

16Mb(1M x 16 bit) Low Power SRAM

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Document Title**1M x16 bit Super Low Power and Low Voltage Full CMOS Static RAM****Revision History**

| <u>Revision No.</u> | <u>History</u> | <u>Draft Date</u> | <u>Remark</u> |
|----------------------------|---------------------------------------|--------------------------|----------------------|
| 0.0 | Initial draft | November 14, 2003 | Preliminary |
| 1.0 | Finalize | March 31, 2005 | Final |
| 2.0 | Revised - Added Lead Free Products | May 11, 2005 | Final |

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1M x 16 bit Super Low Power and Low Voltage Full CMOS Static RAM

FEATURES

- Process Technology: Full CMOS
- Organization: 1M x16
- Power Supply Voltage: 2.7~3.3V
- Low Data Retention Voltage: 1.5V(Min)
- Three State Outputs
- Package Type: 48-FBGA - 6.00x7.00

GENERAL DESCRIPTION

The K6F1616U6C families are fabricated by SAMSUNG's advanced full CMOS process technology. The families support industrial operating temperature ranges. The families also support low data retention voltage for battery back-up operation with low data retention current.

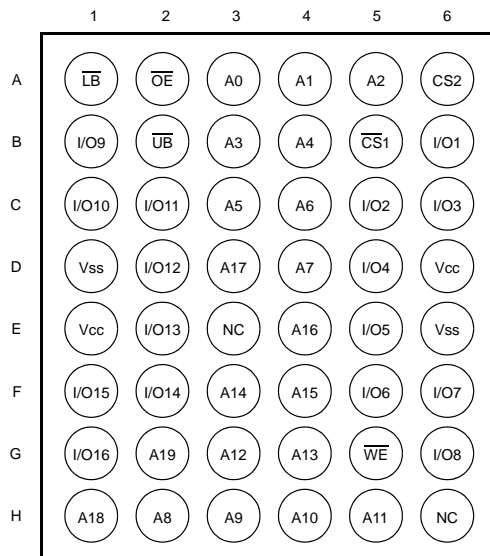
PRODUCT FAMILY

| Product Family | Operating Temperature | Vcc Range | Speed | Power Dissipation | | PKG Type |
|----------------|-----------------------|-----------|------------------------|-----------------------------------|------------------------------------|---------------------|
| | | | | Standby (I _{sb1} , Typ.) | Operating (I _{cc1} , Max) | |
| K6F1616U6C-F | Industrial(-40~85°C) | 2.7~3.3V | 55 ¹⁾ /70ns | 5μA ²⁾ | 5mA | 48-FBGA - 6.00x7.00 |

1. The parameter is measured with 30pF test load.

2. Typical value is measured at Vcc=3.0V, TA=25°C and not 100% tested.

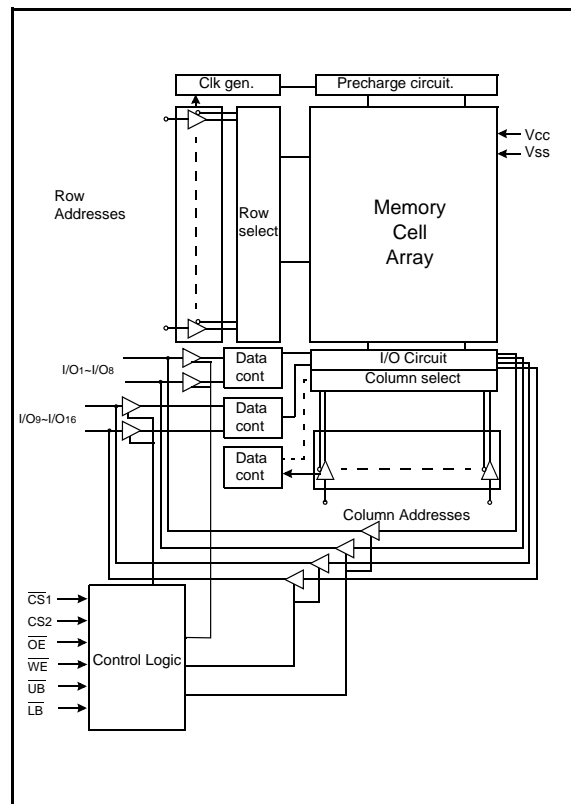
PIN DESCRIPTION



48-FBGA: Top View (Ball Down)

| Name | Function | Name | Function |
|------------|---------------------|------|---------------------|
| CS1, CS2 | Chip Select Inputs | Vcc | Power |
| OE | Output Enable Input | Vss | Ground |
| WE | Write Enable Input | UB | Upper Byte(I/O9~16) |
| A0~A19 | Address Inputs | LB | Lower Byte(I/O1~8) |
| I/O1~I/O16 | Data Inputs/Outputs | NC | No Connection |

