

# RMLV1616A Series

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

R10DS0258EJ0101

Rev.1.01

2020.02.20

## Description

The RMLV1616A Series is a family of 16-Mbit static RAMs organized 1,048,576-word × 16-bit, fabricated by Renesas's high-performance Advanced LPSRAM technologies. The RMLV1616A Series has realized higher density, higher performance and low power consumption. The RMLV1616A Series offers low power standby power dissipation; therefore, it is suitable for battery backup systems. It is offered in 48pin TSOP (I), 52pin  $\mu$ TSOP (II) or 48-ball fine pitch ball grid array.

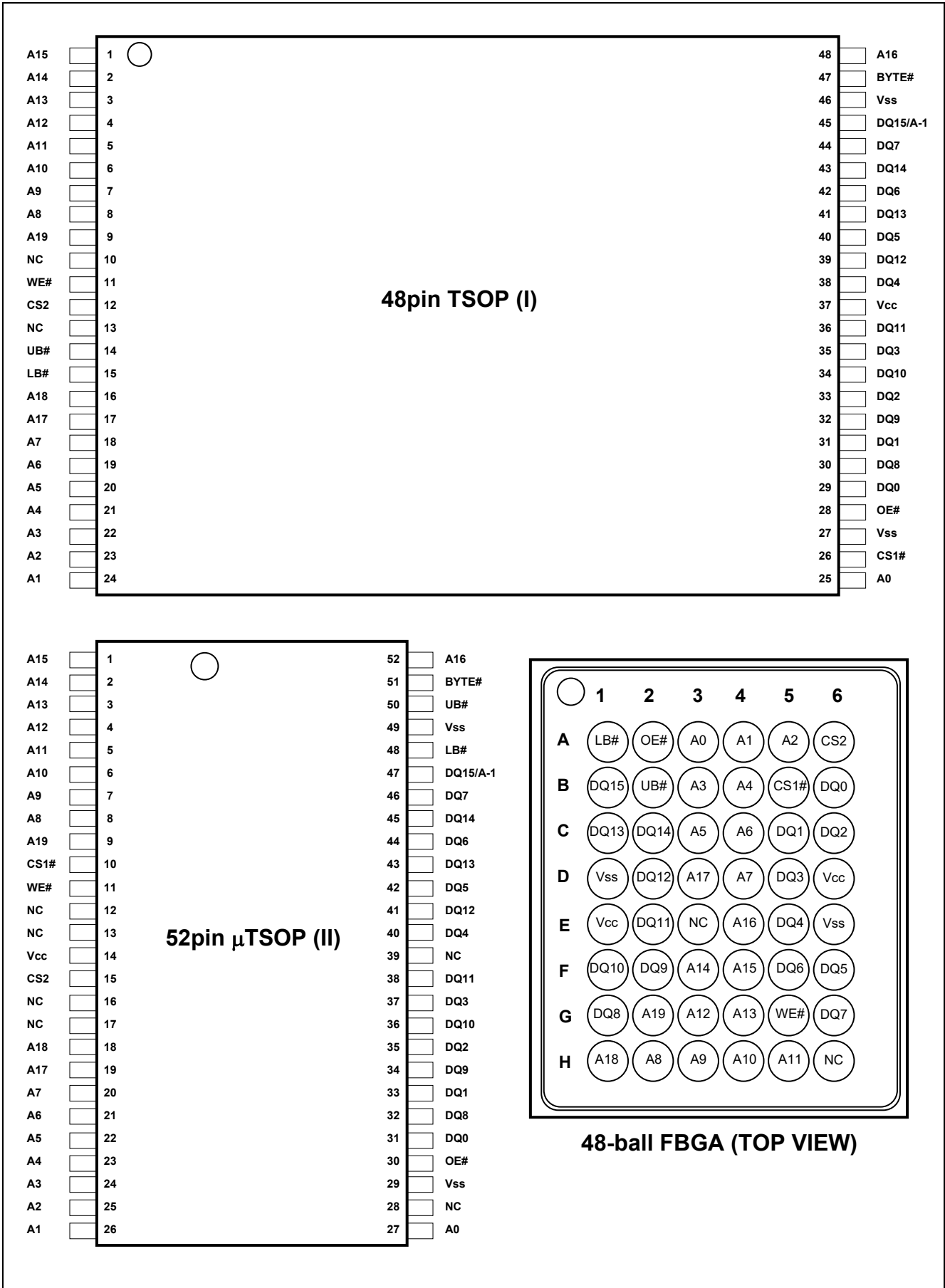
## Features

- Single 3V supply: 2.7V to 3.6V
- Access time: 55ns (max.)
- Current consumption:
  - Standby: 0.5 $\mu$ A (typ.)
- Common data input and output
  - Three state output
- Directly TTL compatible
  - All inputs and outputs
- Battery backup operation

## Part Name Information

Part Name	Access time	Temperature Range	Package
RMLV1616AGSA-5S2	55 ns	-40 ~ +85°C	12mm x 20mm 48pin plastic TSOP (I)
RMLV1616AGSD-5S2			10.79mm × 10.49mm 52pin plastic $\mu$ TSOP (II)
RMLV1616AGBG-5S2			48-ball FBGA with 0.75mm ball pitch

