

### n FEATURES

- Wide  $V_{CC}$  operation voltage :
  - C-grade : 1.8V ~ 3.6V
  - I-grade : 1.9V ~ 3.6V
  - ( $V_{CC\_min.}=1.65V$  at 25°C)
- Ultra low power consumption :
  - $V_{CC} = 2.0V$  C-grade : 10mA(Max.) operating current
  - I-grade : 12mA(Max.) operating current
  - 0.3uA (Typ.) CMOS standby current
  - $V_{CC} = 3.0V$  C-grade : 13mA(Max.) operating current
  - I-grade : 15mA(Max.) operating current
  - 0.45uA (Typ.) CMOS standby current
- High speed access time :
  - 85 85ns (Max.)
  - 10 100ns (Max.)
- Automatic power down when chip is deselected
- Easy expansion with CE and OE options

- I/O Configuration x8/x16 selectable by LB and UB pin.
- Three state outputs and TTL compatible
- Fully static operation
- Data retention supply voltage as low as 1.2V

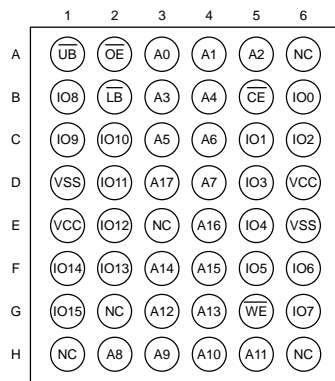
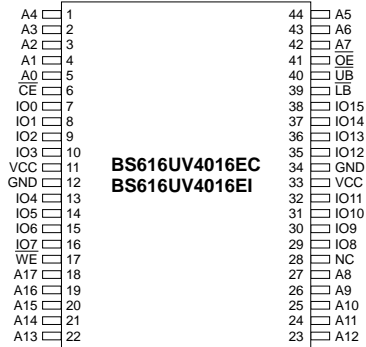
### n DESCRIPTION

The BS616UV4016 is a high performance, ultra low power CMOS Static Random Access Memory organized as 262,144 words by 16 bits and operates from a wide range of 1.8V to 3.6V supply voltage. Advanced CMOS technology and circuit techniques provide both high speed and low power features with typical CMOS standby current of 0.3uA at 2.0V/25°C and maximum access time of 85ns at 85°C. Easy memory expansion is provided by an active LOW chip enable ( $\overline{CE}$ ) and active LOW output enable ( $\overline{OE}$ ) and three-state output drivers. The BS616UV4016 has an automatic power down feature, reducing the power consumption significantly when chip is deselected. The BS616UV4016 is available in DICE form, JEDEC standard 44-pin TSOP Type II and 48-ball BGA package.

### n PRODUCT FAMILY

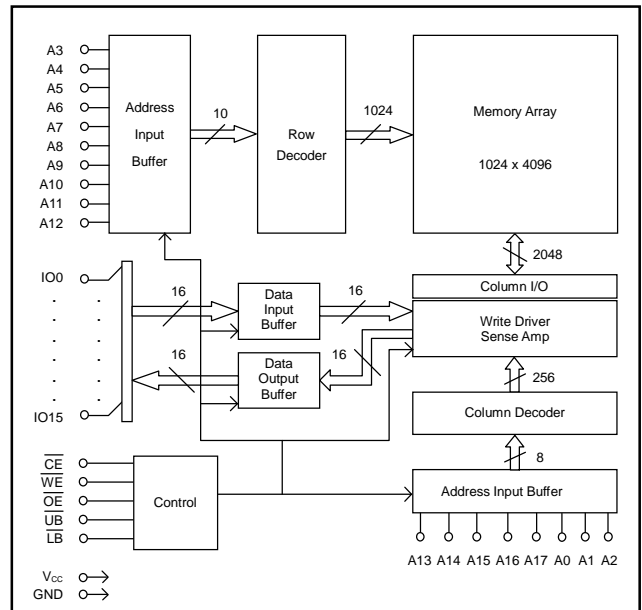
PRODUCT FAMILY	OPERATING TEMPERATURE	$V_{CC}$ RANGE	SPEED (ns)	POWER DISSIPATION				PKG TYPE
				STANDBY ( $I_{CCSBT, Max}$ )		Operating ( $I_{CC, Max}$ )		
				$V_{CC}=3.0V$	$V_{CC}=2.0V$	$V_{CC}=3.0V$	$V_{CC}=2.0V$	
BS616UV4016DC	+0°C to +70°C	1.8V ~ 3.6V	85/100	6.0uA	3.0uA	13mA	10mA	DICE
BS616UV4016EC								TSOP2-44
BS616UV4016AC								BGA-48-0608
BS616UV4016DI	-40°C to +85°C	1.9V ~ 3.6V	85/100	8.0uA	5.0uA	15mA	12mA	DICE
BS616UV4016EI								TSOP2-44
BS616UV4016AI								BGA-48-0608

