

# RMLV1616A-U Series

16Mbit LPSRAM (1M word × 16bit / 2M word × 8bit)

R10DS0314EJ0100

Rev.1.00

2022.12.05

## Description

The RMLV1616A-U Series is a family of 16-Mbit asynchronous SRAMs organized 1,048,576-word × 16-bit. The RMLV1616A-U Series has realized higher soft error immunity compared to typical SRAMs with on-chip ECC, achieved by Renesas's unique Advanced LPSRAM technologies. Therefore, it is suitable for battery backup systems. It is offered in 48pin TSOP (I) or 48-ball fine pitch ball grid array.

## Features

- Ultra-low standby current consumption:
  - ~ 25°C: 0.4μA (typ.) / 3μA (max.)
  - ~ 85°C: 4.4μA (typ.) / 8μA (max.)
- High speed access time: 45ns / 55ns (max.)
- Higher soft error immunity (< 0.04 FIT/Mb)<sup>\*1</sup> compared to typical SRAMs with on-chip ECC
- Single 3V supply: 2.7V to 3.6V
- Organized 1,048,576-word × 16-bit  
(48pin TSOP (I) also configurable as 2,097,152-word × 8bit)
- Easy memory expansion by CS1# and CS2
- No clocks, No refresh
- Common data input and output
  - Three state output
- Directly TTL compatible
  - All inputs and outputs
- Battery backup operation
- Available in Pb-free and RoHS applicable package

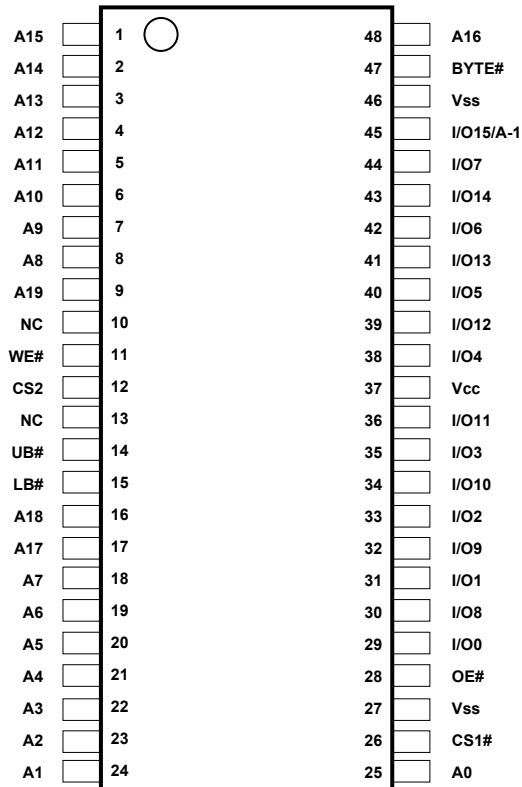
## Part Name Information

Part Name	Access time	Temperature Range	Package
RMLV1616AGSA-4U2	45 ns	-40 ~ +85°C	12mm x 20mm 48pin plastic TSOP (I) (JEITA Package Code: P-TSOP(1)48-12×18.4-0.50)
RMLV1616AGSA-5U2	55 ns		
RMLV1616AGBG-4U2	45 ns		48-ball FBGA with 0.75mm ball pitch (JEITA Package Code: P-TFBGA48-7.5x8.5-0.75)
RMLV1616AGBG-5U2	55 ns		

Note 1. Based on an accelerated test that complies with JEDEC standard JESD89A. Contact us for details.

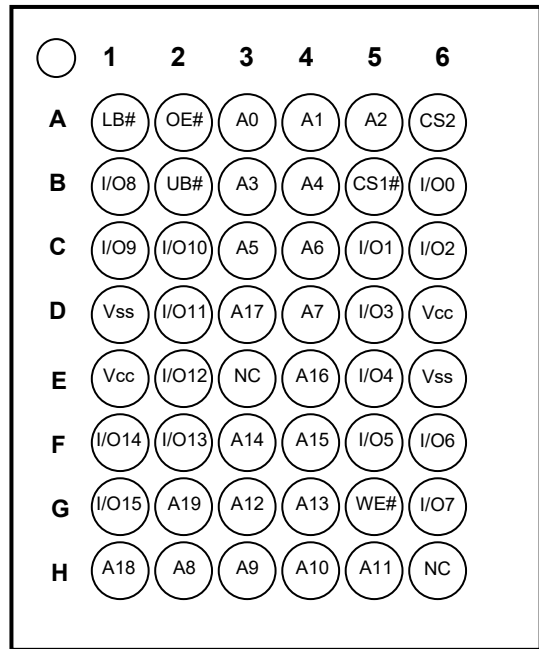
Pin Arrangement

48pin TSOP (I)



(Top view)