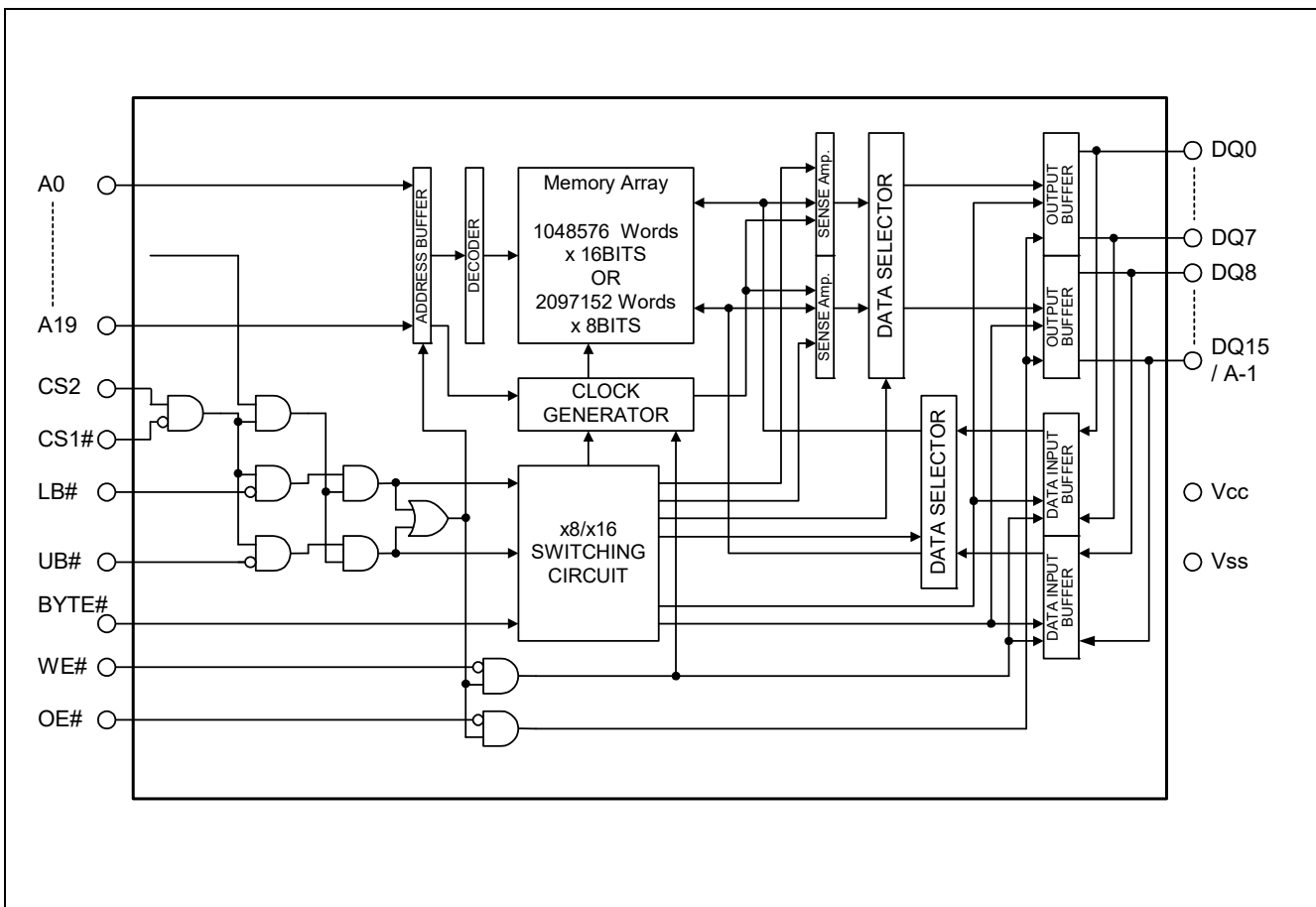
Pin Arrangement



### Pin Description

Pin name	Function
Vcc	Power supply
Vss	Ground
A0 to A19	Address input (word mode)
A-1 to A19	Address input (byte mode)
DQ0 to DQ15	Data input/output
CS1#	Chip select 1
CS2	Chip select 2
OE#	Output enable
WE#	Write enable
LB#	Lower byte select
UB#	Upper byte select
BYTE#	Byte control mode enable
NC	No connection

### Block Diagram



Note 1. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.

## Operation Table

CS1#	CS2	BYTE#	UB#	LB#	WE#	OE#	DQ0~7	DQ8~14	DQ15	Operation
H	X	X	X	X	X	X	High-Z	High-Z	High-Z	Stand-by
X	L	X	X	X	X	X	High-Z	High-Z	High-Z	Stand-by
X	X	H	H	H	X	X	High-Z	High-Z	High-Z	Stand-by
L	H	H	H	L	L	X	Din	High-Z	High-Z	Write in lower byte
L	H	H	H	L	H	L	Dout	High-Z	High-Z	Read in lower byte
L	H	H	H	L	H	H	High-Z	High-Z	High-Z	Output disable
L	H	H	L	H	L	X	High-Z	Din	Din	Write in upper byte
L	H	H	L	H	H	L	High-Z	Dout	Dout	Read in upper byte
L	H	H	L	H	H	H	High-Z	High-Z	High-Z	Output disable
L	H	H	L	L	L	X	Din	Din	Din	Word write
L	H	H	L	L	H	L	Dout	Dout	Dout	Word read
L	H	H	L	L	H	H	High-Z	High-Z	High-Z	Output disable
L	H	L	X	X	L	X	Din	High-Z	A-1	Byte write
L	H	L	X	X	H	L	Dout	High-Z	A-1	Byte read
L	H	L	X	X	H	H	High-Z	High-Z	A-1	Output disable

Note 2. H:  $V_{IH}$  L:  $V_{IL}$  X:  $V_{IH}$  or  $V_{IL}$

3. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.  
48-ball FBGA type equals BYTE#=H 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 $V_{SS}$	$V_T$	$-0.5^{*4}$ to $V_{CC}+0.3^{*5}$	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 4. -2.0V for pulse  $\leq$  30ns (full width at half maximum)

5. 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	6
Ambient temperature range	$T_a$	-40	—	+85	°C	

Note 6. -2.0V for pulse  $\leq$  30ns (full width at half maximum)

## DC Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test conditions <sup>*7</sup>	
Input leakage current	I <sub>LI</sub>	—	—	1	μA	V <sub>in</sub> = V <sub>SS</sub> to V <sub>CC</sub>	
Output leakage current	I <sub>LO</sub>	—	—	1	μA	CS1# = V <sub>IH</sub> or CS2 = V <sub>IL</sub> or OE# = V <sub>IH</sub> or WE# = V <sub>IL</sub> or LB# = UB# = V <sub>IH</sub> , V <sub>I/O</sub> = V <sub>SS</sub> to V <sub>CC</sub>	
Average operating current	I <sub>CC1</sub>	—	23 <sup>*8</sup>	30	mA	Cycle = 55ns, duty = 100%, I <sub>I/O</sub> = 0mA, CS1# = V <sub>IL</sub> , CS2 = V <sub>IH</sub> , Others = V <sub>IH</sub> /V <sub>IL</sub>	
	I <sub>CC2</sub>	—	1.6 <sup>*8</sup>	4	mA	Cycle = 1μs, duty = 100%, I <sub>I/O</sub> = 0mA, CS1# ≤ 0.2V, CS2 ≥ V <sub>CC</sub> -0.2V, V <sub>IH</sub> ≥ V <sub>CC</sub> -0.2V, V <sub>IL</sub> ≤ 0.2V	
Standby current	I <sub>SB</sub>	—	—	0.3	mA	CS2 = V <sub>IL</sub> , Others = V <sub>SS</sub> to V <sub>CC</sub>	
Standby current	I <sub>SB1</sub>	—	0.5 <sup>*8</sup>	3	μA	~+25°C	V <sub>in</sub> = V <sub>SS</sub> to V <sub>CC</sub> , (1) CS2 ≤ 0.2V or (2) CS1# ≥ V <sub>CC</sub> -0.2V, CS2 ≥ V <sub>CC</sub> -0.2V or (3) LB# = UB# ≥ V <sub>CC</sub> -0.2V, CS1# ≤ 0.2V, CS2 ≥ V <sub>CC</sub> -0.2V
		—	0.8 <sup>*9</sup>	5	μA	~+40°C	
		—	2.5 <sup>*10</sup>	12	μA	~+70°C	
		—	5 <sup>*11</sup>	16	μA	~+85°C	
Output high voltage	V <sub>OH</sub>	2.4	—	—	V	I <sub>OH</sub> = -1mA	
	V <sub>OH2</sub>	V <sub>CC</sub> - 0.2	—	—	V	I <sub>OH</sub> = -0.1mA	
Output low voltage	V <sub>OL</sub>	—	—	0.4	V	I <sub>OL</sub> = 2mA	
	V <sub>OL2</sub>	—	—	0.2	V	I <sub>OL</sub> = 0.1mA	