FUNCTIONAL BLOCK DIAGRAM



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PRODUCT LIST

| Industrial Temperature Products(-40~85°C) | |
|---|---------------------------------------|
| Part Name | Function |
| K6F1616U6C-FF55 | 48-FBGA, 55ns, 3.0V |
| K6F1616U6C-XF55 | 48-FBGA, 55ns, 3.0V, LF ¹⁾ |
| K6F1616U6C-FF70 | 48-FBGA, 70ns, 3.0V |
| K6F1616U6C-XF70 | 48-FBGA, 70ns, 3.0V, LF ¹⁾ |

1. LF : Lead Free Product

FUNCTIONAL DESCRIPTION

| \overline{CS}_1 | CS_2 | \overline{OE} | \overline{WE} | \overline{LB} | \overline{UB} | I/O ₁₋₈ | I/O ₉₋₁₆ | Mode | Power |
|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|--------------------|---------------------|------------------|---------|
| H | X ¹⁾ | X ¹⁾ | X ¹⁾ | X ¹⁾ | X ¹⁾ | High-Z | High-Z | Deselected | Standby |
| X ¹⁾ | L | X ¹⁾ | X ¹⁾ | X ¹⁾ | X ¹⁾ | High-Z | High-Z | Deselected | Standby |
| X ¹⁾ | X ¹⁾ | X ¹⁾ | X ¹⁾ | H | H | High-Z | High-Z | Deselected | Standby |
| L | H | H | H | L | X ¹⁾ | High-Z | High-Z | Output Disabled | Active |
| L | H | H | H | X ¹⁾ | L | High-Z | High-Z | Output Disabled | Active |
| L | H | L | H | L | H | Dout | High-Z | Lower Byte Read | Active |
| L | H | L | H | H | L | High-Z | Dout | Upper Byte Read | Active |
| L | H | L | H | L | L | Dout | Dout | Word Read | Active |
| L | H | X ¹⁾ | L | L | H | Din | High-Z | Lower Byte Write | Active |
| L | H | X ¹⁾ | L | H | L | High-Z | Din | Upper Byte Write | Active |
| L | H | X ¹⁾ | L | L | L | Din | Din | Word Write | Active |

1. X means don't care. (Must be low or high state)

ABSOLUTE MAXIMUM RATINGS¹⁾

| Item | Symbol | Ratings | Unit |
|---------------------------------------|------------------------------------|--|------|
| Voltage on any pin relative to Vss | V _{IN} , V _{OUT} | -0.2 to V _{CC} +0.3V(Max. 3.6V) | V |
| Voltage on Vcc supply relative to Vss | V _{CC} | -0.2 to 3.6 | V |
| Power Dissipation | P _d | 1.0 | W |
| Storage temperature | T _{STG} | -65 to 150 | °C |
| Operating Temperature | T _A | -40 to 85 | °C |

1. Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Functional operation should be restricted to recommended operating condition. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

RECOMMENDED DC OPERATING CONDITIONS¹⁾

| Item | Symbol | Min | Typ | Max | Unit |
|--------------------|-----------------|--------------------|-----|------------------------------------|------|
| Supply voltage | V _{CC} | 2.7 | 3.0 | 3.3 | V |
| Ground | V _{SS} | 0 | 0 | 0 | V |
| Input high voltage | V _{IH} | 2.2 | - | V _{CC} +0.2 ²⁾ | V |
| Input low voltage | V _{IL} | -0.2 ³⁾ | - | 0.6 | V |

Note:

1. T_A=-40 to 85°C, otherwise specified
2. Overshoot: V_{CC}+2.0V in case of pulse width ≤20ns.
3. Undershoot: -2.0V in case of pulse width ≤20ns.
4. Overshoot and Undershoot are sampled, not 100% tested.