48-ball FBGA



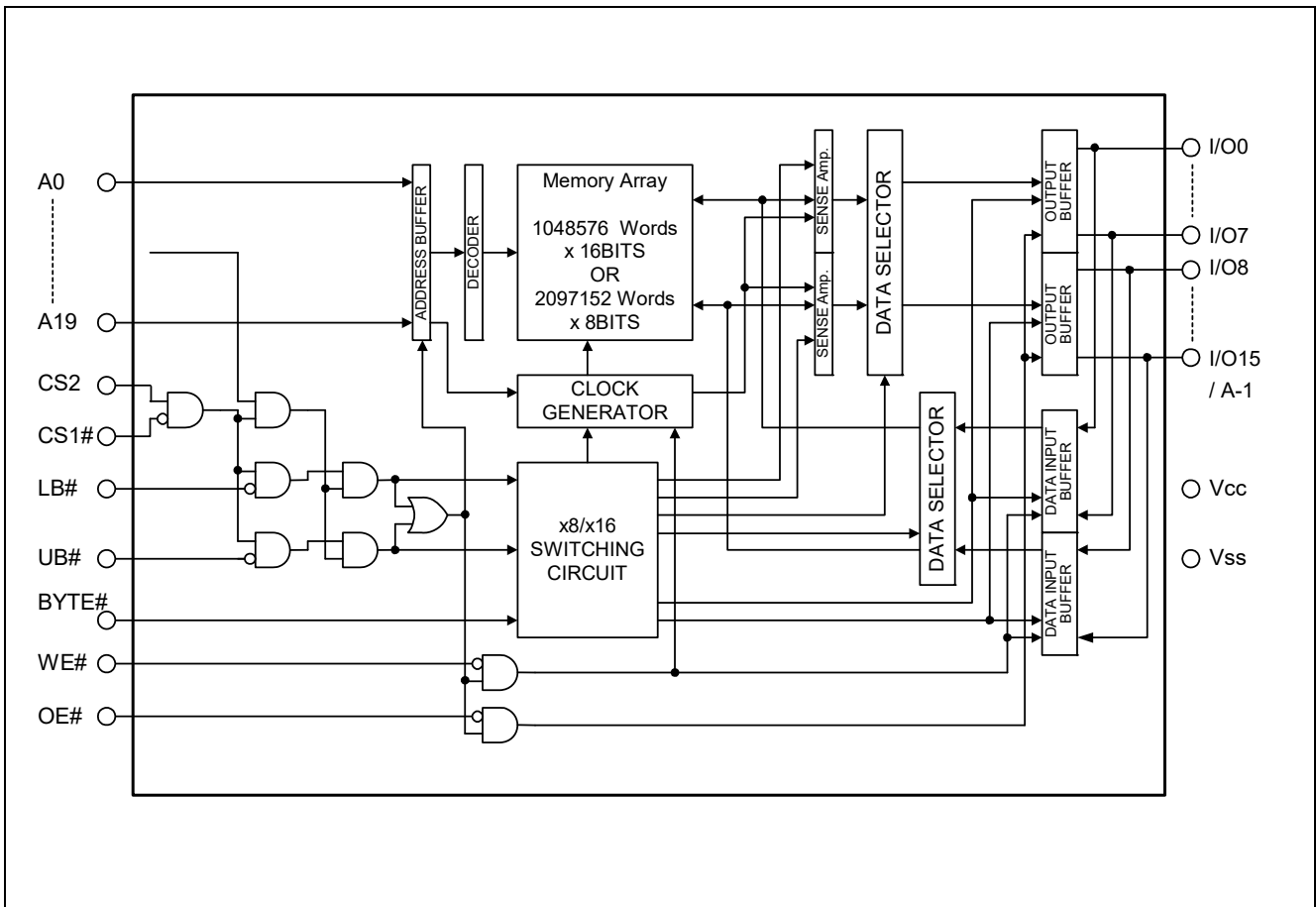
(Top view)

### Pin Description

Pin name	Function
A0 to A19	Address input (word mode)
A-1 to A19	Address input (byte mode)
I/O0 to I/O15	Data input/output
CS1#	Chip select 1
CS2	Chip select 2
WE#	Write enable
OE#	Output enable
LB#	Lower byte select
UB#	Upper byte select
BYTE#	Byte enable
V <sub>cc</sub>	Power supply
V <sub>ss</sub>	Ground
NC <sup>2</sup>	No connection

Note 2. NC pins are not connected internally to the silicon die.

### Block Diagram



Note 3. BYTE# pin applies only to 48pin TSOP (I).

## Operation Table

### Byte mode

CS1#	CS2	WE#	OE#	UB#	LB#	BYTE#	I/O0~7	I/O8~14	I/O15	Operation
H	X	X	X	X	X	L	High-Z	High-Z	High-Z	Stand-by
X	L	X	X	X	X	L	High-Z	High-Z	High-Z	Stand-by
L	H	H	L	X	X	L	Dout	High-Z	A-1	Read
L	H	L	X	X	X	L	Din	High-Z	A-1	Write
L	H	H	H	X	X	L	High-Z	High-Z	A-1	Output disable

Note 4. H:  $V_{IH}$  L:  $V_{IL}$  X:  $V_{IH}$  or  $V_{IL}$

5. BYTE# pin applies only to 48pin TSOP (I).  
48-ball FBGA type equals BYTE#=H mode (Word mode).

### Word mode

CS1#	CS2	WE#	OE#	UB#	LB#	BYTE#	I/O0~7	I/O8~14	I/O15	Operation
H	X	X	X	X	X	H	High-Z	High-Z	High-Z	Stand-by
X	L	X	X	X	X	H	High-Z	High-Z	High-Z	Stand-by
X	X	X	X	H	H	H	High-Z	High-Z	High-Z	Stand-by
L	H	H	L	L	L	H	Dout	Dout	Dout	Read
L	H	H	L	H	L	H	Dout	High-Z	High-Z	Lower byte read
L	H	H	L	L	H	H	High-Z	Dout	Dout	Upper byte read
L	H	L	X	L	L	H	Din	Din	Din	Write
L	H	L	X	H	L	H	Din	High-Z	High-Z	Lower byte write
L	H	L	X	L	H	H	High-Z	Din	Din	Upper byte write
L	H	H	H	L	L	H	High-Z	High-Z	High-Z	Output disable
L	H	H	H	H	L	H	High-Z	High-Z	High-Z	Output disable
L	H	H	H	L	H	H	High-Z	High-Z	High-Z	Output disable

Note 6. H:  $V_{IH}$  L:  $V_{IL}$  X:  $V_{IH}$  or  $V_{IL}$

7. BYTE# pin applies only to 48pin TSOP (I).  
48-ball FBGA type equals BYTE#=H mode (Word mode).

## Absolute Maximum Ratings

Parameter	Symbol	Value	unit
Power supply voltage relative to $V_{SS}$	$V_{CC}$	-0.5 to +4.6	V
Terminal voltage on any pin relative to $V_{SS}$	$V_T$	-0.5 <sup>8</sup> to $V_{CC}+0.3$ <sup>9</sup>	V
Power dissipation	$P_T$	0.7	W
Operation temperature	$T_{opr}$	-40 to +85	°C
Storage temperature range	$T_{stg}$	-65 to +150	°C
Storage temperature range under bias	$T_{bias}$	-40 to +85	°C

Note 8. -2.0V for pulse  $\leq$  30ns (full width at half maximum)