### n PIN CONFIGURATIONS



48-ball BGA top view

### n BLOCK DIAGRAM



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**n PIN DESCRIPTIONS**

Name	Function
<b>A0-A17 Address Input</b>	These 18 address inputs select one of the 262,144 x 16-bit words in the RAM
<b><math>\overline{\text{CE}}</math> Chip Enable 1 Input</b>	$\overline{\text{CE}}$ is active LOW. Chip enable must be active when data read from or write to the device. If either chip enable is not active, the device is deselected and is in standby power mode. The IO pins will be in the high impedance state when the device is deselected.
<b><math>\overline{\text{WE}}</math> Write Enable Input</b>	The write enable input is active LOW and controls read and write operations. With the chip selected, when $\overline{\text{WE}}$ is HIGH and $\overline{\text{OE}}$ is LOW, output data will be present on the IO pins; when $\overline{\text{WE}}$ is LOW, the data present on the IO pins will be written into the selected memory location.
<b><math>\overline{\text{OE}}</math> Output Enable Input</b>	The output enable input is active LOW. If the output enable is active while the chip is selected and the write enable is inactive, data will be present on the IO pins and they will be enabled. The IO pins will be in the high impedance state when $\overline{\text{OE}}$ is inactive.
<b><math>\overline{\text{LB}}</math> and <math>\overline{\text{UB}}</math> Data Byte Control Input</b>	Lower byte and upper byte data input/output control pins.
<b>IO0-IO15 Data Input/Output Ports</b>	16 bi-directional ports are used to read data from or write data into the RAM.
<b><math>V_{\text{CC}}</math></b>	Power Supply
<b>GND</b>	Ground

**n TRUTH TABLE**

MODE	$\overline{\text{CE}}$	$\overline{\text{WE}}$	$\overline{\text{OE}}$	$\overline{\text{LB}}$	$\overline{\text{UB}}$	IO0-IO7	IO8-IO15	$V_{\text{CC}}$ CURRENT
Chip De-selected (Power Down)	H	X	X	X	X	High Z	High Z	$I_{\text{CCSB}}$ , $I_{\text{CCSB1}}$
	X	X	X	H	H	High Z	High Z	$I_{\text{CCSB}}$ , $I_{\text{CCSB1}}$
Output Disabled	L	H	H	L	X	High Z	High Z	$I_{\text{CC}}$
	L	H	H	X	L	High Z	High Z	$I_{\text{CC}}$
Read	L	H	L	L	L	$D_{\text{OUT}}$	$D_{\text{OUT}}$	$I_{\text{CC}}$
				H	L	High Z	$D_{\text{OUT}}$	$I_{\text{CC}}$
				L	H	$D_{\text{OUT}}$	High Z	$I_{\text{CC}}$
Write	L	L	X	L	L	$D_{\text{IN}}$	$D_{\text{IN}}$	$I_{\text{CC}}$
				H	L	X	$D_{\text{IN}}$	$I_{\text{CC}}$
				L	H	$D_{\text{IN}}$	X	$I_{\text{CC}}$

NOTES: H means  $V_{\text{IH}}$ ; L means  $V_{\text{IL}}$ ; X means don't care (Must be  $V_{\text{IH}}$  or  $V_{\text{IL}}$  state)

**n ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>**

SYMBOL	PARAMETER	RATING	UNITS
$V_{TERM}$	Terminal Voltage with Respect to GND	-0.5 <sup>(2)</sup> to 4.6V	V
$T_{BIAS}$	Temperature Under Bias	-40 to +85	°C
$T_{STG}$	Storage Temperature	-60 to +150	°C
$P_T$	Power Dissipation	1.0	W
$I_{OUT}$	DC Output Current	20	MA

1. Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

2. -2.0V in case of AC pulse width less than 30 ns

**n OPERATING RANGE**

RANG	AMBIENT TEMPERATURE	V <sub>cc</sub>
Commercial	0°C to + 70°C	1.8V ~ 3.6V
Industrial	-40°C to + 85°C	1.9V ~ 3.6V

**n CAPACITANCE <sup>(1)</sup> (T<sub>A</sub> = 25°C, f = 1.0MHz)**

SYMBOL	PARAMETER	CONDITIONS	MAX.	UNITS
$C_{IN}$	Input Capacitance	$V_{IN} = 0V$	6	pF
$C_{IO}$	Input/Output Capacitance	$V_{I/O} = 0V$	8	pF

