 25°C; f = 1 MHz

Parameter	Symbol	Max	Unit	Pins Under Test
Input capacitance	C_{I1}	5	pF	Addresses
	C_{I2}	7	pF	$\overline{LWE}$, $\overline{UWE}$, $\overline{OE}$, $\overline{RAS}$
Input/output capacitance	C_O	7	pF	I/O_1 - I/O_{18}

Recommended Operating Conditions

		5-Volt Devices			3.3-Volt Devices			
Parameter	Symbol	Min	Typ	Max	Min	Typ	Max	Unit
Input voltage, high	V_{IH}	2.4		V_{CC} + 1.0	2.0		V_{CC} +0.3	V
Input voltage, low	V_{IL}	−1.0		0.8	−0.5		0.8	V
Supply voltage	V_{CC}	4.5	5.0	5.5	3.0	3.3	3.6	V
Ambient temperature	T_A	0		+70	0		+70	°C

Self-Refresh Current

T_A = 0 to +70°C; V_{CC} = +5 V ±10% (42S4190A) or +3.3 V ±0.3 V (42S4190L)

Symbol	42S4190A	42S4190L	Conditions
I_{CC7}	300 μA max	100 μA max	I/O pins: $V_{IH} \geq V_{CC} - 0.2$ V; $V_{IL} \leq 0.2$ V or open. Other input pins: $V_{IH} \geq V_{CC} - 0.2$ V; $V_{IL} \leq 0.2$ V or open. $t_{RAS} \geq 100$ μs

DC Characteristics; 5-Volt Devices

T_A = 0 to +70°C; V_{CC} = +5.0 V ±10%

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Standby current	I_{CC2}			2.0	mA	$\overline{RAS}$ = $\overline{CAS}$ ≥ V_{IH} (min); I_O = 0 mA
				300	μA	$\overline{RAS}$ = $\overline{CAS}$ ≥ V_{CC} − 0.2 V; I_O = 0 mA
Input leakage current	$I_{I(L)}$	−10		10	μA	V_{IN} = 0 V to V_{CC}; all other pins not under test = 0 V
Output leakage current	$I_{O(L)}$	−10		10	μA	D_{OUT} disabled; V_{OUT} = 0 V to V_{CC}
Output voltage, low	V_{OL}			0.4	V	I_{OL} = 4.2 mA
Output voltage, high	V_{OH}	2.4			V	I_{OH} = −5 mA

DC Characteristics; 3.3-Volt Devices

T_A = 0 to +70°C; V_{CC} = +3.3 V ±0.3 V

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Standby current	I_{CC2}			500	μA	$\overline{RAS}$ = $\overline{CAS}$ ≥ V_{IH} (min); I_O = 0 mA
				100	μA	$\overline{RAS}$ = $\overline{CAS}$ ≥ V_{CC} – 0.2 V; I_O = 0 mA
Input leakage current	$I_{I(L)}$	–5		5	μA	V_{IN} = 0 V to V_{CC}; all other pins not under test = 0 V
Output leakage current	$I_{O(L)}$	–5		5	μA	D_{OUT} disabled; V_{OUT} = 0 V to V_{CC}
Output voltage, low	V_{OL}			0.4	V	I_{OL} = –2.0 mA
Output voltage, high	V_{OH}	2.4			V	I_{OH} = –2.0 mA

AC Characteristics

T_A = 0 to +70°C

μPD424190A, 42S4190A: V_{CC} = +5.0 V ±10%

μPD424190L, 42S4190L: V_{CC} = +3.3 V ±0.3 V

		-60		-70		-80			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Test Conditions
Operating current, average	I_{CC1} (+5)		130		120		110	mA	$\overline{RAS}$, $\overline{CAS}$ cycling; t_{RC} = t_{RC} min (Note 5)
	I_{CC1} (+3.3)		120		110		100		
Operating current, $\overline{RAS}$-only refresh cycle, average	I_{CC3} (+5)		130		120		110	mA	$\overline{RAS}$ cycling; $\overline{CAS}$ ≥ V_{IH} min; t_{RC} = t_{RC} min (Note 5)
	I_{CC3} (+3.3)		120		110		100		
Operating current, fast-page cycle, average	I_{CC4} (+5)		110		100		90	mA	$\overline{RAS}$ ≤ V_{IL}; $\overline{CAS}$ cycling; t_{PC} = t_{PC} min (Note 5)
	I_{CC4} (+3.3)		110		100		90		
Operating current, $\overline{CAS}$ before $\overline{RAS}$ refresh cycle, average	I_{CC5} (+5)		140		130		120	mA	$\overline{RAS}$ cycling; $\overline{CAS}$ ≤ V_{IL} max; t_{RC} = t_{RC} min (Note 5)
	I_{CC5} (+3.3)		130		120		110		
Access time from column address	t_{AA}		30		35		40	ns	(Notes 3, 4, 7, 8)
Access time from $\overline{CAS}$ precharge (rising edge)	t_{ACP}		35		40		45	ns	(Notes 3, 4, 7, 8)
Column address setup time	t_{ASC}	0		0		0		ns	
Row address setup time	t_{ASR}	0		0		0		ns	
Column address to $\overline{WE}$ delay time	t_{AWD}	50		55		70		ns	(Note 14)
Access time from $\overline{CAS}$ (falling edge)	t_{CAC}		20		20		20	ns	(Notes 3, 4, 7, 8)
Column address hold time	t_{CAH}	15		15		15		ns	
$\overline{CAS}$ pulse width	t_{CAS}	20	10,000	20	10,000	20	10,000	ns	
$\overline{CAS}$ hold time for $\overline{CAS}$ before $\overline{RAS}$ refreshing	t_{CHR}	15		15		15		ns	(Note 15)
$\overline{CAS}$ hold time (CBR self-refresh mode)	t_{CHS}	–35		–40		–50		ns	For 42S4190A/L only

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AC Characteristics (cont)

Parameter	Symbol	-60 Min	-60 Max	-70 Min	-70 Max	-80 Min	-80 Max	Unit	Test Conditions
$\overline{CAS}$ to output in low-Z	t_{CLZ}	0		0		0		ns	(Notes 4, 7)
Fast-page $\overline{CAS}$ precharge time	t_{CP}	10		10		10		ns	
$\overline{CAS}$ precharge time	t_{CPN}	10		10		10		ns	
Fast-page $\overline{CAS}$ precharge to $\overline{WE}$ delay time	t_{CPWD}	55		60		75		ns	(Note 14)
$\overline{CAS}$ to $\overline{RAS}$ precharge time	t_{CRP}	10		10		10		ns	(Note 10)
$\overline{CAS}$ hold time	t_{CSH}	60		70		80		ns	
$\overline{CAS}$ setup time for $\overline{CAS}$ before $\overline{RAS}$ refresh cycle	t_{CSR}	5		5		5		ns	(Note 15)
$\overline{CAS}$ to $\overline{WE}$ delay	t_{CWD}	40		40		50		ns	(Note 14)
Write command referenced to $\overline{CAS}$ lead time	t_{CWL}	15		15		15		ns	
Data-in hold time	t_{DH}	15		15		15		ns	(Notes 13, 16)
Data-in setup time	t_{DS}	0		0		0		ns	(Notes 13, 16)
Masked write hold time referenced to $\overline{CAS}$	t_{MCH}	0		0		0		ns	
Masked write setup time	t_{MCS}	0		0		0		ns	
Masked write hold time referenced to $\overline{RAS}$	t_{MRH}	0		0		0		ns	
Access time from $\overline{OE}$	t_{OEA}		20		20		20	ns	(Notes 3, 4, 7, 8)
$\overline{OE}$ data delay time	t_{OED}	15		15		15		ns	
$\overline{OE}$ command hold time	t_{OEH}	0		0		0		ns	
$\overline{OE}$ to $\overline{RAS}$ inactive setup time	t_{OES}	0		0		0		ns	
Output turnoff delay from $\overline{OE}$	t_{OEZ}	0	15	0	15	0	15	ns	(Note 9)
Output disable from $\overline{CAS}$ high	t_{OFF}	0	15	0	15	0	20	ns	(Note 9)
$\overline{OE}$ to output in low-Z	t_{OLZ}	0		0		0		ns	(Notes 5, 7)
Fast-page read or write cycle time	t_{PC}	40		45		50		ns	(Note 6)
Fast-page read-modify-write cycle time with exended data output	t_{PRWC}	85		90		100		ns	(Note 6)

AC Characteristics (cont)