9. Maximum voltage is +4.6V.

## DC Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Supply voltage	$V_{CC}$	2.7	3.0	3.6	V	
	$V_{SS}$	0	0	0	V	
Input high voltage	$V_{IH}$	2.2	—	$V_{CC}+0.3$	V	
Input low voltage	$V_{IL}$	-0.3	—	0.6	V	10
Ambient temperature range	$T_a$	-40	—	+85	°C	

Note 10. -2.0V for pulse  $\leq$  30ns (full width at half maximum)

## DC Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test conditions <sup>*11</sup>	
Input leakage current	$ I_{LI} $	—	—	1	$\mu\text{A}$	$V_{in} = V_{SS}$ to $V_{CC}$	
Output leakage current	$ I_{LO} $	—	—	1	$\mu\text{A}$	CS1# = $V_{IH}$ or CS2 = $V_{IL}$ or OE# = $V_{IH}$ or WE# = $V_{IL}$ or LB# = UB# = $V_{IH}$ , $V_{I/O} = V_{SS}$ to $V_{CC}$	
Average operating current	$I_{CC1}$	—	27 <sup>*12</sup>	35	mA	Cycle = 45ns, duty = 100%, $I_{I/O} = 0\text{mA}$ , CS1# = $V_{IL}$ , CS2 = $V_{IH}$ , Others = $V_{IH}/V_{IL}$	
		—	23 <sup>*12</sup>	30	mA	Cycle = 55ns, duty = 100%, $I_{I/O} = 0\text{mA}$ , CS1# = $V_{IL}$ , CS2 = $V_{IH}$ , Others = $V_{IH}/V_{IL}$	
	$I_{CC2}$	—	1.6 <sup>*12</sup>	4	mA	Cycle = 1 $\mu\text{s}$ , duty = 100%, $I_{I/O} = 0\text{mA}$ , CS1# $\leq 0.2\text{V}$ , CS2 $\geq V_{CC}-0.2\text{V}$ , $V_{IH} \geq V_{CC}-0.2\text{V}$ , $V_{IL} \leq 0.2\text{V}$	
Standby current	$I_{SB}$	—	0.1 <sup>*12</sup>	0.3	mA	CS2 = $V_{IL}$ , Others = $V_{SS}$ to $V_{CC}$	
Standby current	$I_{SB1}$	—	0.4 <sup>*12</sup>	3	$\mu\text{A}$	$\sim +25^\circ\text{C}$	$V_{in} = V_{SS}$ to $V_{CC}$ , (1) CS2 $\leq 0.2\text{V}$ or (2) CS1# $\geq V_{CC}-0.2\text{V}$ , CS2 $\geq V_{CC}-0.2\text{V}$ or (3) LB# = UB# $\geq V_{CC}-0.2\text{V}$ , CS1# $\leq 0.2\text{V}$ , CS2 $\geq V_{CC}-0.2\text{V}$
		—	0.6 <sup>*13</sup>	5	$\mu\text{A}$	$\sim +40^\circ\text{C}$	
		—	2.2 <sup>*14</sup>	6	$\mu\text{A}$	$\sim +70^\circ\text{C}$	
		—	4.4 <sup>*15</sup>	8	$\mu\text{A}$	$\sim +85^\circ\text{C}$	
Output high voltage	$V_{OH}$	2.4	—	—	V	$I_{OH} = -1\text{mA}$	
	$V_{OH2}$	$V_{CC} - 0.2$	—	—	V	$I_{OH} = -0.1\text{mA}$	
Output low voltage	$V_{OL}$	—	—	0.4	V	$I_{OL} = 2\text{mA}$	
	$V_{OL2}$	—	—	0.2	V	$I_{OL} = 0.1\text{mA}$	

Note 11. BYTE# pin applies only to 48pin TSOP (I).

BYTE#  $\geq V_{CC} - 0.2\text{V}$  or BYTE#  $\leq 0.2\text{V}$

12. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=25^\circ\text{C}$ ), and not 100% tested.  
 13. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=40^\circ\text{C}$ ), and not 100% tested.  
 14. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=70^\circ\text{C}$ ), and not 100% tested.  
 15. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=85^\circ\text{C}$ ), and not 100% tested.

## Capacitance

( $T_a = 25^\circ\text{C}$ ,  $f = 1\text{MHz}$ )

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test conditions	Note
Input capacitance	$C_{in}$	—	—	8	pF	$V_{in} = 0\text{V}$	16
Input / output capacitance	$C_{I/O}$	—	—	10	pF	$V_{I/O} = 0\text{V}$	16

Note 16. This parameter is sampled and not 100% tested.

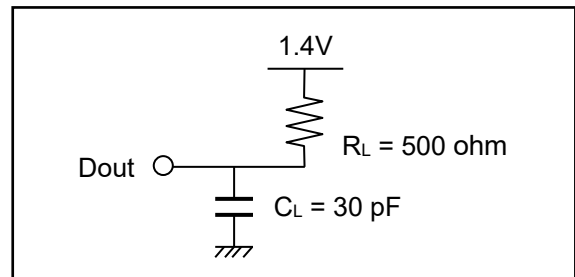
## Thermal Resistance and Thermal Characterization Parameter

Parameter	Symbol	48pin TSOP (I)	48-ball FBGA	Unit	Note
Thermal resistance, junction to ambient	$\Theta_{ja}$	70.3	37.6	$^\circ\text{C/W}$	Reference value Air flow = 0 m/s (still air)
Thermal resistance, junction to case	$\Theta_{jc}$	8.6	10.4	$^\circ\text{C/W}$	
Thermal characterization parameter, package top surface to junction	$\Psi_{jt}$	0.20	0.30	$^\circ\text{C/W}$	

## AC Characteristics

Test Conditions ( $V_{CC} = 2.7V \sim 3.6V$ ,  $T_a = -40 \sim +85^\circ C$ )

- Input pulse levels:  $V_{IL} = 0.4V$ ,  $V_{IH} = 2.4V$
- Input rise and fall time: 5ns
- Input and output timing reference level: 1.4V
- Output load: See figures (Including scope and jig)