1. This parameter is guaranteed and not 100% tested.

**n DC ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = -40°C to +85°C)**

PARAMETER NAME	PARAMETER	TEST CONDITIONS	MIN.	TYP. <sup>(1)</sup>	MAX.	UNITS
<b>V<sub>cc</sub></b>	Power Supply		1.9	--	3.6	V
<b>V<sub>IL</sub></b>	Input Low Voltage	$V_{CC}=2.0V$	-0.3 <sup>(2)</sup>	--	0.6	V
		$V_{CC}=3.0V$			0.8	
<b>V<sub>IH</sub></b>	Input High Voltage	$V_{CC}=2.0V$	1.4	--	$V_{CC}+0.3$ <sup>(3)</sup>	V
		$V_{CC}=3.0V$	2.0			
<b>I<sub>IL</sub></b>	Input Leakage Current	$V_{IN} = 0V$ to $V_{CC}$ , $\overline{CE} = V_{IH}$	--	--	1	µA
<b>I<sub>LO</sub></b>	Output Leakage Current	$V_{I/O} = 0V$ to $V_{CC}$ $\overline{CE} = V_{IH}$ , or $\overline{OE} = V_{IH}$	--	--	1	µA
<b>V<sub>OL</sub></b>	Output Low Voltage	$V_{CC} = \text{Max}$ , $I_{OL} = 0.1mA$	$V_{CC}=2.0V$	--	0.2	V
		$V_{CC} = \text{Max}$ , $I_{OL} = 2.0mA$	$V_{CC}=3.0V$		0.4	
<b>V<sub>OH</sub></b>	Output High Voltage	$V_{CC} = \text{Min}$ , $I_{OH} = -0.1mA$	$V_{CC}=2.0V$	--	--	V
		$V_{CC} = \text{Min}$ , $I_{OH} = -1.0mA$	$V_{CC}=3.0V$			
<b>I<sub>CC</sub></b>	Operating Power Supply Current	$\overline{CE} = V_{IL}$ , $I_{IO} = 0mA$ , $f = F_{MAX}$ <sup>(4)</sup>	$V_{CC}=2.0V$	--	12	mA
			$V_{CC}=3.0V$		15	
<b>I<sub>CCSB</sub></b>	Standby Current – TTL	$\overline{CE} = V_{IH}$ , $I_{IO} = 0mA$	$V_{CC}=2.0V$	--	0.5	mA
			$V_{CC}=3.0V$		1.0	
<b>I<sub>CCSB1</sub></b> <sup>(5)</sup>	Standby Current – CMOS	$\overline{CE} \geq V_{CC}-0.2V$ , $V_{IN} \geq V_{CC}-0.2V$ or $V_{IN} \leq 0.2V$	$V_{CC}=2.0V$	--	0.3	µA
			$V_{CC}=3.0V$		0.45	

1. Typical characteristics are at T<sub>A</sub>=25°C.

2. Undershoot: -1.0V in case of pulse width less than 20 ns.

3. Overshoot: V<sub>CC</sub>+1.0V in case of pulse width less than 20 ns.

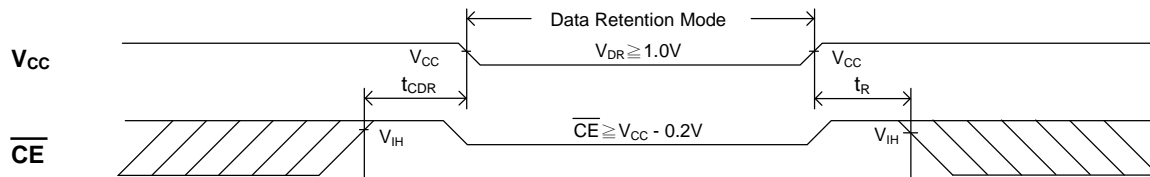
4.  $F_{MAX}=1/t_{RC}$ .

5. I<sub>CCSB1(MAX)</sub> is 3.0/6.0µA at V<sub>CC</sub>=2.0V/3.0V and T<sub>A</sub>=70°C.

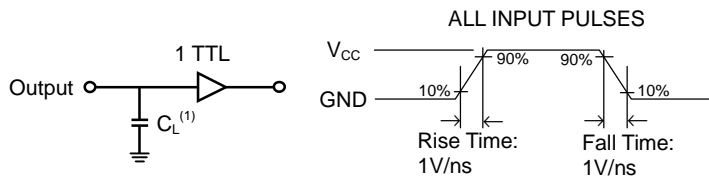
**n DATA RETENTION CHARACTERISTICS ( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ )**

SYMBOL	PARAMETER	TEST CONDITIONS	MIN.	TYP. <sup>(1)</sup>	MAX.	UNITS
$V_{DR}$	$V_{CC}$ for Data Retention	$\overline{CE} \geq V_{CC}-0.2\text{V}$ , $V_{IN} \geq V_{CC}-0.2\text{V}$ or $V_{IN} \leq 0.2\text{V}$	1.2	--	--	V
$I_{CCDR}^{(3)}$	Data Retention Current	$\overline{CE} \geq V_{CC}-0.2\text{V}$ , $V_{IN} \geq V_{CC}-0.2\text{V}$ or $V_{IN} \leq 0.2\text{V}$	--	0.15	1.7	$\mu\text{A}$
$t_{CDR}$	Chip Deselect to Data Retention Time	See Retention Waveform	0	--	--	ns
$t_R$	Operation Recovery Time		$t_{RC}^{(2)}$	--	--	ns

- $V_{CC}=1.2\text{V}$ ,  $T_A=25^{\circ}\text{C}$ .
- $t_{RC}$  = Read Cycle Time.
- $I_{CCRD\_Max}$  is  $1.2\mu\text{A}$  at  $T_A=70^{\circ}\text{C}$ .