Parameter	Symbol	-60 Min	-60 Max	-70 Min	-70 Max	-80 Min	-80 Max	Unit	Test Conditions
Access time from $\overline{RAS}$	t_{RAC}		60		70		80	ns	(Notes 3, 4, 7, 8)
$\overline{RAS}$ to column address delay time	t_{RAD}	15	30	15	35	15	40	ns	(Note 8)
Row address hold time	t_{RAH}	10		10		10		ns	
Column address lead time referenced to $\overline{RAS}$ (rising edge)	t_{RAL}	30		35		40		ns	
$\overline{RAS}$ pulse width	t_{RAS}	60	10,000	70	10,000	80	10,000	ns	
Fast-page $\overline{RAS}$ pulse width	t_{RASP}	60	125,000	70	125,000	80	125,000	ns	
$\overline{RAS}$ pulse width (CBR self-refresh mode)	t_{RASS}	100		100		100		μs	For 42S4190A/L
Random read or write cycle time	t_{RC}	120		130		150		ns	(Note 6)
$\overline{RAS}$ to $\overline{CAS}$ delay time	t_{RCD}	20	40	20	50	20	60	ns	(Note 8)
Read command hold time referenced to $\overline{CAS}$	t_{RCH}	0		0		0		ns	(Note 11)
Read command setup time	t_{RCS}	0		0		0		ns	
Refresh period	t_{REF}		16		16		16	ms	Addresses A_0 - A_9
$\overline{RAS}$ hold time referenced to $\overline{CAS}$ precharge	t_{RHCP}	35		40		45		ns	
$\overline{RAS}$ precharge time	t_{RP}	50		50		60		ns	
$\overline{RAS}$ precharge $\overline{CAS}$ hold time	t_{RPC}	0		0		0		ns	
$\overline{RAS}$ precharge time (CBR self-refresh mode)	t_{RPS}	120		130		150		ns	For 42S4190A/L
Read command hold time referenced to $\overline{RAS}$	t_{RRH}	0		0		0		ns	(Note 11)
$\overline{RAS}$ hold time	t_{RSH}	20		20		25		ns	
Read-modify-write cycle time	t_{RWC}	165		175		200		ns	(Note 6)
$\overline{RAS}$ to $\overline{WE}$ delay	t_{RWD}	80		90		105		ns	(Note 14)
Write command referenced to $\overline{RAS}$ lead time	t_{RWL}	20		20		20		ns	
Rise and fall times	t_T	3	50	3	50	3	50	ns	(Note 4)
Write command hold time	t_{WCH}	15		15		15		ns	(Note 12)

AC Characteristics (cont)

Parameter	Symbol	-60 Min	-60 Max	-70 Min	-70 Max	-80 Min	-80 Max	Unit	Test Conditions
Write command setup time	t_{WCS}	0		0		0		ns	(Note 14)
Write command pulse width	t_{WP}	15		15		15		ns	(Note 12)

Notes:

(1) All voltages are referenced to GND.

(2) An initial pause of 100 μs is required after power-up, followed by any eight $\overline{RAS}$ cycles, before proper device operation is achieved.

(3) Ac measurements assume t_T = 5 ns.

(4) V_{IH} (min) and V_{IL} (max) are reference levels for measuring the timing of input signals. Transition times are measured between V_{IH} and V_{IL}.

(5) I_{CC1}, I_{CC3}, I_{CC4}, and I_{CC5} depend on output loading and cycle rates. Specified values are obtained with the output open. I_{CC3} is measured assuming that all column address inputs are held at either a high level or a low level during $\overline{RAS}$-only refresh cycles. I_{CC4} is measured assuming that all column address inputs are switched only once during each fast-page cycle.

(6) The minimum specifications are used only to indicate the cycle time at which proper operation over the full temperature range (T_A = 0 to +70°C) is assured.

(7) Load = 2 TTL (–1 mA, +4 mA) loads and 100 pF. For 3.3-volt devices, V_{OH} = 2.0 V and V_{OL} = 0.8 V (ac reference levels).

(8) If $t_{RCD} \leq t_{RCD}$ (max) and $t_{RAD} \leq t_{RAD}$ (max), access time is defined by t_{RAC} (max).
If $t_{RCD} \geq t_{RCD}$ (max), access time is defined by t_{CAC} (max).
If $t_{RAD} \geq t_{RAD}$ (max), access time is defined by t_{AA} (max).

(9) t_{OFF} (max) and t_{OEZ} (max) define the time at which the outputs become open-circuit and are not referenced to V_{OH} or V_{OL}.

(10) The t_{CRP} requirement should be applicable for $\overline{RAS}/\overline{CAS}$ cycles preceded by any cycle.

(11) Either t_{RRH} or t_{RCH} must be satisfied for a read cycle.

(12) Parameter t_{WP} is applicable for a delayed write cycle such as a read-write/read-modify-write cycle. For early write cycles, both t_{WCS} and t_{WCH} must be met.

(13) These parameters are referenced to the falling edge of $\overline{CAS}$ for early write cycles and to the falling edge of $\overline{WE}$ for delayed write or read-modify-write cycles.

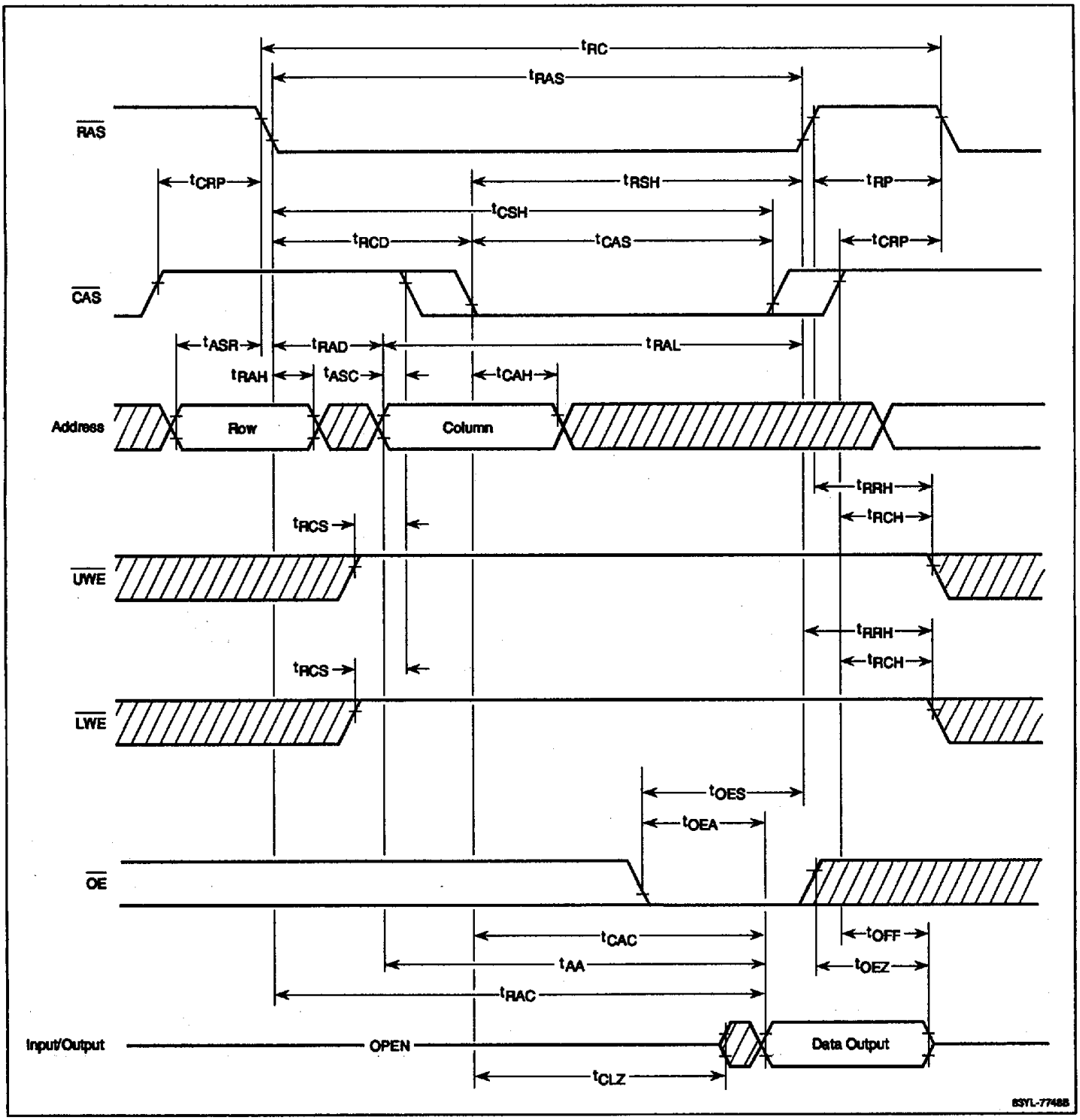
(14) t_{WCS}, t_{RWD}, t_{CWD}, t_{CPWD} and t_{AWD} are restrictive operating parameters in read-write/read-modify-write cycles only. If $t_{WCS} \geq t_{WCS}$ (min), the cycle is an early write cycle and the data I/O pins will remain open-circuit throughout the entire cycle. If $t_{CWD} \geq t_{CWD}$ (min), $t_{RWD} \geq t_{RWD}$ (min), and $t_{AWD} \geq t_{AWD}$ (min), then the cycle is a read-write cycle and the data I/O pins will contain data read from the selected cells. If neither of the above conditions is met, the condition of the data I/O pins (at access time and until $\overline{CAS}$ returns to V_{IH}) is indeterminate.

(15) Holding $\overline{CAS}$ low prior to $\overline{RAS}$ going negative will initiate a $\overline{CAS}$ before $\overline{RAS}$ refresh cycle (t_{CSR} and t_{CHR} must be satisfied).

(16) The first $\overline{WE}$ falling edge is used as a reference for the setup and hold requirements of t_{DS} and t_{DH} (late write cycle).