### Read Cycle

Parameter	Symbol	-4U2		-5U2		Unit	Note
		Min.	Max.	Min.	Max.		
Read cycle time	$t_{RC}$	45	—	55	—	ns	
Address access time	$t_{AA}$	—	45	—	55	ns	
Chip select access time	$t_{ACS1}$	—	45	—	45	ns	
	$t_{ACS2}$	—	45	—	45	ns	
Output enable to output valid	$t_{OE}$	—	22	—	22	ns	
Output hold from address change	$t_{OH}$	10	—	10	—	ns	
LB#, UB# access time	$t_{BA}$	—	45	—	45	ns	
Chip select to output in low-Z	$t_{CLZ1}$	10	—	10	—	ns	18,19
	$t_{CLZ2}$	10	—	10	—	ns	18,19
LB#, UB# enable to low-Z	$t_{BLZ}$	5	—	5	—	ns	18,19
Output enable to output in low-Z	$t_{OLZ}$	5	—	5	—	ns	18,19
Chip deselect to output in high-Z	$t_{CHZ1}$	0	18	0	18	ns	17,18,19
	$t_{CHZ2}$	0	18	0	18	ns	17,18,19
LB#, UB# disable to high-Z	$t_{BHZ}$	0	15	0	18	ns	17,18,19
Output disable to output in high-Z	$t_{OHZ}$	0	15	0	18	ns	17,18,19

### Write Cycle

Parameter	Symbol	-4U2		-5U2		Unit	Note
		Min.	Max.	Min.	Max.		
Write cycle time	$t_{WC}$	45	—	55	—	ns	
Address valid to end of write	$t_{AW}$	35	—	35	—	ns	
Chip selection to end of write	$t_{CW}$	35	—	35	—	ns	21
Write pulse width	$t_{WP}$	35	—	35	—	ns	20
LB#,UB# valid to end of write	$t_{BW}$	35	—	35	—	ns	
Address setup time	$t_{AS}$	0	—	0	—	ns	22
Write recovery time	$t_{WR}$	0	—	0	—	ns	23
Data to write time overlap	$t_{DW}$	25	—	25	—	ns	
Data hold from write time	$t_{DH}$	0	—	0	—	ns	
Output active from end of write	$t_{OW}$	5	—	5	—	ns	18
Output disable to output in high-Z	$t_{OHZ}$	0	15	0	18	ns	17,18
Write to output in high-Z	$t_{WHZ}$	0	15	0	18	ns	17,18

Note 17.  $t_{CHZ}$ ,  $t_{OHZ}$ ,  $t_{WHZ}$  and  $t_{BHZ}$  are defined as the time at which the outputs achieve the open circuit conditions and are not referred to output voltage levels.

18. This parameter is sampled and not 100% tested.

19. At any given temperature and voltage condition,  $t_{HZ}$  max is less than  $t_{LZ}$  min both for a given device and from device to device.

20. A write occurs during the overlap of a low CS1#, a high CS2, a low WE# and a low LB# or a low UB#. A write begins at the latest transition among CS1# going low, CS2 going high, WE# going low and LB# going low or UB# going low. A write ends at the earliest transition among CS1# going high, CS2 going low, WE# going high and LB# going high or UB# going high.  $t_{WP}$  is measured from the beginning of write to the end of write.

21.  $t_{CW}$  is measured from the later of CS1# going low or CS2 going high to the end of write.

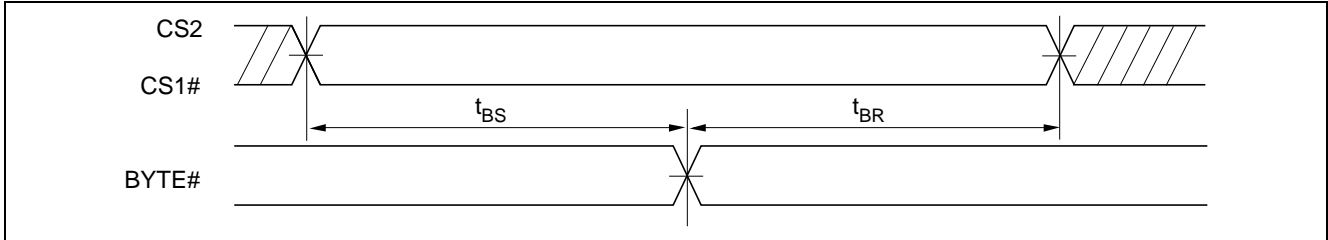
22.  $t_{AS}$  is measured from the address valid to the beginning of write.

23.  $t_{WR}$  is measured from the earliest of CS1# or WE# going high or CS2 going low to the end of write cycle.

**BYTE# Timing Conditions** (BYTE# pin supported by only 48pin TSOP (I) type)

Parameter	Symbol	Min.	Max.	Unit	Note
BYTE# setup time	$t_{BS}$	5	-	ms	
BYTE# recovery time	$t_{BR}$	5	-	ms	