Note 7. BYTE# pin supported by only 48pin TSOP (I) and 52pin μTSOP (II) types.  
BYTE# ≥ V<sub>CC</sub> - 0.2V or BYTE# ≤ 0.2V

8. Typical parameter indicates the value for the center of distribution at 3.0V (T<sub>a</sub>=25°C), and not 100% tested.
9. Typical parameter indicates the value for the center of distribution at 3.0V (T<sub>a</sub>=40°C), and not 100% tested.
10. Typical parameter indicates the value for the center of distribution at 3.0V (T<sub>a</sub>=70°C), and not 100% tested.
11. Typical parameter indicates the value for the center of distribution at 3.0V (T<sub>a</sub>=85°C), and not 100% tested.

## Capacitance

(T<sub>a</sub> =25°C, f =1MHz)

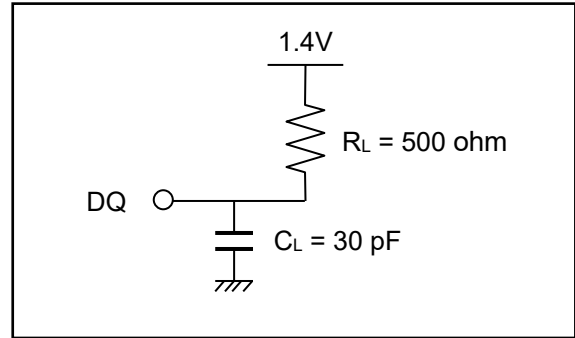
Parameter	Symbol	Min.	Typ.	Max.	Unit	Test conditions	Note
Input capacitance	C <sub>in</sub>	—	—	8	pF	V <sub>in</sub> =0V	12
Input / output capacitance	C <sub>I/O</sub>	—	—	10	pF	V <sub>I/O</sub> =0V	12

Note 12. This parameter is sampled and not 100% tested.

## 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	Min.	Max.	Unit	Note
Read cycle time	$t_{RC}$	55		ns	
Address access time	$t_{AA}$	—	55	ns	
Chip select access time	$t_{ACS1}$	—	45	ns	
	$t_{ACS2}$	—	45	ns	
Output enable to output valid	$t_{OE}$	—	22	ns	
Output hold from address change	$t_{OH}$	10	—	ns	
LB#, UB# access time	$t_{BA}$	—	45	ns	
Chip select to output in low-Z	$t_{CLZ1}$	10	—	ns	13,14
	$t_{CLZ2}$	10	—	ns	13,14
LB#, UB# enable to low-Z	$t_{BLZ}$	5	—	ns	13,14
Output enable to output in low-Z	$t_{OLZ}$	5	—	ns	13,14
Chip deselect to output in high-Z	$t_{CHZ1}$	0	18	ns	13,14,15
	$t_{CHZ2}$	0	18	ns	13,14,15
LB#, UB# disable to high-Z	$t_{BHZ}$	0	18	ns	13,14,15
Output disable to output in high-Z	$t_{OHZ}$	0	18	ns	13,14,15

Note 13. This parameter is sampled and not 100% tested.

14. At any given temperature and voltage condition,  $t_{CHZ1}$  max is less than  $t_{CLZ1}$  min,  $t_{CHZ2}$  max is less than  $t_{CLZ2}$  min,  $t_{BHZ}$  max is less than  $t_{BLZ}$  min, and  $t_{OHZ}$  max is less than  $t_{OLZ}$  min, for any device.

15.  $t_{CHZ1}$ ,  $t_{CHZ2}$ ,  $t_{BHZ}$  and  $t_{OHZ}$  are defined as the time when the DQ pins enter a high-impedance state and are not referred to the DQ levels.

**Write Cycle**

Parameter	Symbol	Min.	Max.	Unit	Note
Write cycle time	$t_{WC}$	55	—	ns	
Address valid to write end	$t_{AW}$	35	—	ns	
Chip select to write end	$t_{CW}$	35	—	ns	
Write pulse width	$t_{WP}$	35	—	ns	16
LB#,UB# valid to write end	$t_{BW}$	35	—	ns	
Address setup time to write start	$t_{AS}$	0	—	ns	
Write recovery time from write end	$t_{WR}$	0	—	ns	
Data to write time overlap	$t_{DW}$	25	—	ns	
Data hold from write end	$t_{DH}$	0	—	ns	
Output enable from write end	$t_{OW}$	5	—	ns	17
Output disable to output in high-Z	$t_{OHZ}$	0	18	ns	17,18
Write to output in high-Z	$t_{WHZ}$	0	18	ns	17,18

Note 16.  $t_{WP}$  is the interval between write start and write end.

A write starts when all of (CS1#), (CS2), (WE#) and (one or both of LB# and UB#) become active.

A write is performed during the overlap of a low CS1#, a high CS2, a low WE# and a low LB# or a low UB#.

A write ends when any of (CS1#), (CS2), (WE#) or (one or both of LB# and UB#) becomes inactive.