CAPACITANCE¹⁾ (f=1MHz, T_A=25°C)

| Item | Symbol | Test Condition | Min | Max | Unit |
|--------------------------|-----------------|---------------------|-----|-----|------|
| Input capacitance | C _{IN} | V _{IN} =0V | - | 8 | pF |
| Input/Output capacitance | C _{IO} | V _{IO} =0V | - | 10 | pF |

1. Capacitance is sampled, not 100% tested

DC AND OPERATING CHARACTERISTICS

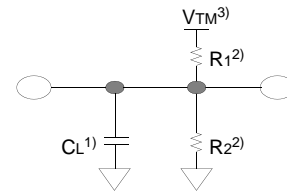
| Item | Symbol | Test Conditions | Min | Typ ¹⁾ | Max | Unit |
|---------------------------|------------------|---|--------------|-------------------|----------|------|
| Input leakage current | I _{LI} | V _{IN} =V _{SS} to V _{CC} | -1 | - | 1 | μA |
| Output leakage current | I _{LO} | $\overline{CS}_1=V_{IH}$ or $CS_2=V_{IL}$ or $\overline{OE}=V_{IH}$ or $\overline{WE}=V_{IL}$ or $\overline{LB}=\overline{UB}=V_{IH}$, V _{IO} =V _{SS} to V _{CC} | -1 | - | 1 | μA |
| Average operating current | I _{CC1} | Cycle time=1μs, 100%duty, I _{IO} =0mA, $\overline{CS}_1 \leq 0.2V$, $\overline{LB} \leq 0.2V$ or/and $\overline{UB} \leq 0.2V$, $CS_2 \geq V_{CC}-0.2V$, V _{IN} ≤0.2V or V _{IN} ≥V _{CC} -0.2V | - | - | 5 | mA |
| | I _{CC2} | Cycle time=Min, I _{IO} =0mA, 100% duty, $\overline{CS}_1=V_{IL}$, CS ₂ =V _{IH} , LB=V _{IL} or/and $\overline{UB}=V_{IL}$, V _{IN} =V _{IL} or V _{IH} | 70ns 55ns | - - | 25 30 | mA |
| Output low voltage | V _{OL} | I _{OL} = 2.1mA | - | - | 0.4 | V |
| Output high voltage | V _{OH} | I _{OH} = -1.0mA | 2.4 | - | - | V |
| Standby Current (CMOS) | I _{SB1} | Other input =0-V _{CC} 1) $\overline{CS}_1 \geq V_{CC}-0.2V$, $CS_2 \geq V_{CC}-0.2V$ (\overline{CS}_1 controlled) or 2) $0V \leq CS_2 \leq 0.2V$ (CS_2 controlled) | - | 5.0 | 25 | μA |

1. Typical values are measured at V_{CC}=3.0V, T_A=25°C and not 100% tested.

AC OPERATING CONDITIONS

TEST CONDITIONS (Test Load and Input/Output Reference)

Input pulse level: 0.2V to $V_{CC}-0.2V$
 Input rising and falling time: 5ns
 Input and output reference voltage: 1.5V
 Output load (see right): $C_L=100pF+1TTL$
 $C_L=30pF+1TTL$



1. Including scope and jig capacitance
2. $R_1=3070\Omega$, $R_2=3150\Omega$
3. $V_{TM}=2.8V$

AC CHARACTERISTICS ($V_{CC}=2.7\sim 3.3V$, $T_A=-40$ to $85^\circ C$)

| Parameter List | | Symbol | Speed Bins | | | | Units |
|--|--|------------------|------------|-----|------|-----|-------|
| | | | 55ns | | 70ns | | |
| | | | Min | Max | Min | Max | |
| Read | Read cycle time | t _{RC} | 55 | - | 70 | - | ns |
| | Address access time | t _{AA} | - | 55 | - | 70 | ns |
| | Chip select to output | t _{CO} | - | 55 | - | 70 | ns |
| | Output enable to valid output | t _{OE} | - | 25 | - | 35 | ns |
| | \overline{LB} , \overline{UB} valid to data output | t _{BA} | - | 55 | - | 70 | ns |
| | Chip select to low-Z output | t _{LZ} | 10 | - | 10 | - | ns |
| | Output enable to low-Z output | t _{OLZ} | 5 | - | 5 | - | ns |
| | \overline{LB} , \overline{UB} enable to low-Z output | t _{BLZ} | 10 | - | 10 | - | ns |
| | Output hold from address change | t _{OH} | 10 | - | 10 | - | ns |
| | Chip disable to high-Z output | t _{HZ} | 0 | 20 | 0 | 25 | ns |
| | \overline{OE} disable to high-Z output | t _{OHZ} | 0 | 20 | 0 | 25 | ns |
| \overline{UB} , \overline{LB} disable to high-Z output | t _{BHZ} | 0 | 20 | 0 | 25 | ns | |
| Write | Write cycle time | t _{WC} | 55 | - | 70 | - | ns |
| | Chip select to end of write | t _{CW} | 45 | - | 60 | - | ns |
| | Address set-up time | t _{AS} | 0 | - | 0 | - | ns |
| | Address valid to end of write | t _{AW} | 45 | - | 60 | - | ns |
| | Write pulse width | t _{WP} | 40 | - | 50 | - | ns |
| | Write recovery time | t _{WR} | 0 | - | 0 | - | ns |
| | Write to output high-Z | t _{WHZ} | 0 | 20 | 0 | 20 | ns |
| | Data to write time overlap | t _{DW} | 25 | - | 30 | - | ns |
| | Data hold from write time | t _{DH} | 0 | - | 0 | - | ns |
| | End write to output low-Z | t _{OW} | 5 | - | 5 | - | ns |
| | \overline{LB} , \overline{UB} valid to end of write | t _{BW} | 45 | - | 60 | - | ns |