**n LOW  $V_{CC}$  DATA RETENTION WAVEFORM (1) ( $\overline{CE}$  Controlled)**

**n AC TEST CONDITIONS  
(Test Load and Input/Output Reference)**

Input Pulse Levels	$V_{CC} / 0\text{V}$	
Input Rise and Fall Times	$1\text{V/ns}$	
Input and Output Timing Reference Level	$0.5V_{CC}$	
Output Load	$t_{CLZ}$ , $t_{OLZ}$ , $t_{CHZ}$ , $t_{OHZ}$ , $t_{WHZ}$	$C_L = 5\text{pF}+1\text{TTL}$
	Others	$C_L = 30\text{pF}+1\text{TTL}$



1. Including jig and scope capacitance.

**n KEY TO SWITCHING WAVEFORMS**

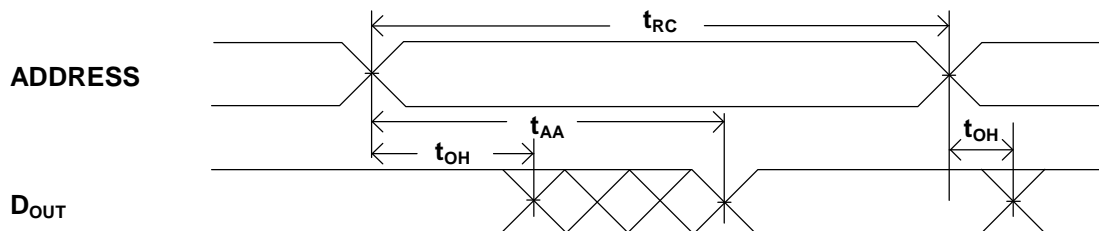
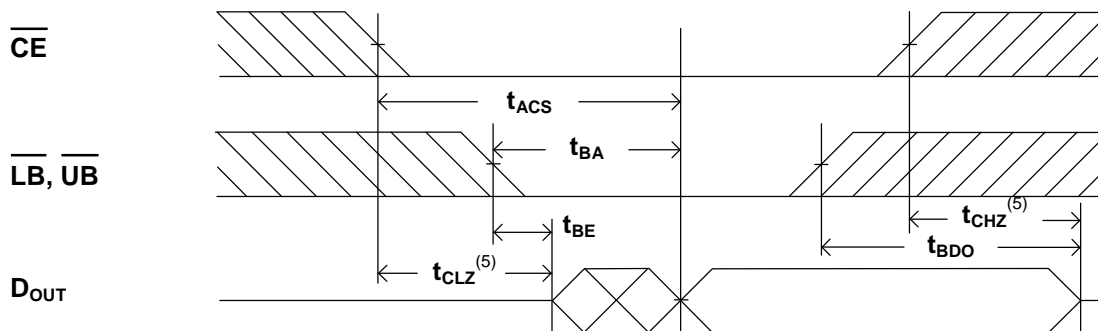
WAVEFORM	INPUTS	OUTPUTS
	MUST BE STEADY	MUST BE STEADY
	MAY CHANGE FROM "H" TO "L"	WILL BE CHANGE FROM "H" TO "L"
	MAY CHANGE FROM "L" TO "H"	WILL BE CHANGE FROM "L" TO "H"
	DON'T CARE ANY CHANGE PERMITTED	CHANGE : STATE UNKNOWN
	DOES NOT APPLY	CENTER LINE IS HIGH IMPEDANCE "OFF" STATE

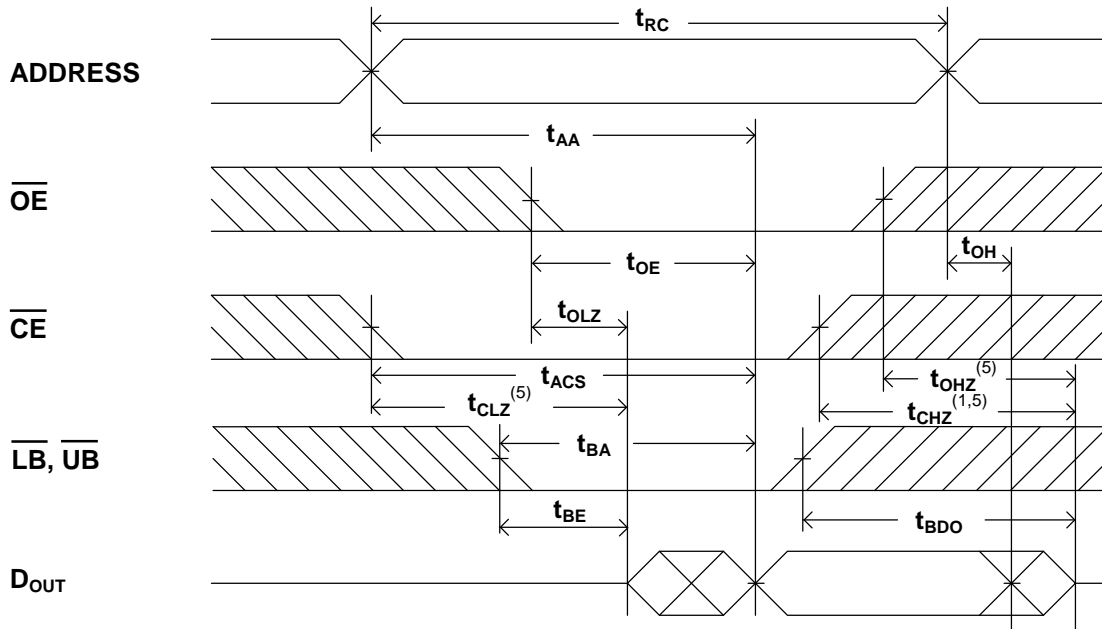
**n AC ELECTRICAL CHARACTERISTICS ( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ )**
**READ CYCLE**