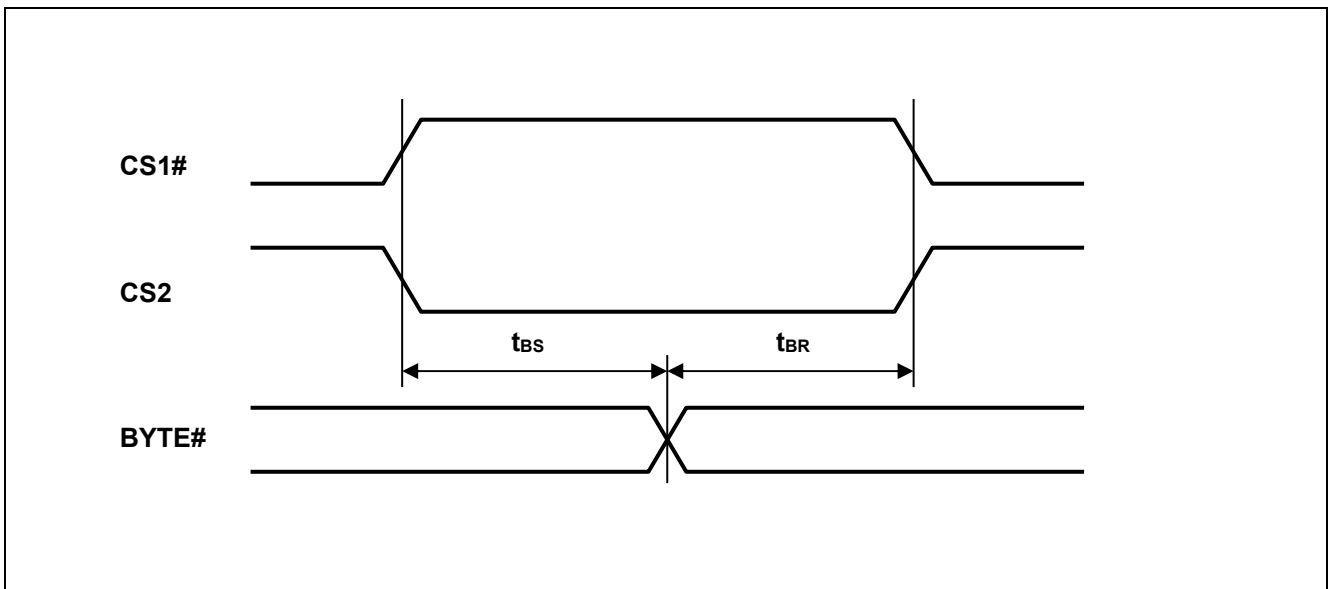
17. This parameter is sampled and not 100% tested.

18.  $t_{OHZ}$  and  $t_{WHZ}$  are defined as the time when the DQ pins enter a high-impedance state and are not referred to the DQ levels.

**BYTE# Timing Conditions** (BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types)

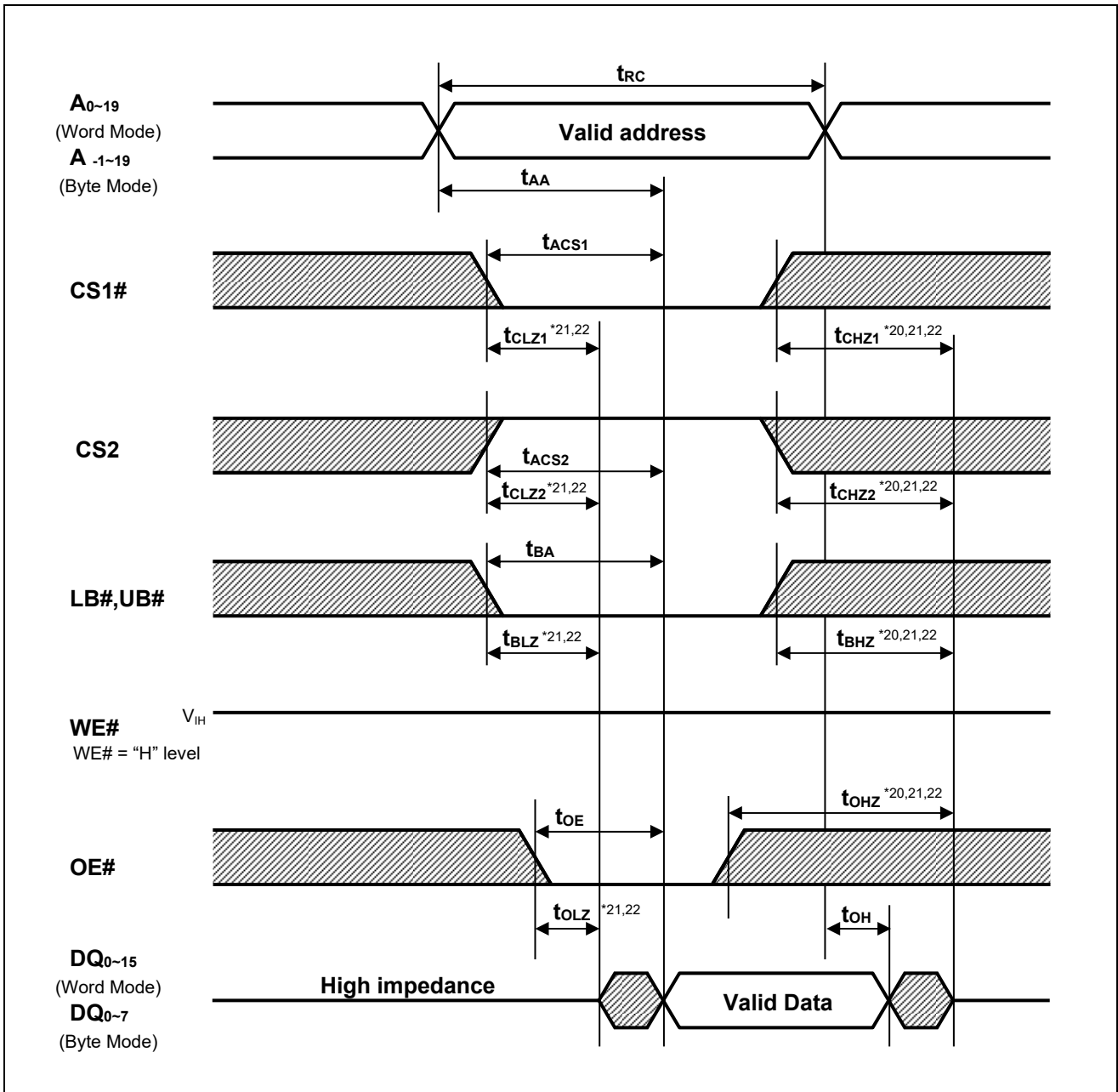
Parameter	Symbol	Min.	Max.	Unit	Note
Byte setup time	$t_{BS}$	5	-	ms	
Byte recovery time	$t_{BR}$	5	-	ms	

**BYTE# Timing Waveforms**



## Timing Waveforms

### Read Cycle<sup>\*19</sup>



Note 19. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.