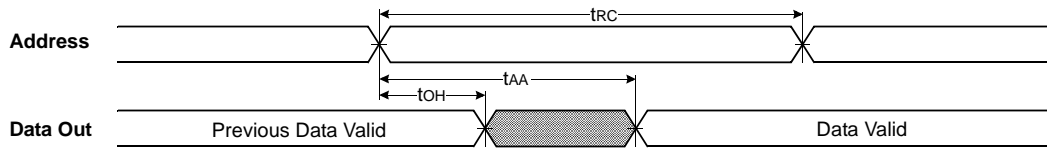
DATA RETENTION CHARACTERISTICS

| Item | Symbol | Test Condition | Min | Typ | Max | Unit |
|------------------------------------|------------------|---|-----------------|--------------------|-----|---------|
| V _{CC} for data retention | VDR | $\overline{CS}_1 \geq V_{CC}-0.2V^{(1)}$, $V_{IN} \geq 0V$ | 1.5 | - | 3.3 | V |
| Data retention current | IDR | $V_{CC}=1.5V$, $\overline{CS}_1 \geq V_{CC}-0.2V^{(1)}$, $V_{IN} \geq 0V$ | - | 1.0 ⁽²⁾ | 15 | μA |
| Data retention set-up time | t _{SDR} | See data retention waveform | 0 | - | - | ns |
| Recovery time | t _{RDR} | | t _{RC} | - | - | |

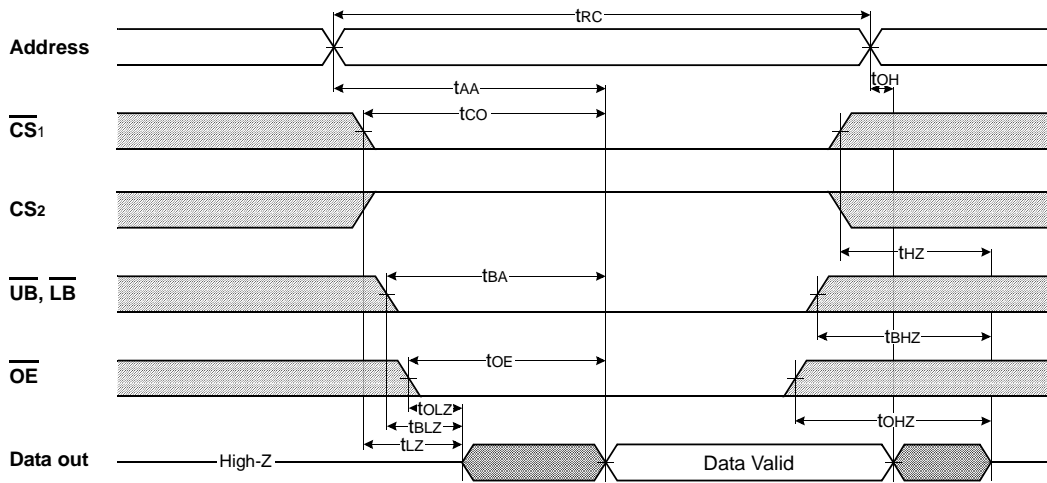
1. 1) $\overline{CS}_1 \geq V_{CC}-0.2V$, $CS_2 \geq V_{CC}-0.2V$ (\overline{CS}_1 controlled) or
 2) $0 \leq CS_2 \leq 0.2V$ (CS_2 controlled)
2. Typical value are measured at $T_A=25^\circ C$ and not 100% tested.