JEDEC PARAMETER NAME	PARAMETER NAME	DESCRIPTION	CYCLE TIME : 85ns ( $V_{CC}=1.9\sim 3.6\text{V}$ )			CYCLE TIME : 100ns ( $V_{CC}=1.9\sim 3.6\text{V}$ )			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$t_{AVAX}$	$t_{RC}$	Read Cycle Time	85	--	--	100	--	--	ns
$t_{AVQX}$	$t_{AA}$	Address Access Time	--	--	85	--	--	100	ns
$t_{ELQV}$	$t_{ACS}$	Chip Select Access Time ( $\overline{\text{CE}}$ )	--	--	85	--	--	100	ns
$t_{BLQV}$	$t_{BA}^{(1)}$	Data Byte Control Access Time ( $\overline{\text{LB}}, \overline{\text{UB}}$ )	--	--	40	--	--	50	ns
$t_{GLQV}$	$t_{OE}$	Output Enable to Output Valid	--	--	40	--	--	50	ns
$t_{ELQX}$	$t_{CLZ}$	Chip Select to Output Low Z ( $\overline{\text{CE}}$ )	15	--	--	15	--	--	ns
$t_{BLQX}$	$t_{BE}$	Data Byte Control to Output Low Z ( $\overline{\text{LB}}, \overline{\text{UB}}$ )	15	--	--	15	--	--	ns
$t_{GLQX}$	$t_{OLZ}$	Output Enable to Output Low Z	15	--	--	15	--	--	ns
$t_{EHQZ}$	$t_{CHZ}$	Chip Select to Output High Z ( $\overline{\text{CE}}$ )	--	--	35	--	--	40	ns
$t_{BHQZ}$	$t_{BDO}$	Data Byte Control to Output High Z ( $\overline{\text{LB}}, \overline{\text{UB}}$ )	--	--	35	--	--	40	ns
$t_{GHQZ}$	$t_{OHZ}$	Output Enable to Output High Z	--	--	35	--	--	40	ns
$t_{AVQX}$	$t_{OH}$	Data Hold from Address Change	15	--	--	15	--	--	ns

NOTE :

 1.  $t_{BA}$  is 40ns/50ns (@speed=85ns/100ns) with address toggle;  $t_{BA}$  is 85ns/100ns (@speed=85ns/100ns) without address toggle

**n SWITCHING WAVEFORMS (READ CYCLE)**
**READ CYCLE 1** <sup>(1,2,4)</sup>

**READ CYCLE 2** <sup>(1,3,4)</sup>


**READ CYCLE 3** <sup>(1, 4)</sup>

**NOTES:**

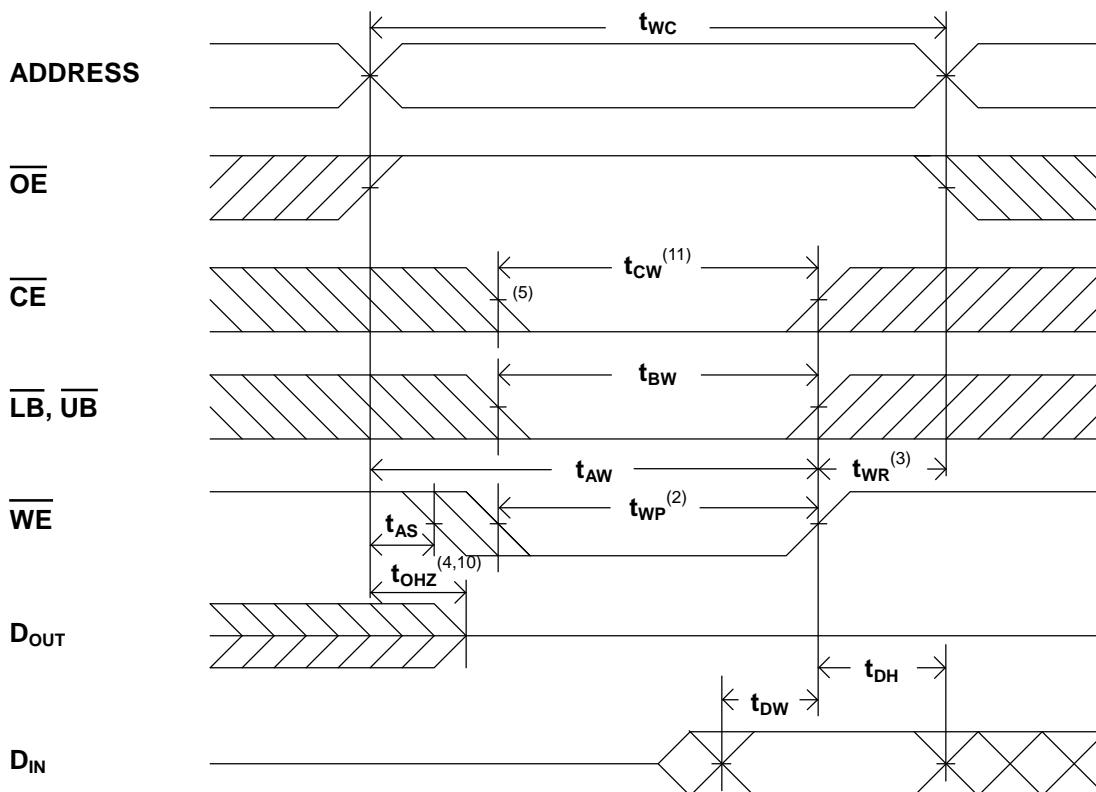
1. WE is high in read Cycle.
2. Device is continuously selected when  $\overline{CE} = V_{IL}$ .
3. Address valid prior to or coincident with CE transition low.
4.  $\overline{OE} = V_{IL}$ .
5. Transition is measured  $\pm 500\text{mV}$  from steady state with  $C_L = 5\text{pF}$ .  
The parameter is guaranteed but not 100% tested.