BYTE#  $\geq V_{CC} - 0.2V$  (Word mode) or BYTE#  $\leq 0.2V$  (Byte mode)

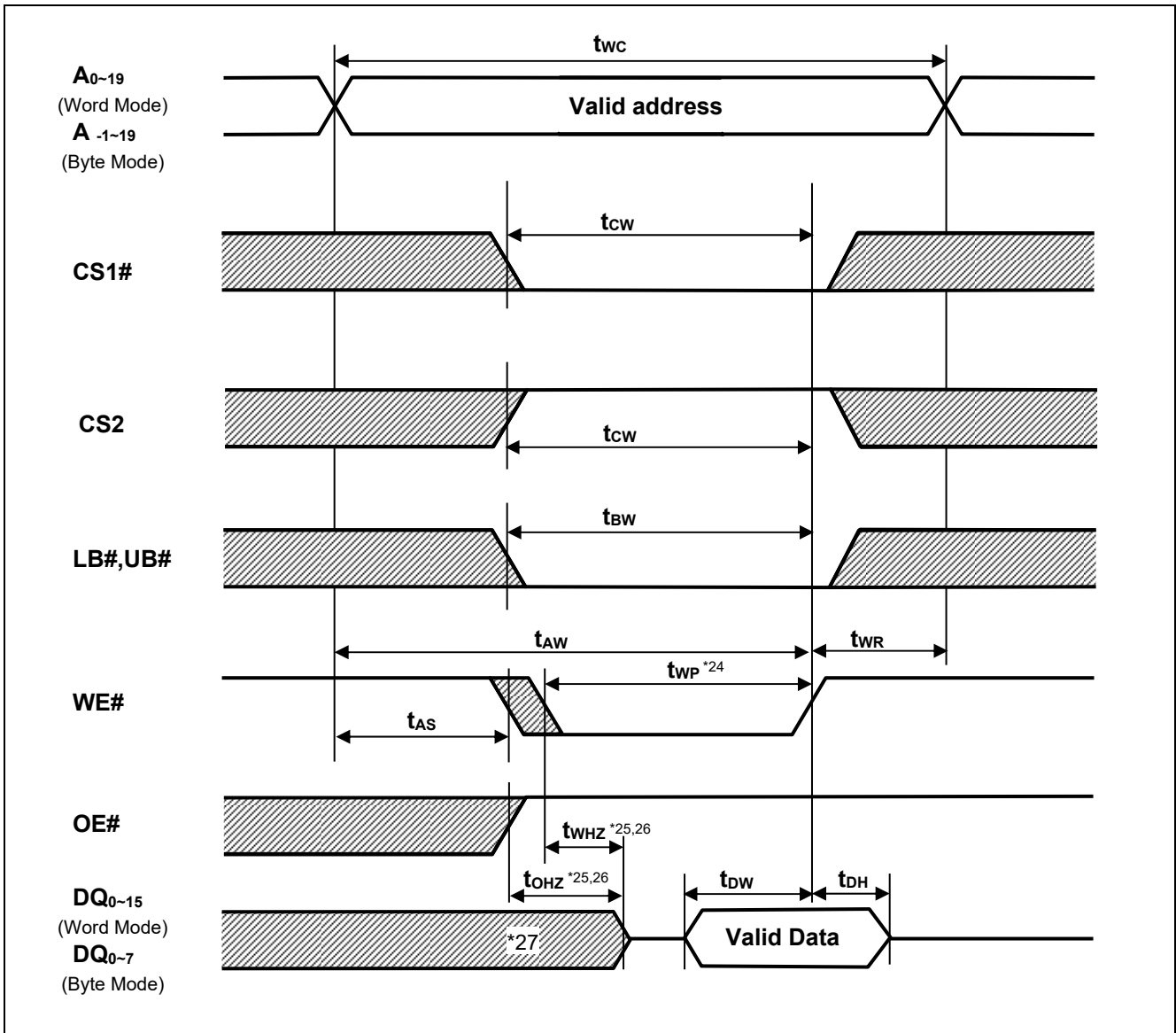
20.  $t_{CHZ1}$ ,  $t_{CHZ2}$ ,  $t_{BHZ}$  and  $t_{OHZ}$  are defined as the time when the DQ pins enter a high-impedance state and are not referred to the DQ levels.

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

22. At any given temperature and voltage condition,  $t_{CHZ1}$  max is less than  $t_{CLZ1}$  min,  $t_{CHZ2}$  max is less than  $t_{CLZ2}$  min,  $t_{BHZ}$  max is less than  $t_{BLZ}$  min, and  $t_{OHZ}$  max is less than  $t_{OLZ}$  min, for any device.



Write Cycle (1)<sup>\*23</sup> (WE# CLOCK, OE#="H" while writing)



Note 23. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.

BYTE#  $\geq V_{cc} - 0.2V$  (Word mode) or BYTE#  $\leq 0.2V$  (Byte mode)

24.  $t_{wp}$  is the interval between write start and write end.

A write starts when all of (CS1#), (CS2), (WE#) and (one or both of LB# and UB#) become active.

A write is performed during the overlap of a low CS1#, a high CS2, a low WE# and a low LB# or a low UB#.