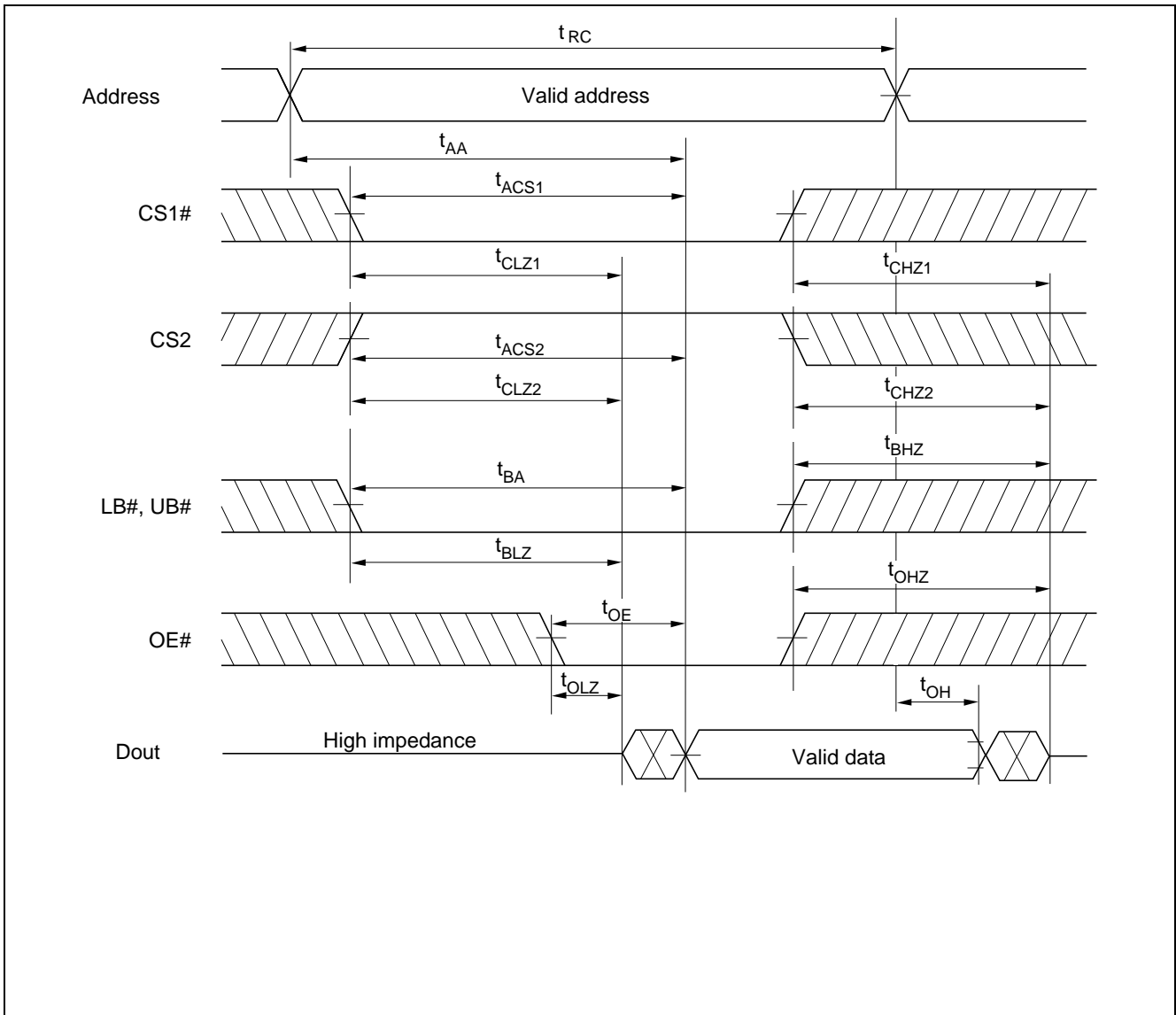
**BYTE# Timing Waveforms**



- Note 24. Timing specs for switching between word-mode (1M x16) and byte-mode (2M x8) on the fly (when dynamically switch while Vcc supply).  
 Tie the BYTE# pin to SRAM's Vcc to use it fixedly as word-mode (1M x16).  
 Tie the BYTE# pin to Vss (GND) to use the SRAM fixedly as byte-mode (2M x8).
25. When used as word-mode together with a battery backup, tie the BYTE# pin to backup Vcc supply (SRAM's Vcc). Do not tie the BYTE# pin to the regular Vcc that is to be discharged to Vss level when power shutdown.