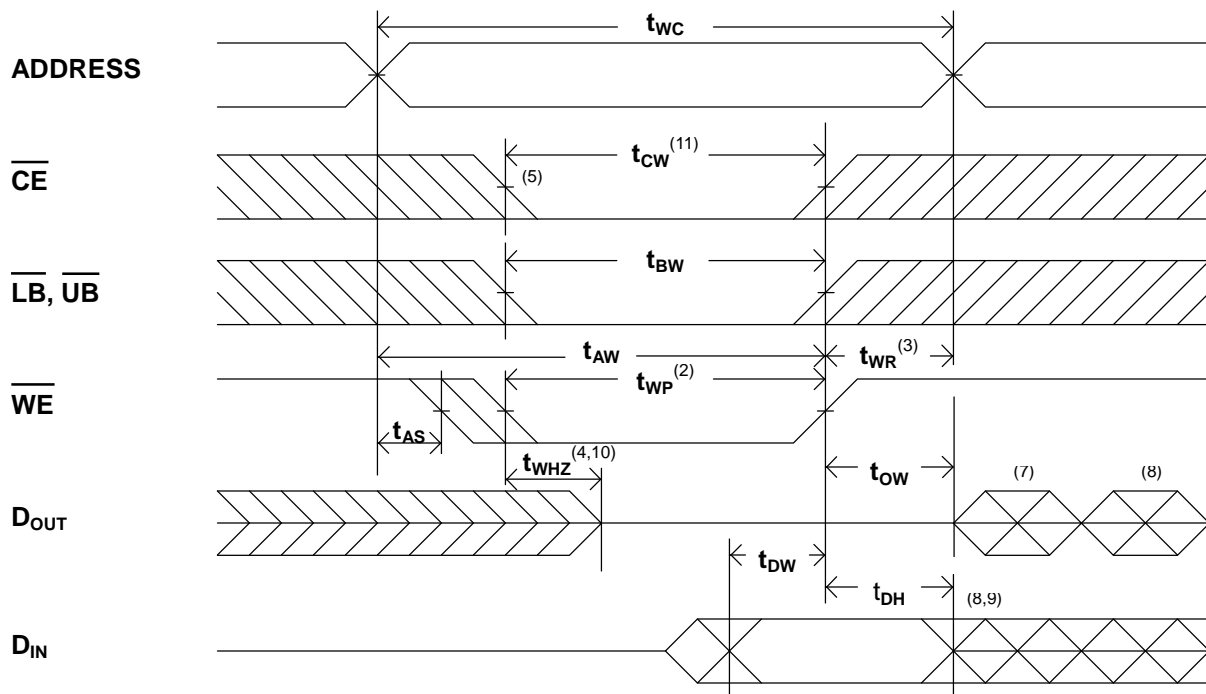
**n AC ELECTRICAL CHARACTERISTICS ( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ )**
**WRITE CYCLE**

JEDEC PARAMETER NAME	PARAMETER NAME	DESCRIPTION	CYCLE TIME : 85ns ( $V_{CC}=1.9\sim 3.6\text{V}$ )			CYCLE TIME : 100ns ( $V_{CC}=1.9\sim 3.6\text{V}$ )			UNITS
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$t_{AVAX}$	$t_{WC}$	Write Cycle Time	85	--	--	100	--	--	ns
$t_{AVWL}$	$t_{AS}$	Address Set up Time	0	--	--	0	--	--	ns
$t_{AVWH}$	$t_{AW}$	Address Valid to End of Write	85	--	--	100	--	--	ns
$t_{ELWH}$	$t_{CW}$	Chip Select to End of Write (CE)	85	--	--	100	--	--	ns
$t_{BLWH}$	$t_{BW}^{(1)}$	Data Byte Control to End of Write (LB, UB)	35	--	--	40	--	--	ns
$t_{WLWH}$	$t_{WP}$	Write Pulse Width	40	--	--	50	--	--	ns
$t_{WHAX}$	$t_{WR}$	Write Recovery Time (CE, WE)	0	--	--	0	--	--	ns
$t_{WLQZ}$	$t_{WHZ}$	Write to Output High Z	--	--	35	--	--	40	ns
$t_{DVWH}$	$t_{DW}$	Data to Write Time Overlap	35	--	--	40	--	--	ns
$t_{WHDX}$	$t_{DH}$	Data Hold from Write Time	0	--	--	0	--	--	ns
$t_{GHQZ}$	$t_{OHZ}$	Output Disable to Output in High Z	--	--	35	--	--	40	ns
$t_{WHQX}$	$t_{OW}$	End of Write to Output Active	10	--	--	10	--	--	ns