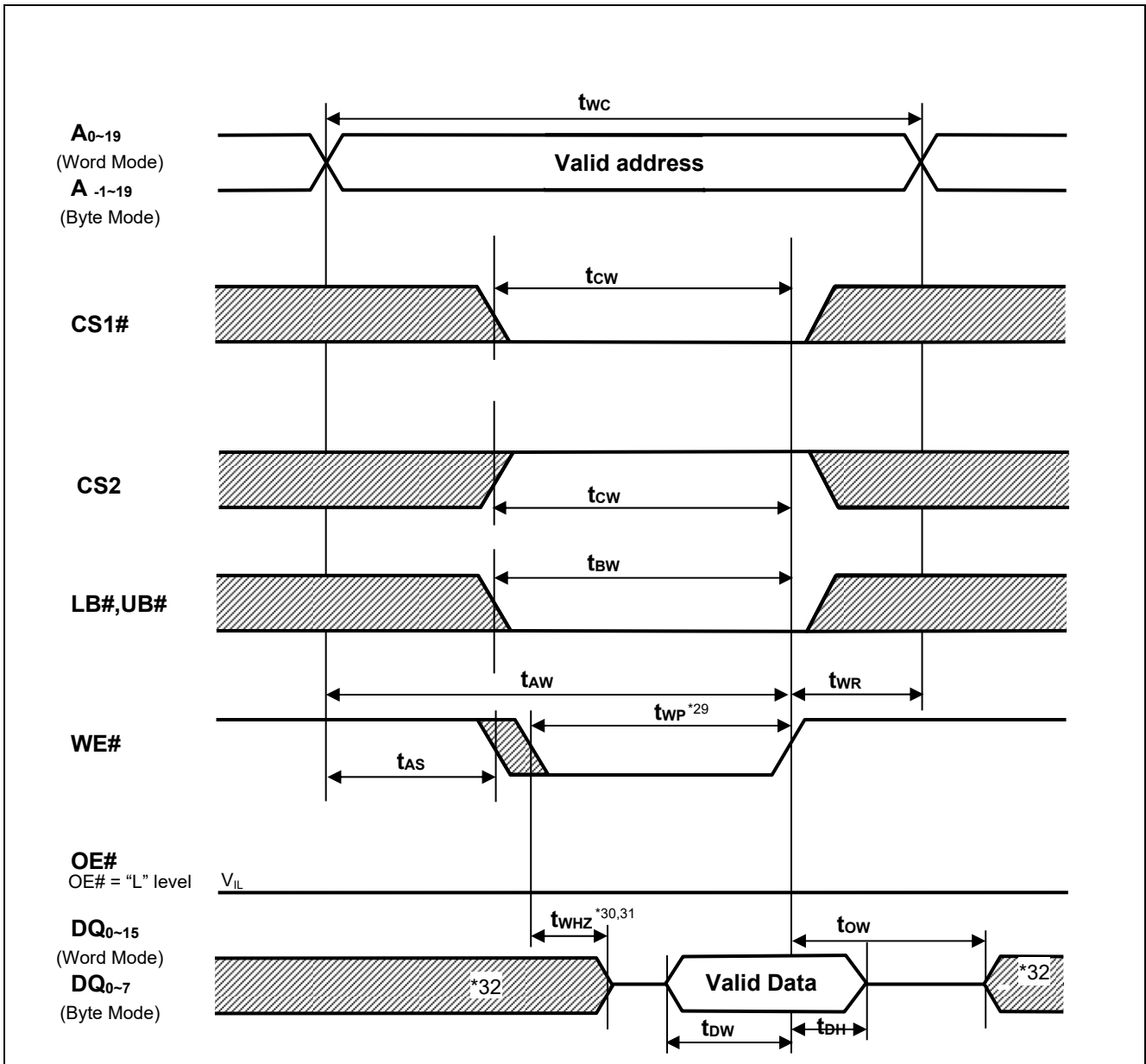
A write ends when any of (CS1#), (CS2), (WE#) or (one or both of LB# and UB#) becomes inactive.

25.  $t_{ohz}$  and  $t_{whz}$  are defined as the time when the DQ pins enter a high-impedance state and are not referred to the DQ levels.

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

27. During this period, DQ pins are in the output state so input signals must not be applied to the DQ pins.

Write Cycle (2)<sup>\*28</sup> (WE# CLOCK, OE# Low Fixed)



Note 28. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.  
 BYTE#  $\geq V_{cc} - 0.2V$  (Word mode) or BYTE#  $\leq 0.2V$  (Byte mode)

29.  $t_{wp}$  is the interval between write start and write end.

A write starts when all of (CS1#), (CS2), (WE#) and (one or both of LB# and UB#) become active.

A write is performed during the overlap of a low CS1#, a high CS2, a low WE# and a low LB# or a low UB#.

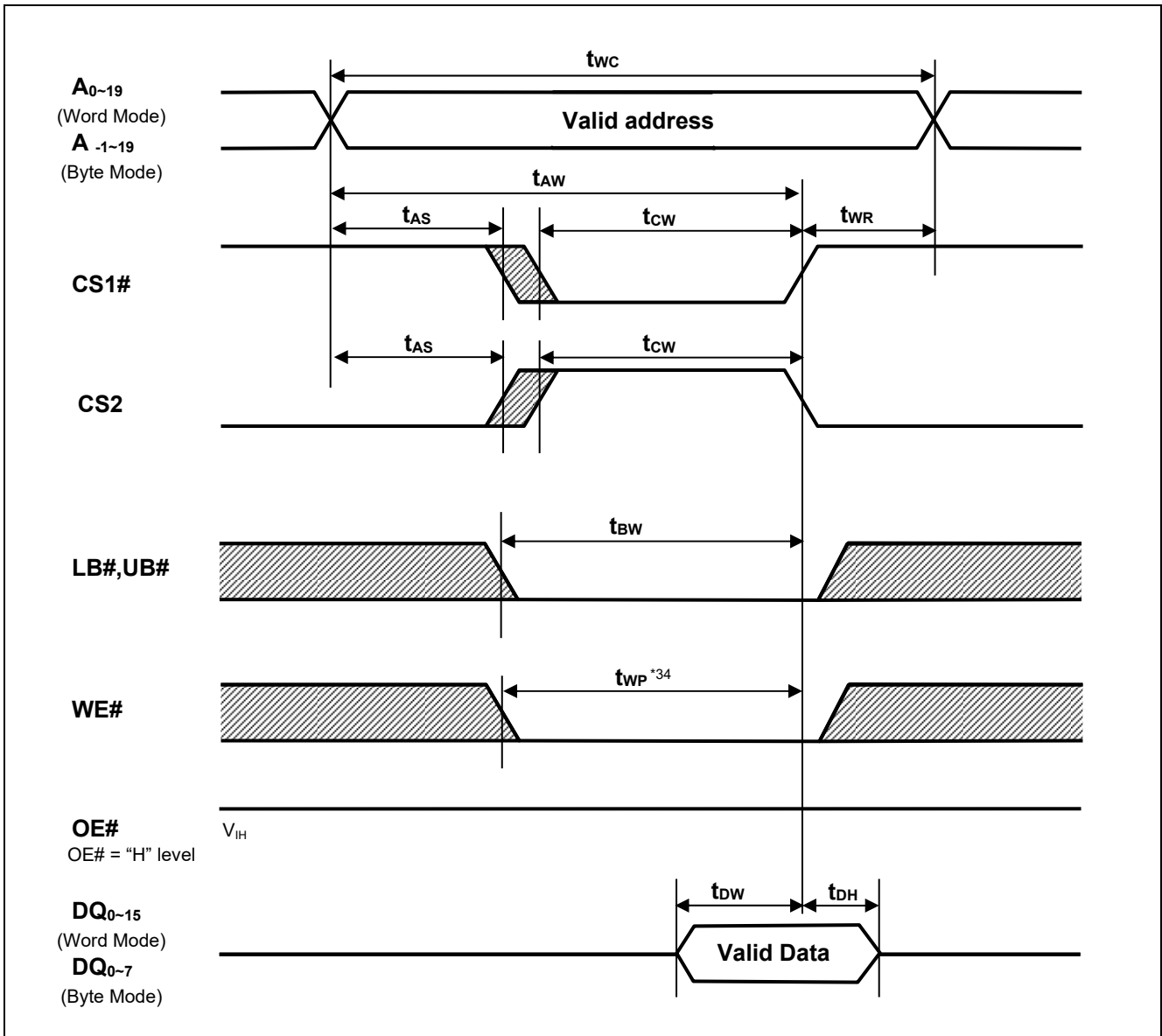
A write ends when any of (CS1#), (CS2), (WE#) or (one or both of LB# and UB#) becomes inactive.