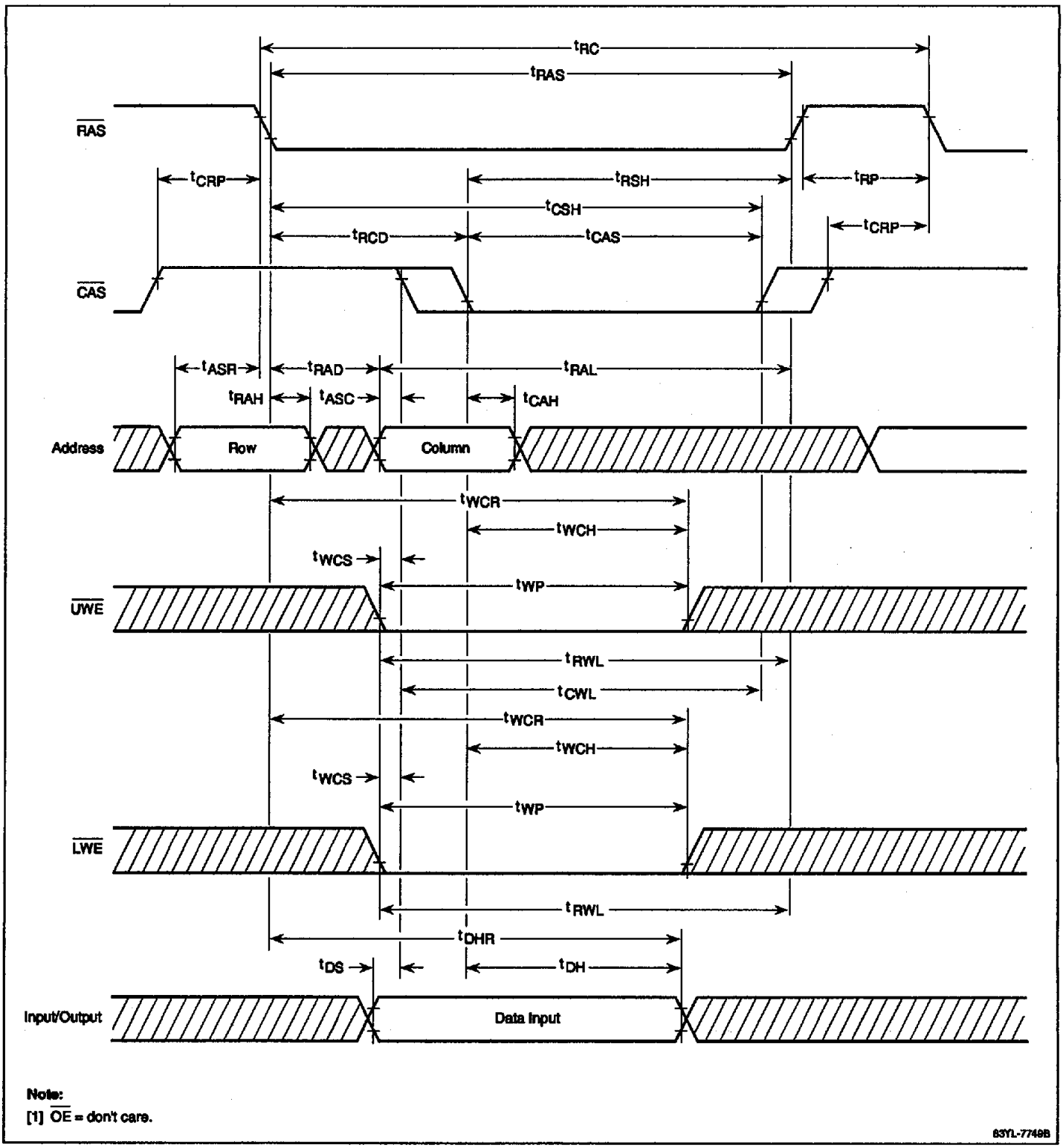
Timing Waveforms

Word Read Cycle



Timing Waveforms (cont)

Word Early-Write Cycle



Note:
[1] $\overline{OE}$ = don't care.

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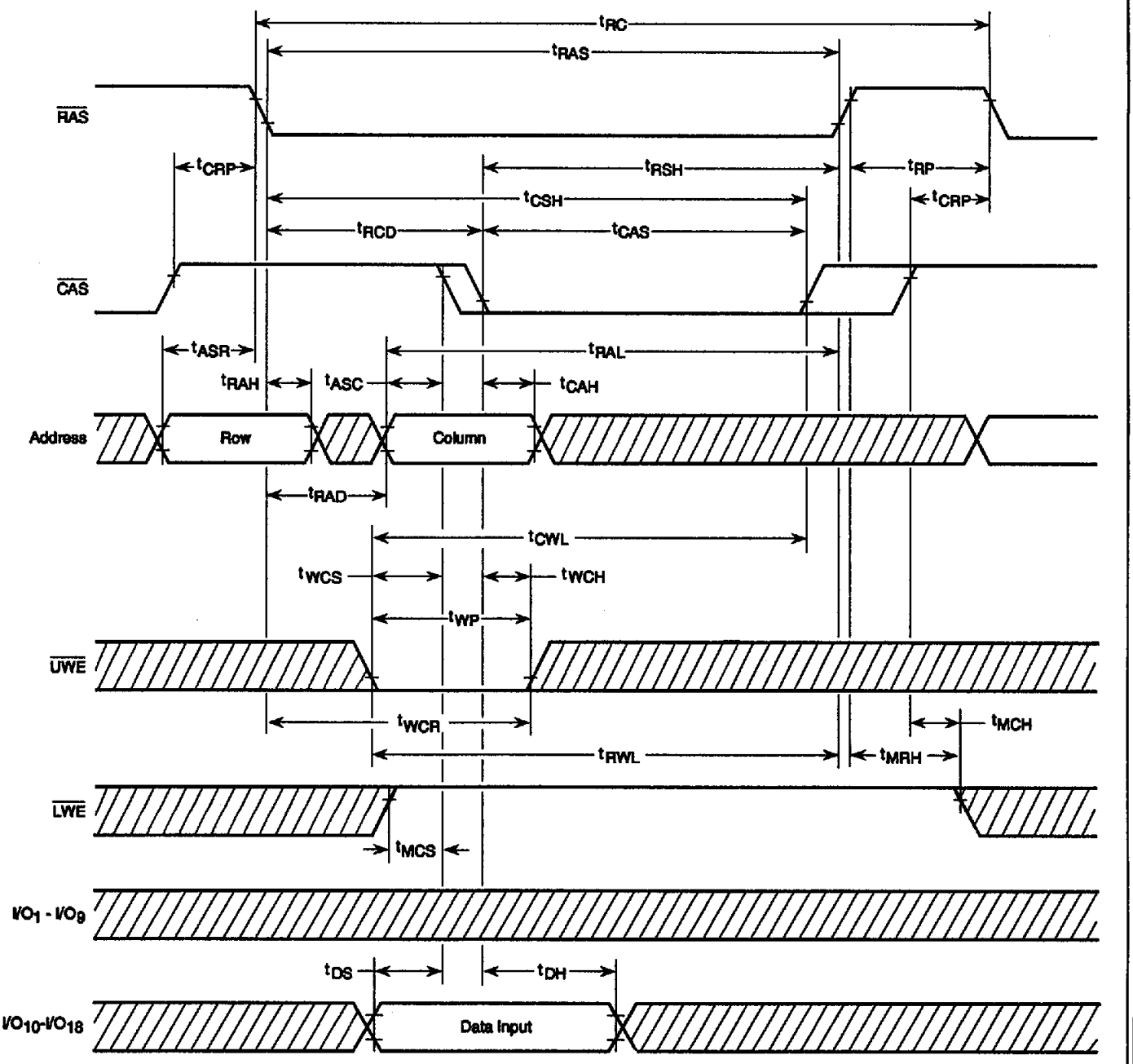
Timing Waveforms (cont)

Byte Early-Write Cycle



Notes:
[1] $\overline{OE}$ = don't care.