NOTE:

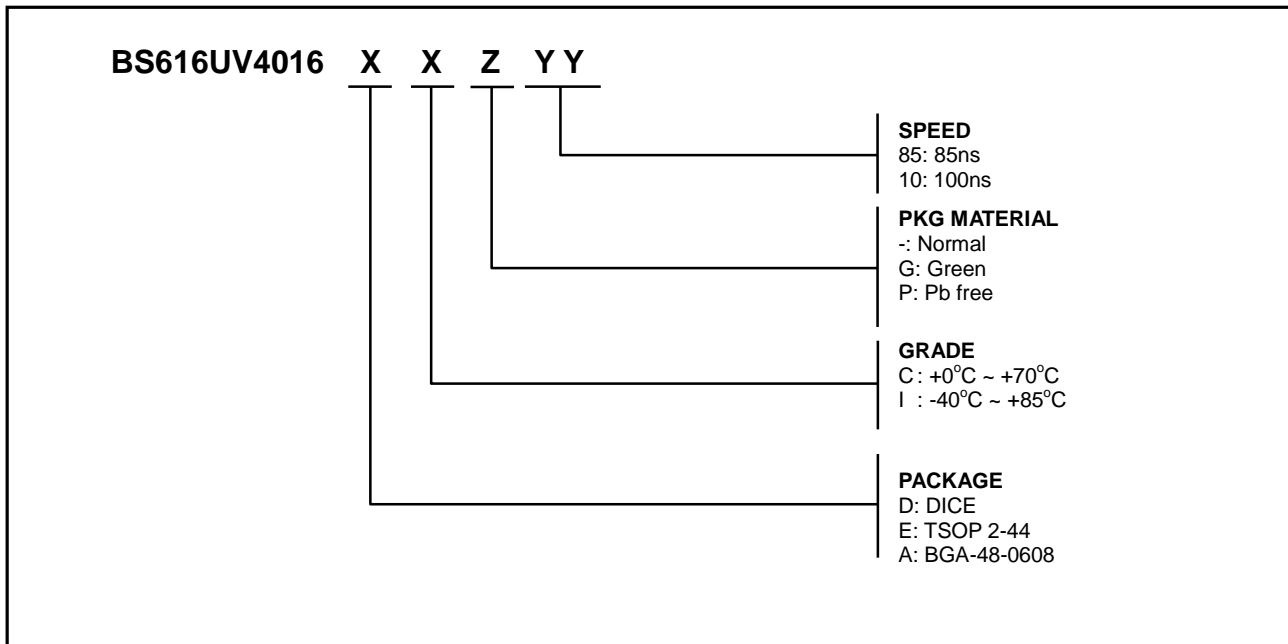
 1.  $t_{BW}$  is 35ns/40ns (@speed=85ns/100ns) with address toggle;  $t_{BW}$  is 85ns/100ns (@speed=85ns/100ns) without address toggle.