## Timing Waveforms

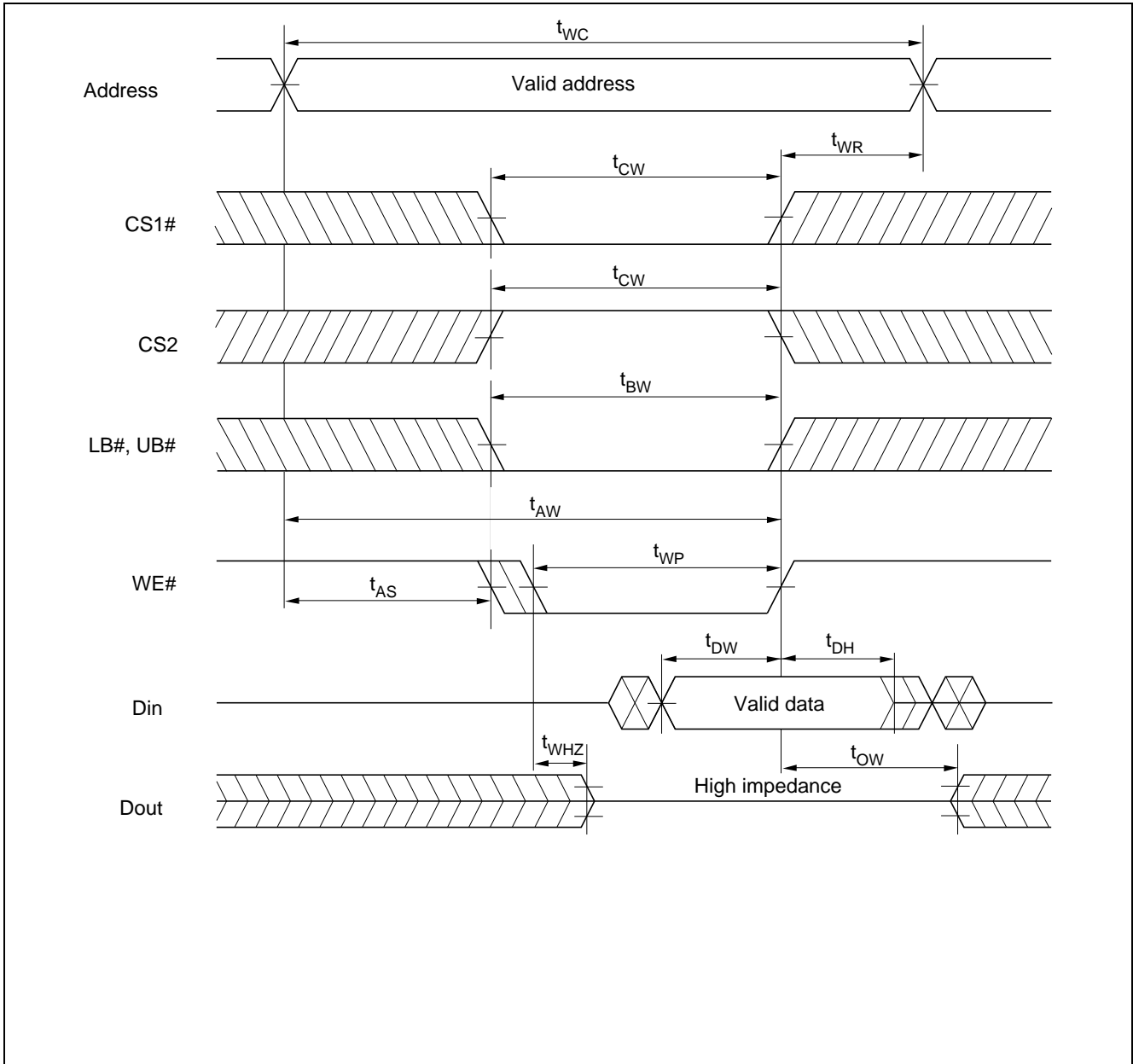
### Read Cycle\*26



Note 26. BYTE# pin applies only to 48pin TSOP (I).  
 BYTE#  $\geq V_{cc} - 0.2V$  (Word mode) or BYTE#  $\leq 0.2V$  (Byte mode)

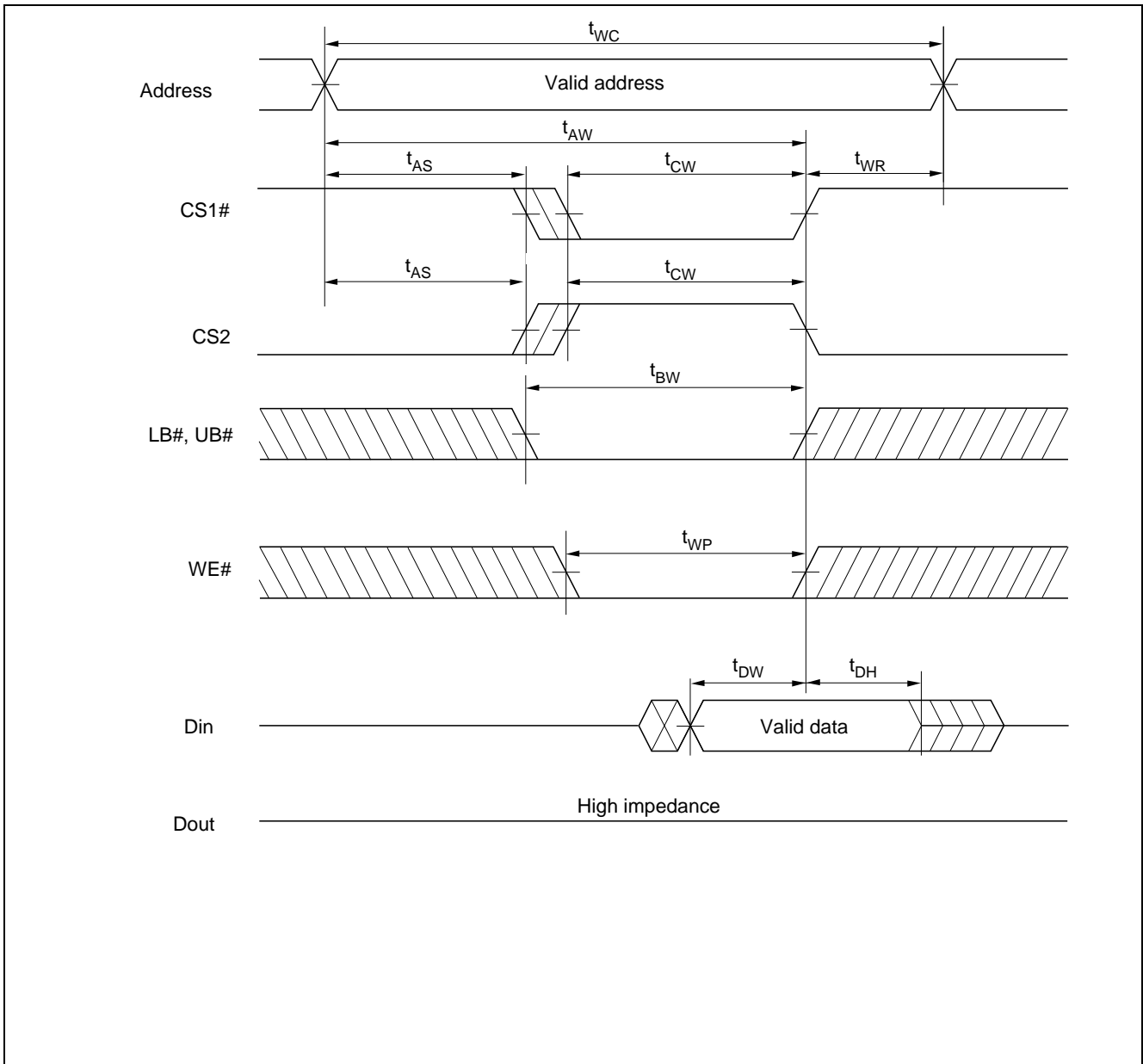


Write Cycle (1)<sup>\*27</sup> (WE# Clock)