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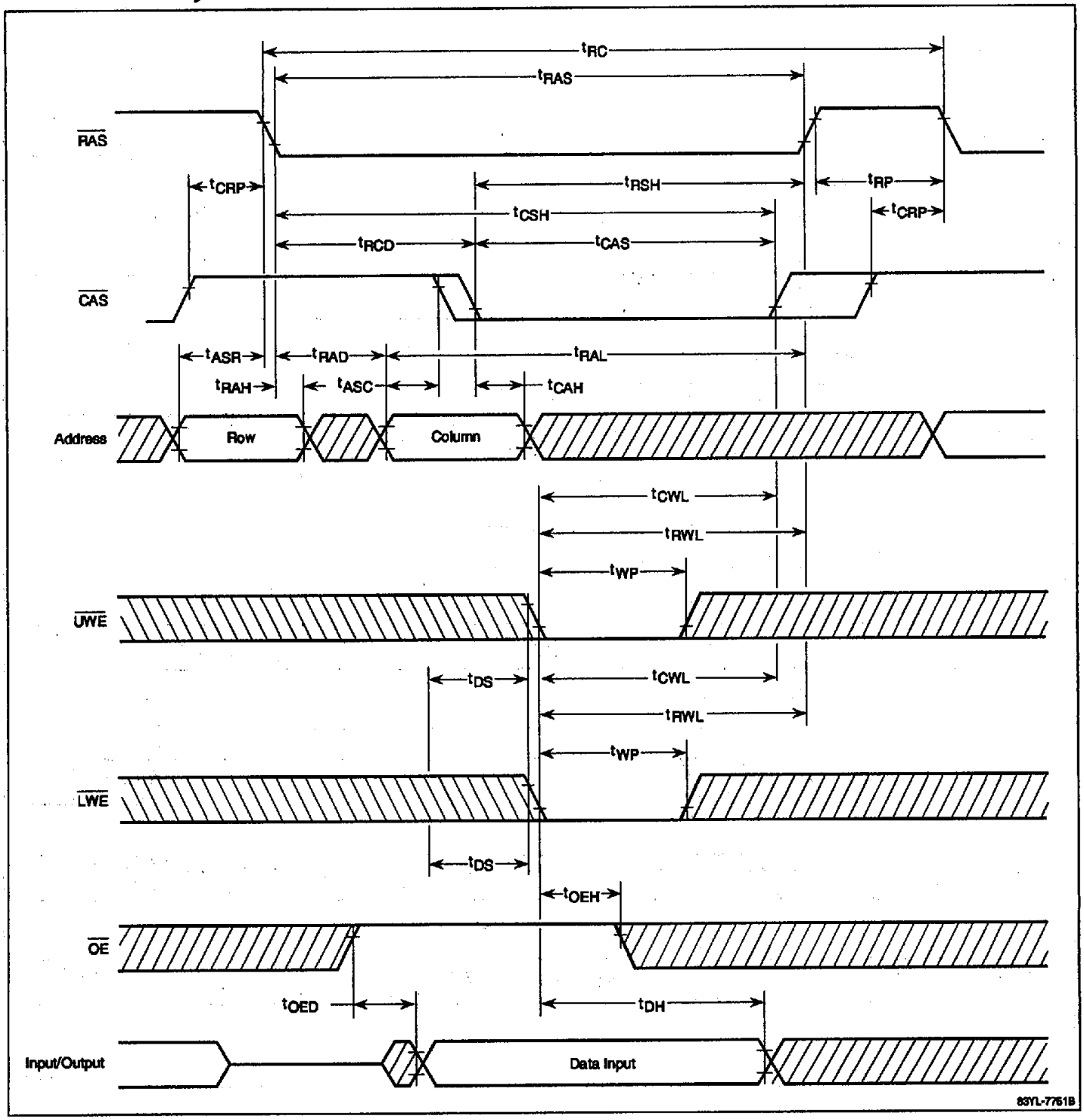
7b

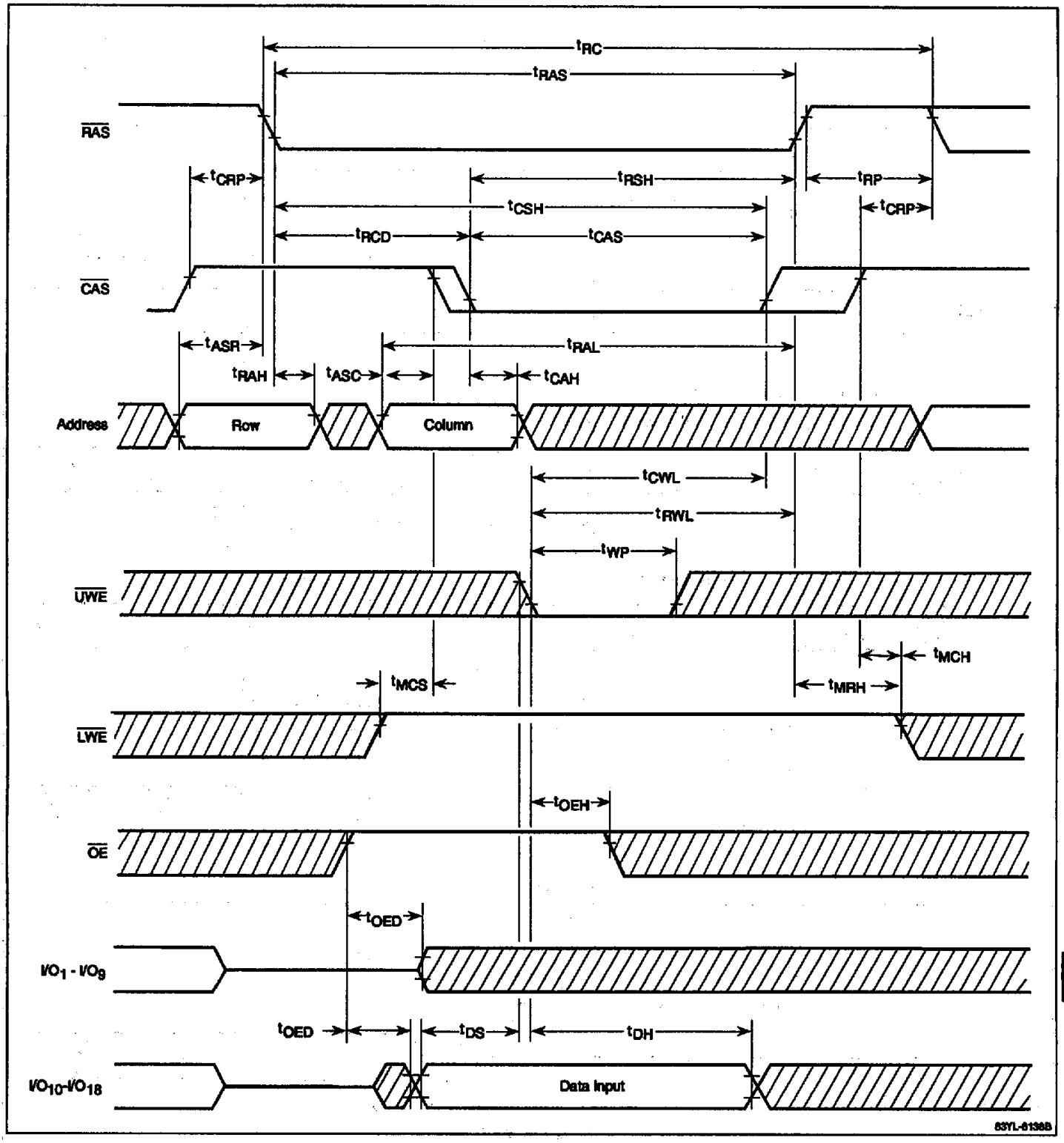
Timing Waveforms (cont)

Word Late-Write Cycle



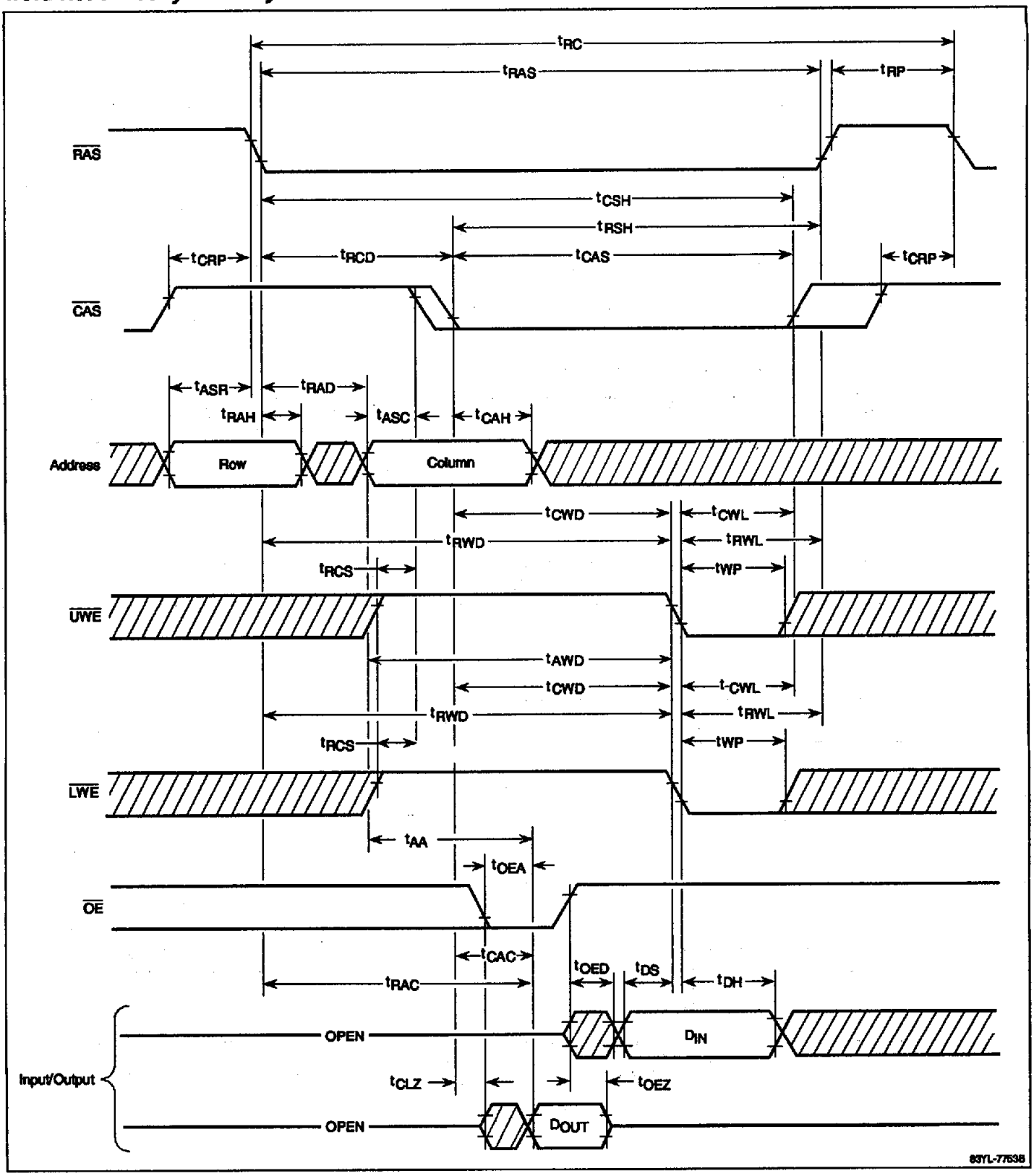
Timing Waveforms (cont)