30.  $t_{whz}$  is defined as the time when the DQ pins enter a high-impedance state and are not referred to the DQ levels.

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

32. During this period, DQ pins are in the output state so input signals must not be applied to the DQ pins.

Write Cycle (3)<sup>\*33</sup> (CS1#, CS2 CLOCK)



Note 33. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.

BYTE#  $\geq V_{CC} - 0.2V$  (Word mode) or BYTE#  $\leq 0.2V$  (Byte mode)

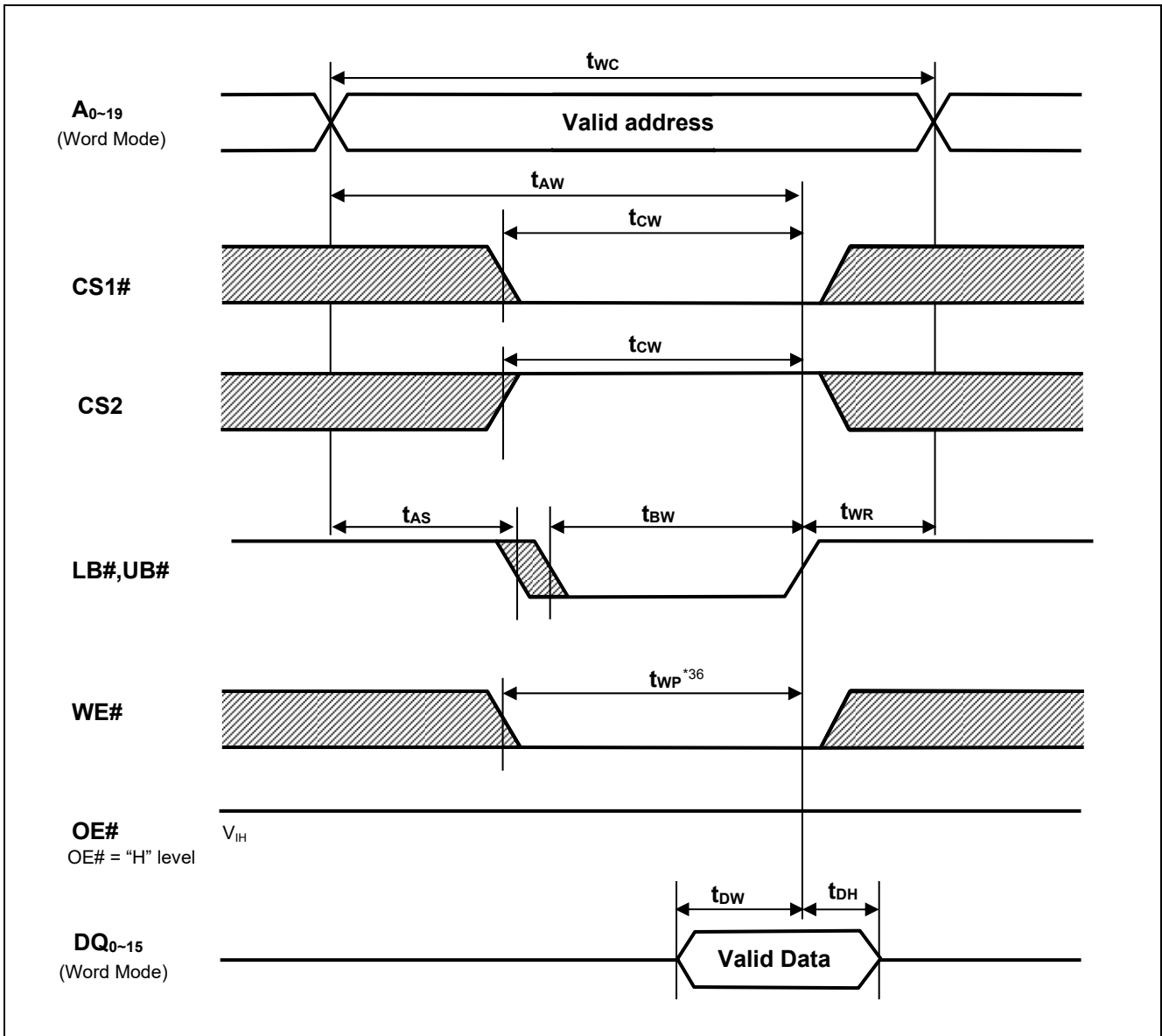
34. t<sub>WP</sub> is the interval between write start and write end.

A write starts when all of (CS1#), (CS2), (WE#) and (one or both of LB# and UB#) become active.

A write is performed during the overlap of a low CS1#, a high CS2, a low WE# and a low LB# or a low UB#.

A write ends when any of (CS1#), (CS2), (WE#) or (one or both of LB# and UB#) becomes inactive.

Write Cycle (4)<sup>\*35</sup> (LB#, UB# CLOCK, Word Mode)



Note 35. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.

BYTE#  $\geq V_{CC} - 0.2V$  (Word mode)

36.  $t_{WP}$  is the interval between write start and write end.

A write starts when all of (CS1#), (CS2), (WE#) and (one or both of LB# and UB#) become active.

A write is performed during the overlap of a low CS1#, a high CS2, a low WE# and a low LB# or a low UB#.

A write ends when any of (CS1#), (CS2), (WE#) or (one or both of LB# and UB#) becomes inactive.

Low  $V_{CC}$  Data Retention Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test conditions <sup>*37,38</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	$I_{CCDR}$	—	$0.5^{*39}$	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) $LB\# = UB\# \geq V_{CC}-0.2V$ , $CS1\# \leq 0.2V$ , $CS2 \geq V_{CC}-0.2V$
		—	$0.8^{*40}$	5	$\mu A$	$\sim +40^{\circ}C$	
		—	$2.5^{*41}$	12	$\mu A$	$\sim +70^{\circ}C$	
		—	$5^{*42}$	16	$\mu A$	$\sim +85^{\circ}C$	
Chip deselect time to data retention	$t_{CDR}$	0	—	—	ns	See retention waveform.	
Operation recovery time	$t_R$	5	—	—	ms		

Note 37. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.