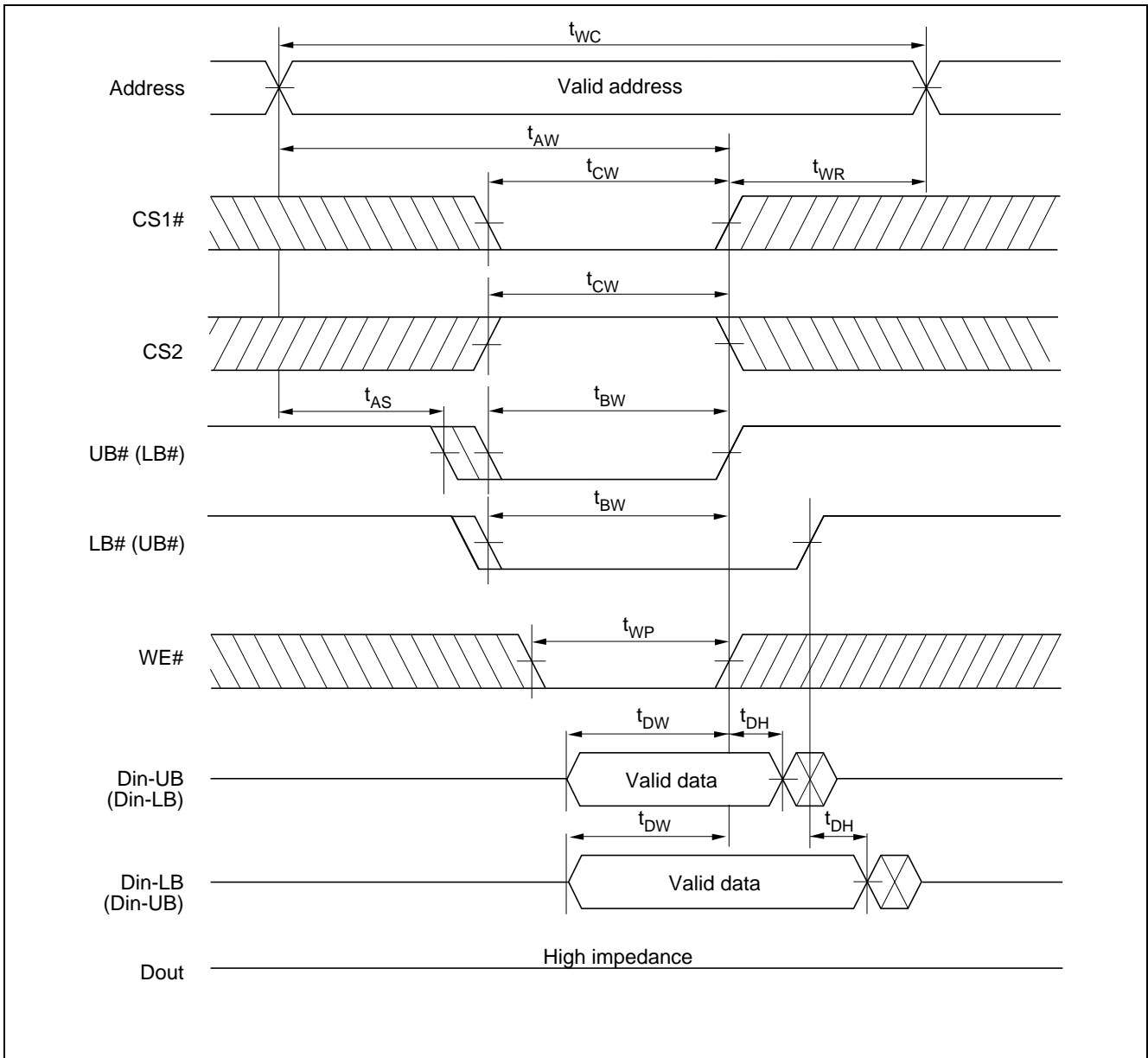
Note 27. BYTE# pin applies only to 48pin TSOP (I).  
 BYTE#  $\geq V_{cc} - 0.2V$  (Word mode) or BYTE#  $\leq 0.2V$  (Byte mode)

Write Cycle (2)<sup>\*28</sup> (CS1#, CS2 Clock, OE# = V<sub>IH</sub>)



Note 28. BYTE# pin applies only to 48pin TSOP (I).  
 BYTE#  $\geq V_{CC} - 0.2V$  (Word mode) or BYTE#  $\leq 0.2V$  (Byte mode)

Write Cycle (3)<sup>\*29</sup> (LB#, UB# Clock, OE# = V<sub>IH</sub>, Word Mode)



Note 29. BYTE# pin applies only to 48pin TSOP (I).  
 BYTE#  $\geq$  V<sub>CC</sub> - 0.2V (Word mode)

Low  $V_{CC}$  Data Retention Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test conditions <sup>*30,31</sup>	
$V_{CC}$ for data retention	$V_{DR}$	1.5	—	3.6	V	$V_{in} \geq 0V$ (1) $CS2 \leq 0.2V$ or (2) $CS1\# \geq V_{CC}-0.2V$ , $CS2 \geq V_{CC}-0.2V$ or (3) $LB\# = UB\# \geq V_{CC}-0.2V$ , $CS1\# \leq 0.2V$ , $CS2 \geq V_{CC}-0.2V$	
Data retention current	$I_{CCDR}$	—	0.4 <sup>*32</sup>	3	$\mu A$	$\sim +25^{\circ}C$	$V_{CC} = 3.0V$ , $V_{in} \geq 0V$ (1) $CS2 \leq 0.2V$ or (2) $CS1\# \geq V_{CC}-0.2V$ , $CS2 \geq V_{CC}-0.2V$ or (3) $LB\# = UB\# \geq V_{CC}-0.2V$ , $CS1\# \leq 0.2V$ , $CS2 \geq V_{CC}-0.2V$
		—	0.6 <sup>*33</sup>	5	$\mu A$	$\sim +40^{\circ}C$	
		—	2.2 <sup>*34</sup>	6	$\mu A$	$\sim +70^{\circ}C$	
		—	4.4 <sup>*35</sup>	8	$\mu A$	$\sim +85^{\circ}C$	
Chip deselection time to data retention	$t_{CDR}$	0	—	—	ns	See retention waveform.	
Operation recovery time	$t_R$	5	—	—	ms		

Note 30. BYTE# pin applies only to 48pin TSOP (I).

BYTE#  $\geq V_{CC} - 0.2V$  or BYTE#  $\leq 0.2V$

31. CS2 controls address buffer, WE# buffer, CS1# buffer, OE# buffer, LB# buffer, UB# buffer and Din buffer.

If CS2 controls data retention mode,  $V_{in}$  levels (address, WE#, CS1#, OE#, LB#, UB#, I/O) can be in the high impedance state. If CS1# controls data retention mode, CS2 must be  $CS2 \geq V_{CC} - 0.2V$  or  $0 \leq CS2 \leq 0.2V$ .