Byte Late-Write Cycle



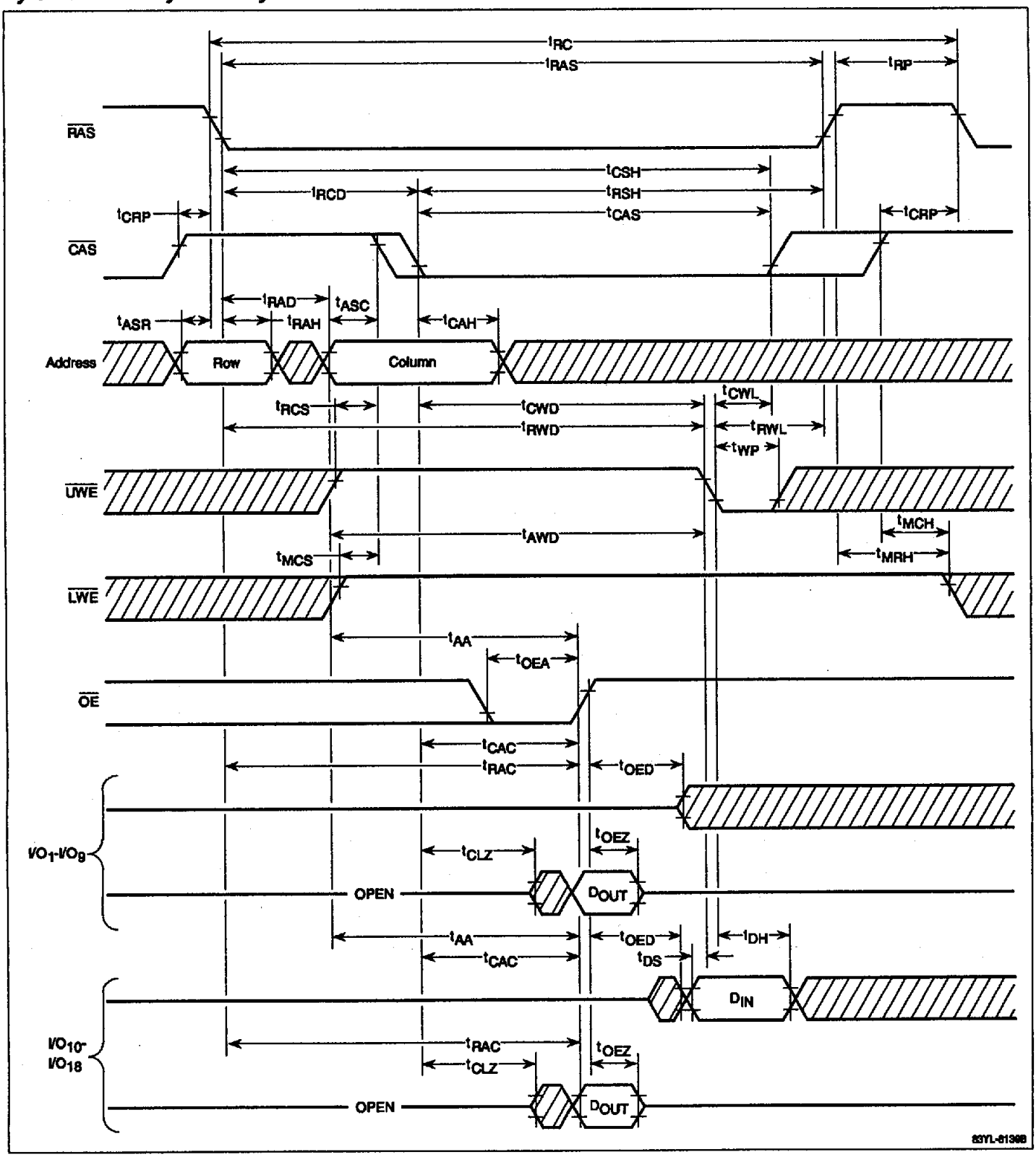
Timing Waveforms (cont)

Word Read-Modify-Write Cycle



Timing Waveforms (cont)