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

38. CS2 controls address buffer, WE# buffer, CS1# buffer, OE# buffer, LB# buffer, UB# buffer and DQ buffer.

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

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

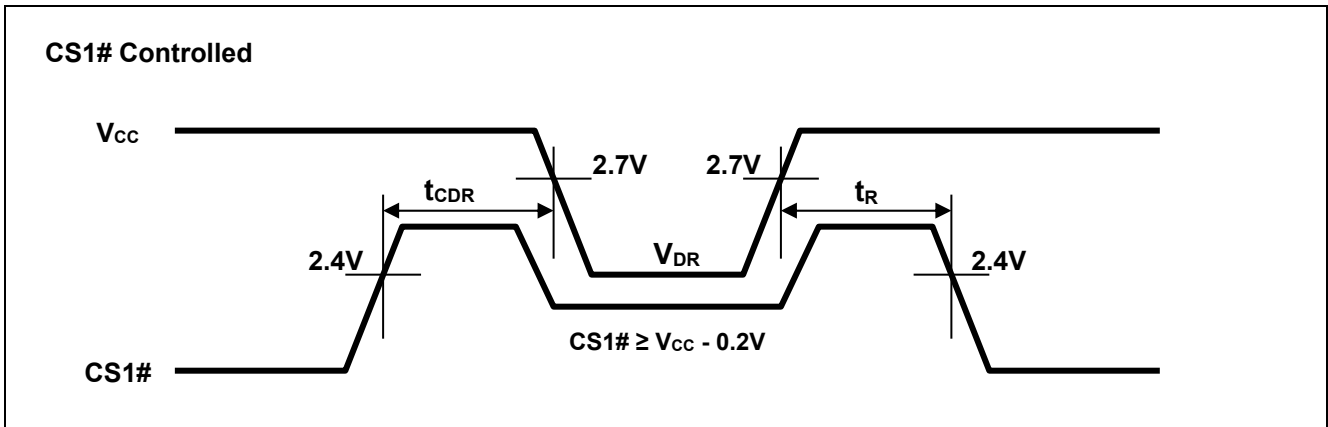
39. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=25^{\circ}C$ ), and not 100% tested.

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

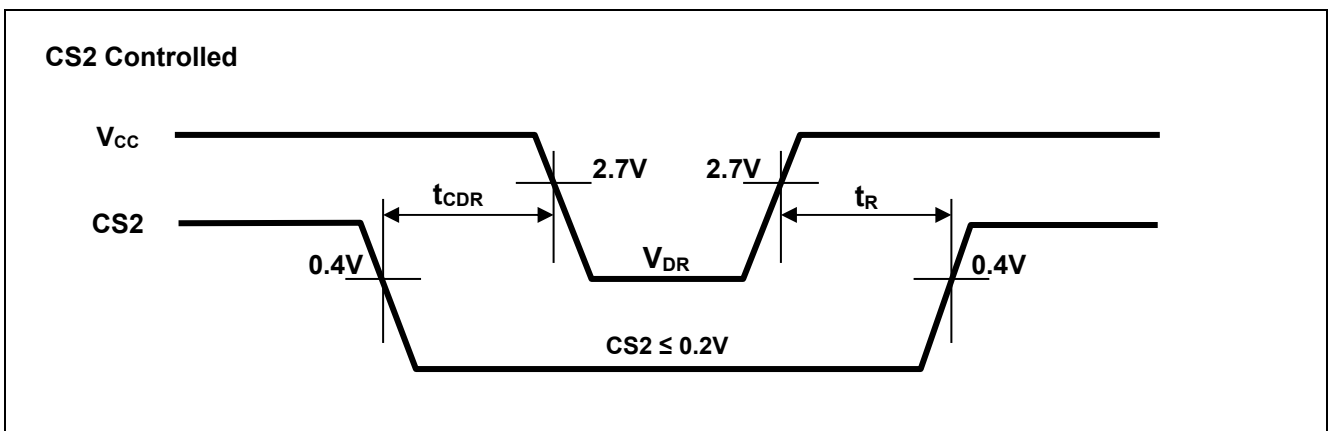
41. Typical parameter indicates the value for the center of distribution at 3.0V ( $T_a=70^{\circ}C$ ), and not 100% tested.

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

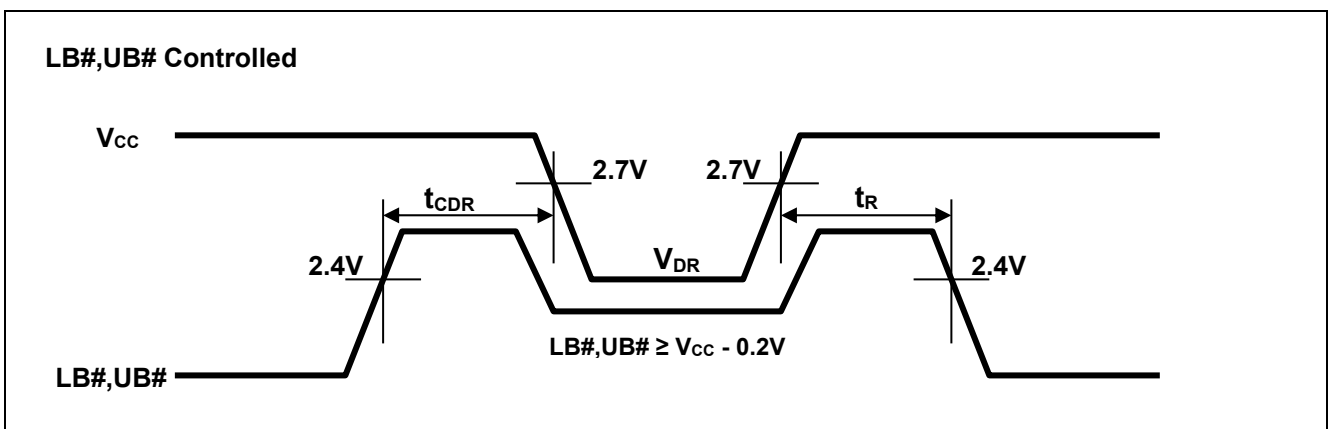
Low Vcc Data Retention Timing Waveforms (CS1# controlled)<sup>\*43</sup>



Low Vcc Data Retention Timing Waveforms (CS2 controlled)<sup>\*43</sup>



Low Vcc Data Retention Timing Waveforms (LB#,UB# controlled, Word Mode)<sup>\*44</sup>



Note 43. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.  
 BYTE# ≥ V<sub>CC</sub> - 0.2V or BYTE# ≤ 0.2V

44. BYTE# pin supported by only 48pin TSOP (I) and 52pin  $\mu$ TSOP (II) types.  
 BYTE# ≥ V<sub>CC</sub> - 0.2V (Word mode)

Revision History	RMLV1616A Series Data Sheet
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Rev.	Date	Description	
		Page	Summary
1.00	2016.01.06	—	First Edition issued
1.01	2020.02.20	Last page	Updated the Notice to the latest version

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(Rev.1.0 Mar 2020)

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