The other inputs levels (address, WE#, OE#, LB#, UB#, I/O) can be in the high impedance state.

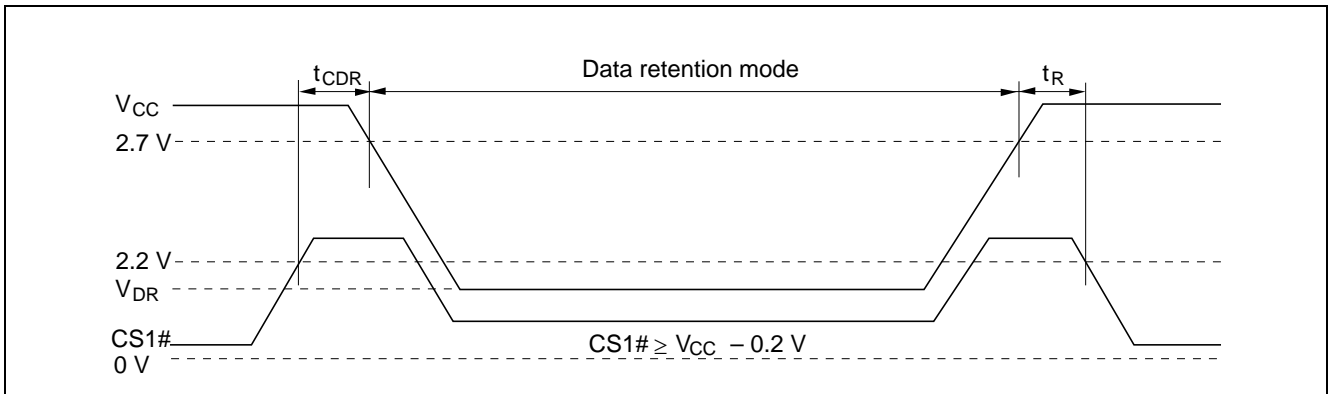
32. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=25^{\circ}C$ ), and not 100% tested.

33. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=40^{\circ}C$ ), and not 100% tested.

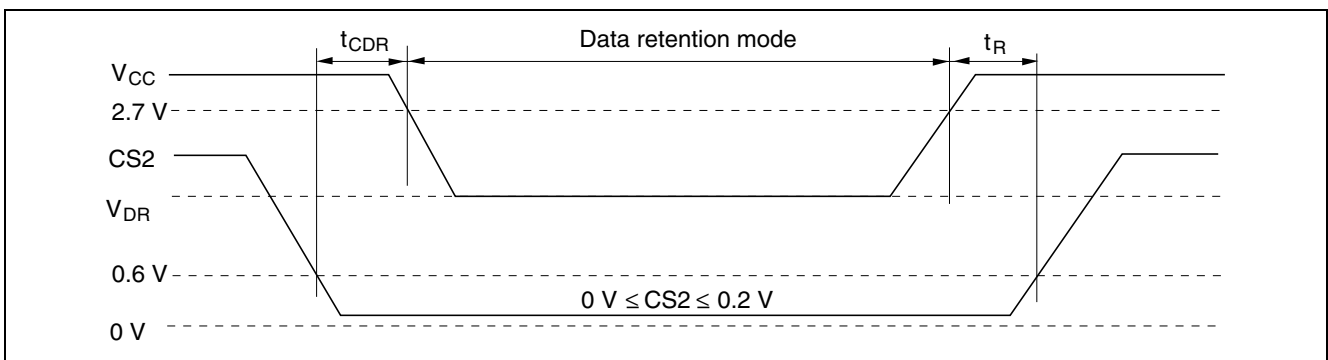
34. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=70^{\circ}C$ ), and not 100% tested.

35. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=85^{\circ}C$ ), and not 100% tested.

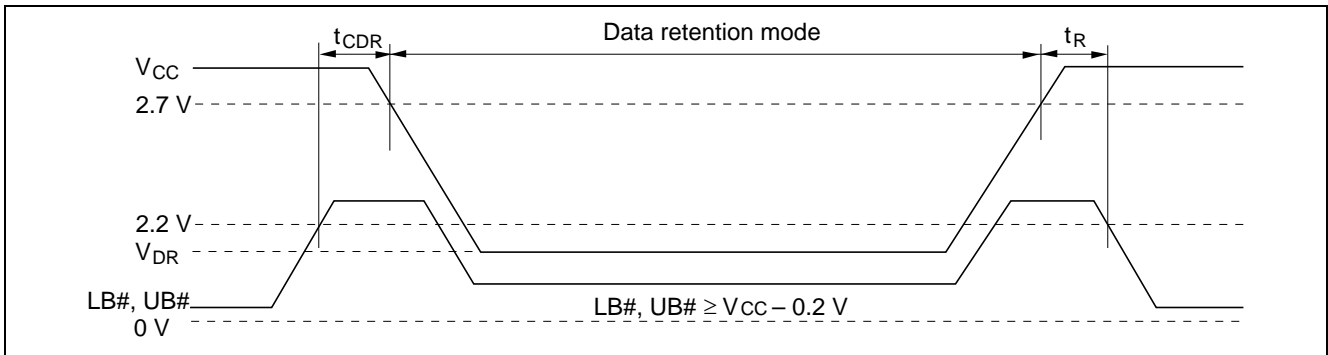
Low Vcc Data Retention Timing Waveforms (1) (CS1# Controlled)<sup>\*36</sup>



Low Vcc Data Retention Timing Waveforms (2) (CS2 Controlled)<sup>\*36</sup>



Low Vcc Data Retention Timing Waveforms (3) (LB#,UB# Controlled, Word Mode)<sup>\*37</sup>



Note 36. BYTE# pin applies only to 48pin TSOP (I).

BYTE# ≥ V<sub>CC</sub> - 0.2V or BYTE# ≤ 0.2V

37. BYTE# pin applies only to 48pin TSOP (I).

BYTE# ≥ V<sub>CC</sub> - 0.2V (Word mode)

Revision History	RMLV1616A-U Series Data Sheet
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Rev.	Date	Description	
		Page	Summary
1.00	2022.12.05	—	First Edition issued

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