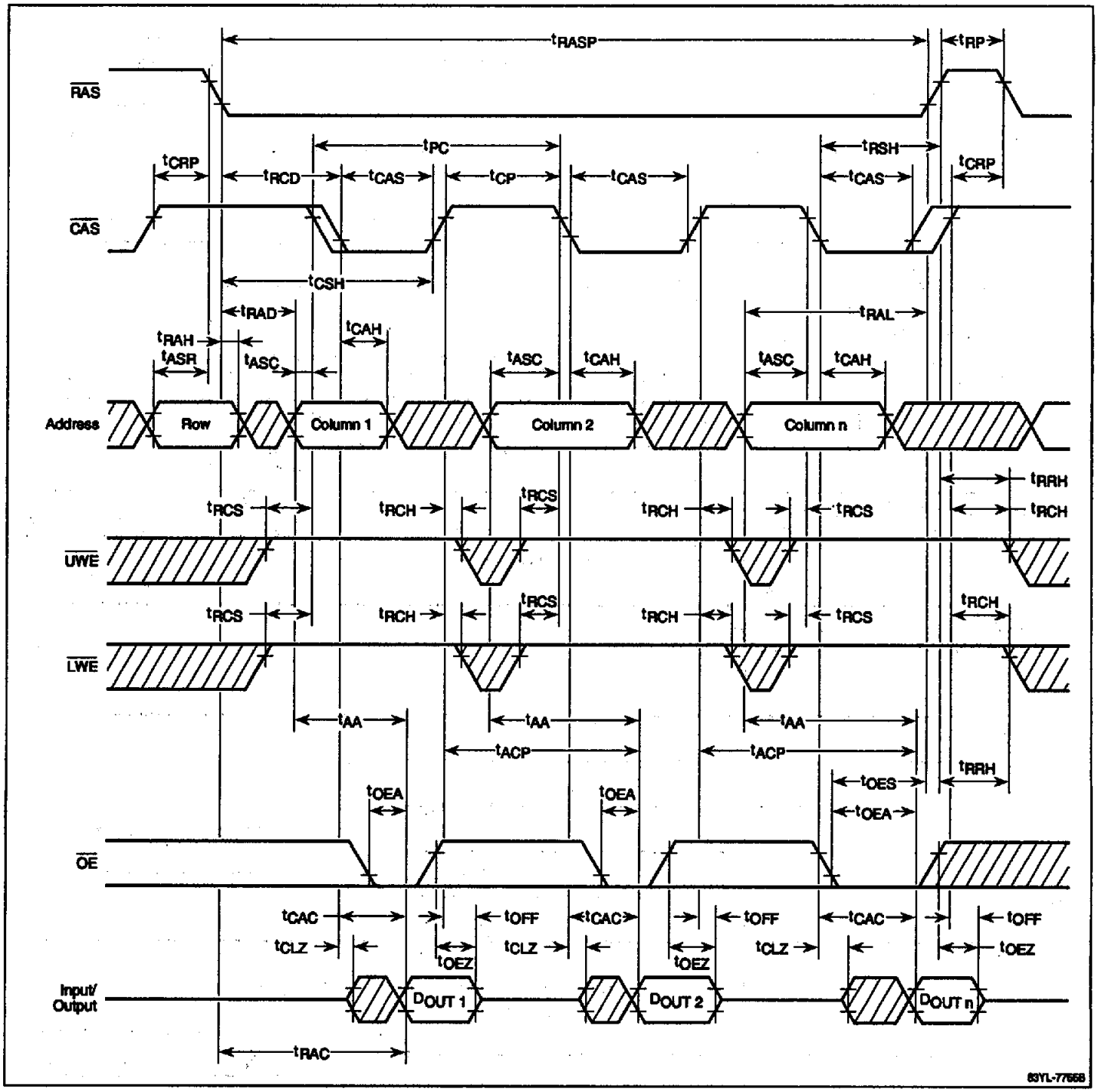
Byte Read-Modify-Write Cycle



7b

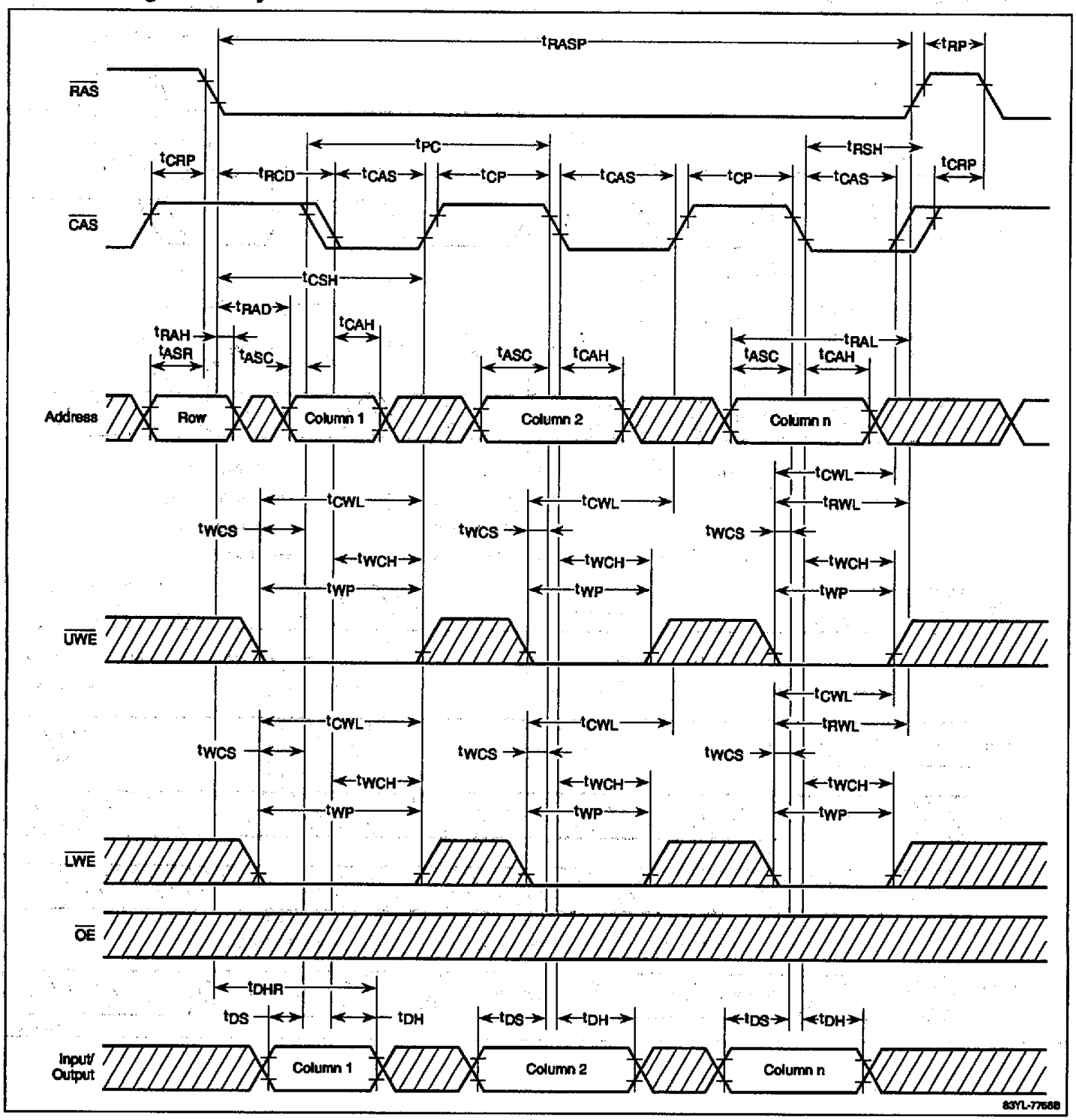
Timing Waveforms (cont)

Fast-Page Read Cycle



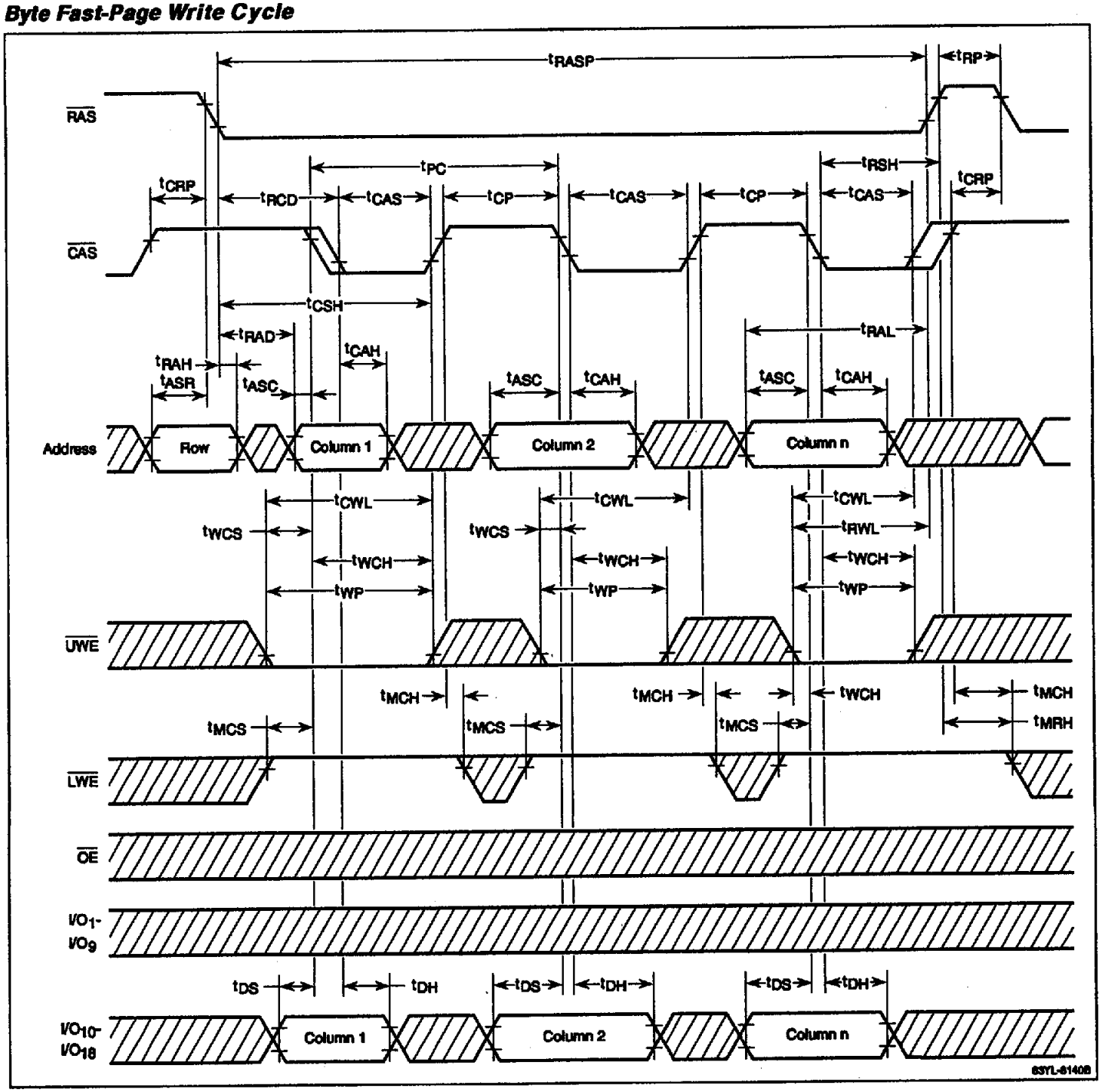
Timing Waveforms (cont)

Word Fast-Page-Write Cycle



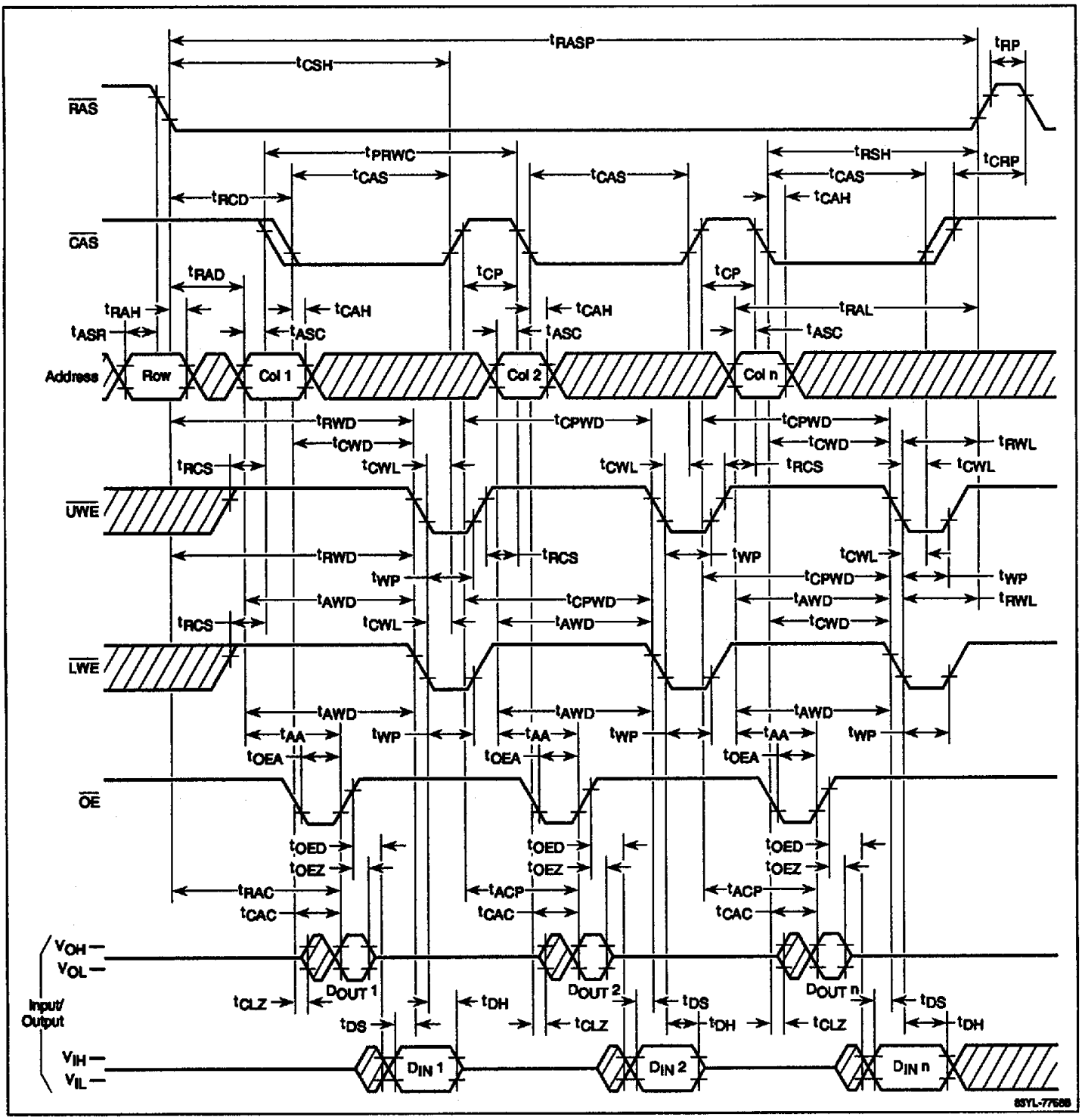
Timing Waveforms (cont)