**n SWITCHING WAVEFORMS (WRITE CYCLE)**
**WRITE CYCLE 1 <sup>(1)</sup>**


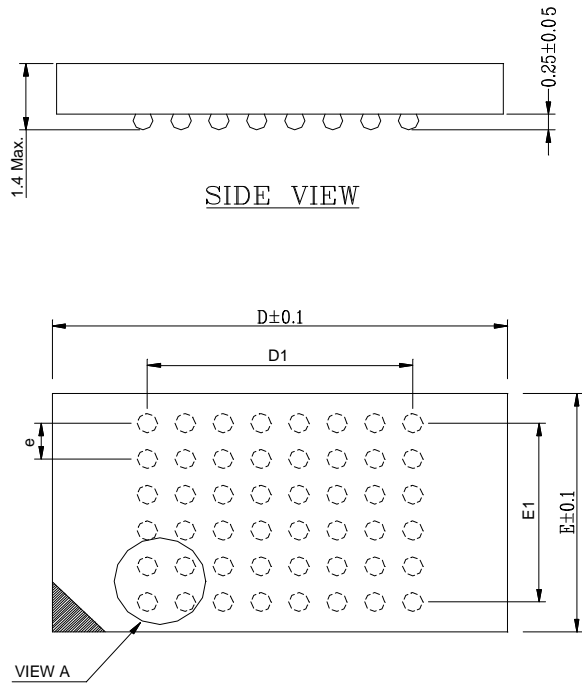
**WRITE CYCLE 2** <sup>(1,6)</sup>

**NOTES:**

1.  $\overline{WE}$  must be high during address transitions.
2. The internal write time of the memory is defined by the overlap of  $\overline{CE}$  and  $\overline{WE}$  low. All signals must be active to initiate a write and any one signal can terminate a write by going inactive. The data input setup and hold timing should be referenced to the second transition edge of the signal that terminates the write.
3.  $t_{WR}$  is measured from the earlier of  $\overline{CE}$  or  $\overline{WE}$  going high at the end of write cycle.
4. During this period, IO pins are in the output state so that the input signals of opposite phase to the outputs must not be applied.
5. If the  $\overline{CE}$  low transition occurs simultaneously with the  $\overline{WE}$  low transitions or after the  $\overline{WE}$  transition, output remain in a high impedance state.
6.  $\overline{OE}$  is continuously low ( $\overline{OE} = V_{IL}$ ).
7.  $D_{OUT}$  is the same phase of write data of this write cycle.
8.  $D_{OUT}$  is the read data of next address.
9. If  $\overline{CE}$  is low during this period, IO pins are in the output state. Then the data input signals of opposite phase to the outputs must not be applied to them.
10. Transition is measured  $\pm 500\text{mV}$  from steady state with  $C_L = 5\text{pF}$ .  
The parameter is guaranteed but not 100% tested.
11.  $t_{CW}$  is measured from the later of  $\overline{CE}$  going low to the end of write.



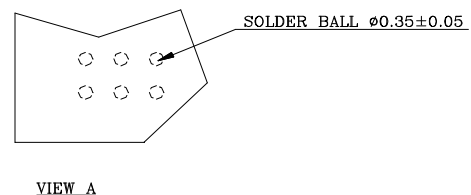
**n ORDERING INFORMATION**

**Note:**

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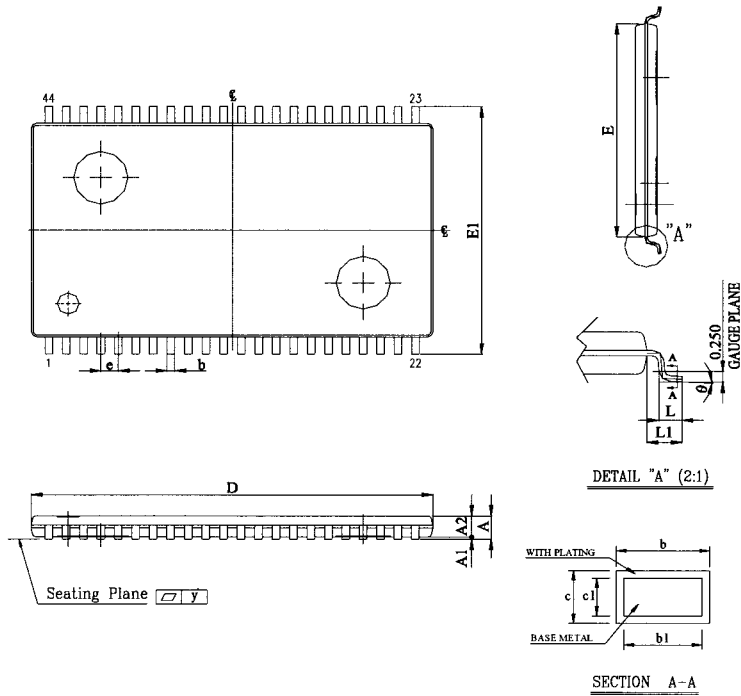
**n PACKAGE DIMENSIONS**

**NOTES**

- 1: CONTROLLING DIMENSIONS ARE IN MILLIMETERS.
- 2: PIN#1 DOT MARKING BY LASER OR PAD PRINT.
- 3: SYMBOL "N" IS THE NUMBER OF SOLDER BALLS.

BALL PITCH e = 0.75				
D	E	N	D1	E1
8.0	6.0	48	5.25	3.75



**TOP VIEW**  
*48 mini-BGA (6 x 8mm)*

**n PACKAGE DIMENSIONS (continued)**


UNIT SYMBOL	INCH	MM
A	0.0433± 0.004	1.10± 0.10
A1	0.004± 0.002	0.10± 0.05
A2	0.039± 0.002	1.00± 0.05
b	0.012 ~ 0.018	0.30 ~ 0.45
b1	0.012 ~ 0.016	0.30 ~ 0.40
c	0.005 ~ 0.008	0.12 ~ 0.21
c1	0.005 ~ 0.006	0.12 ~ 0.16
D	0.725± 0.004	18.41± 0.10
E	0.400± 0.004	10.16± 0.10
E1	0.463± 0.008	11.76± 0.20
e	0.0315± 0.004	0.80± 0.10
L	0.0197± 0.004	0.50± 0.10
L1	0.0315± 0.004	0.80± 0.10
y	0.004 Max.	0.1 Max.
θ	0° ~ 8°	0° ~ 8°

*TSOP2-44*