Byte Fast-Page Write Cycle



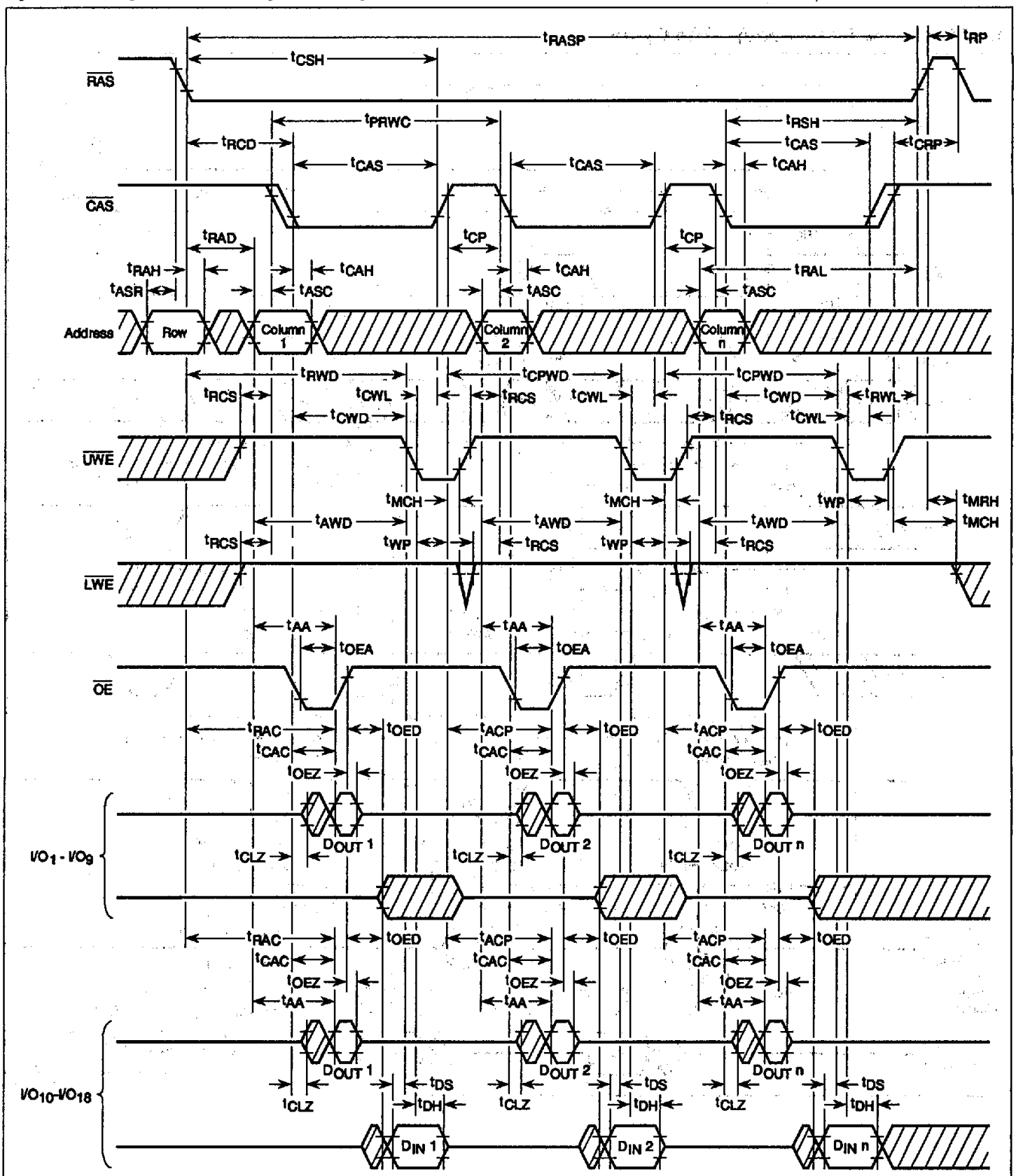
Timing Waveforms (cont)

Word Fast-Page Read-Modify-Write Cycle



7b

Byte Fast-Page Read-Modify-Write Cycle



Notes:

[1] $\overline{WE}$ = $\overline{LWE}$ or $\overline{UWE}$ for lower byte write and upper byte write cycles, respectively.

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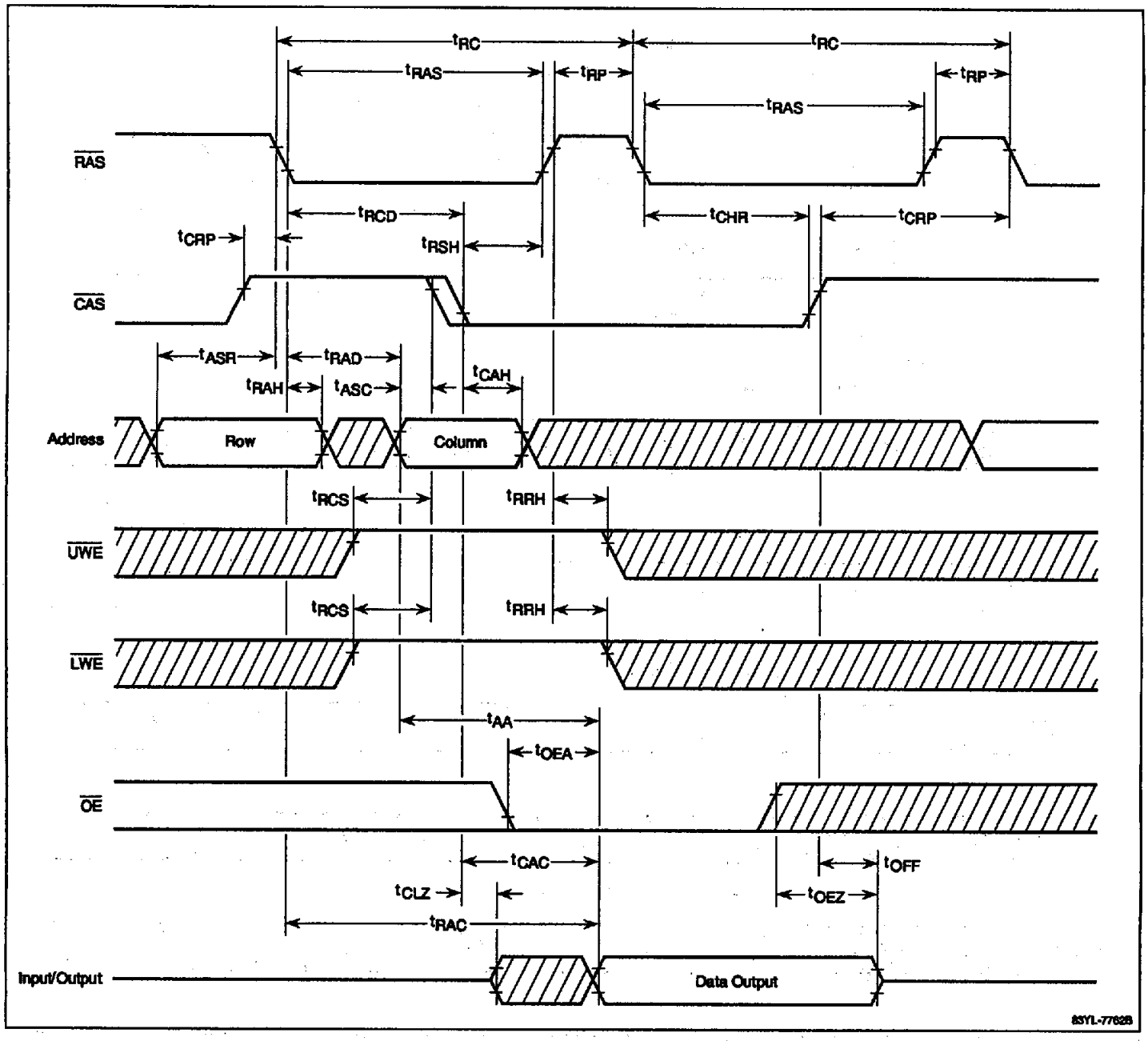
Timing Waveforms (cont)

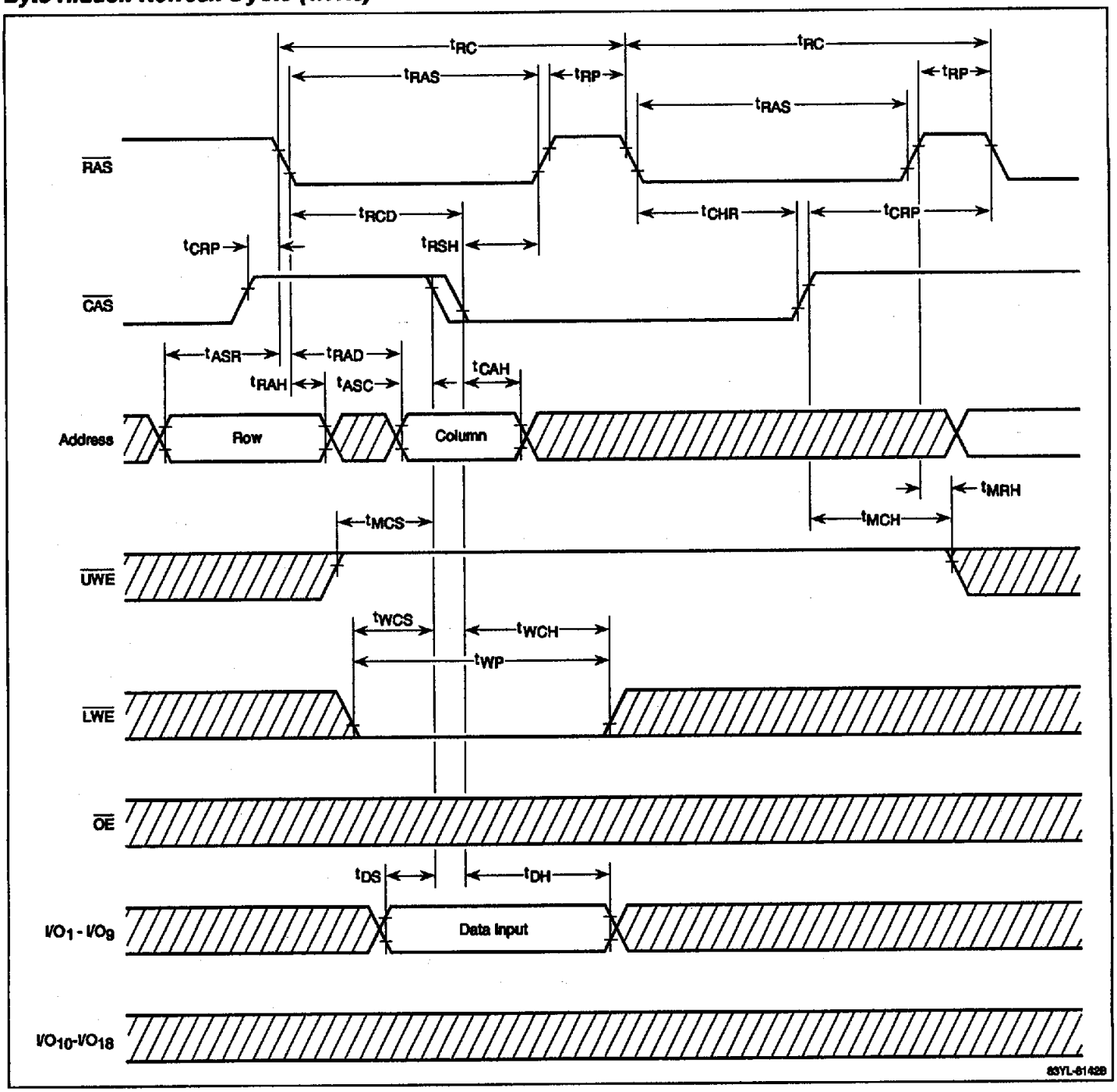
Hidden Refresh Cycle (Read Cycle)



7b

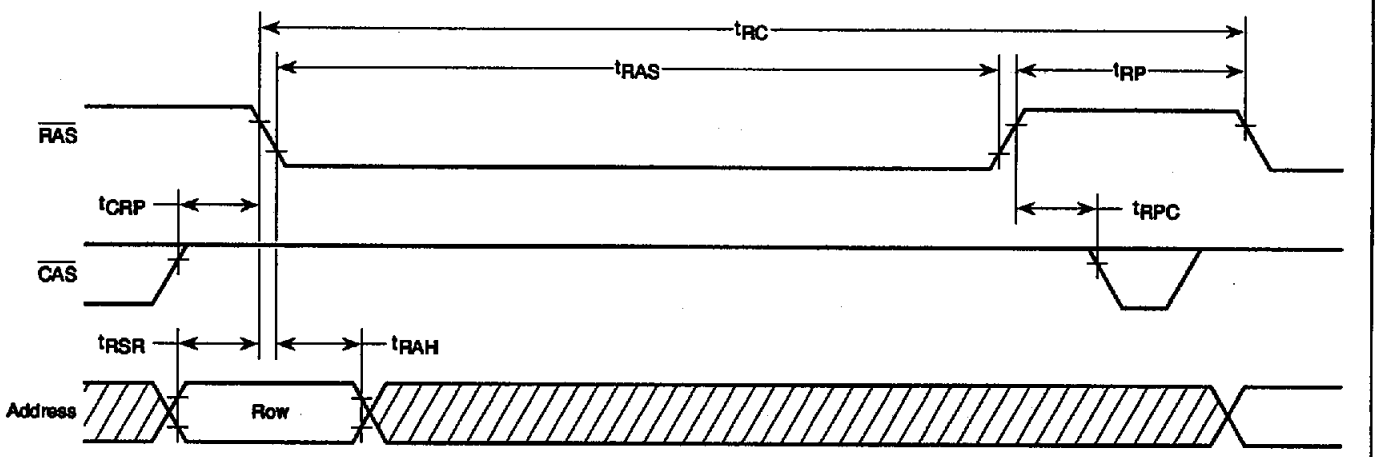
Timing Waveforms (cont)

Byte Hidden-Refresh Cycle (Write)



Timing Waveforms (cont)

$\overline{RAS}$ Refresh Cycle



Notes:
(1) $\overline{UWE}$, $\overline{LWE}$ and $\overline{OE}$ = V_{IH} or V_{IL}.

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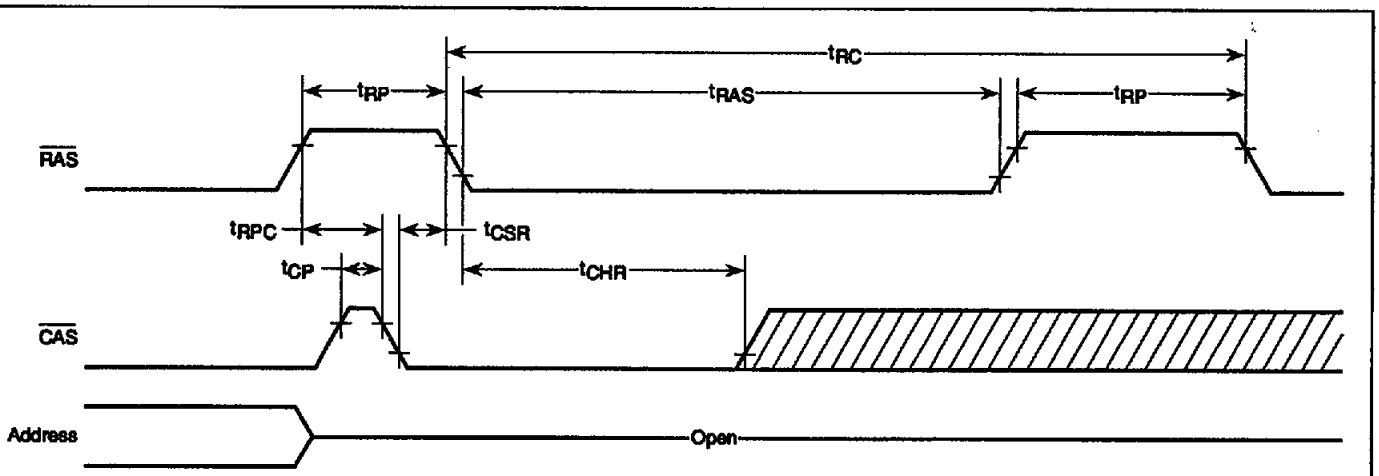
$\overline{CAS}$ Before $\overline{RAS}$ Refresh Cycle



Notes:
(1) D_{IN}, $\overline{UWE}$, $\overline{LWE}$, $\overline{OE}$ and Addresses = V_{IH} or V_{IL}.

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7b

Timing Waveforms (cont)

CBR Self-Refresh Cycle