TIMING DIAGRAMS

TIMING WAVEFORM OF READ CYCLE(1) (Address Controlled, $\overline{CS1}=\overline{OE}=V_{IL}$, $CS2=\overline{WE}=V_{IH}$, \overline{UB} or/and $\overline{LB}=V_{IL}$)



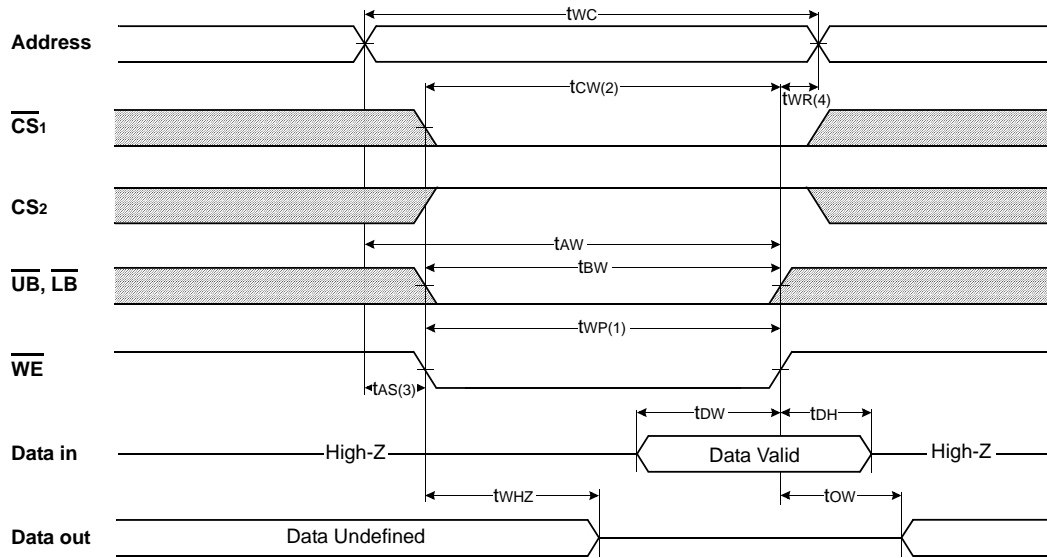
TIMING WAVEFORM OF READ CYCLE(2) ($\overline{WE}=V_{IH}$)



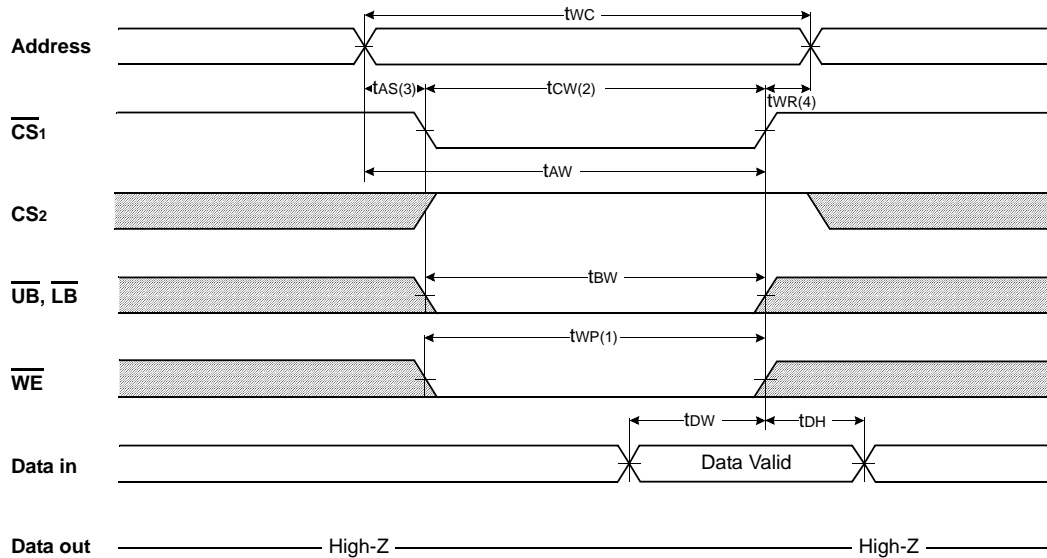
NOTES (READ CYCLE)

1. t_{HZ} and t_{OH} are defined as the time at which the outputs achieve the open circuit conditions and are not referenced to output voltage levels.
2. At any given temperature and voltage condition, $t_{HZ}(\text{Max.})$ is less than $t_{LZ}(\text{Min.})$ both for a given device and from device to device interconnection.

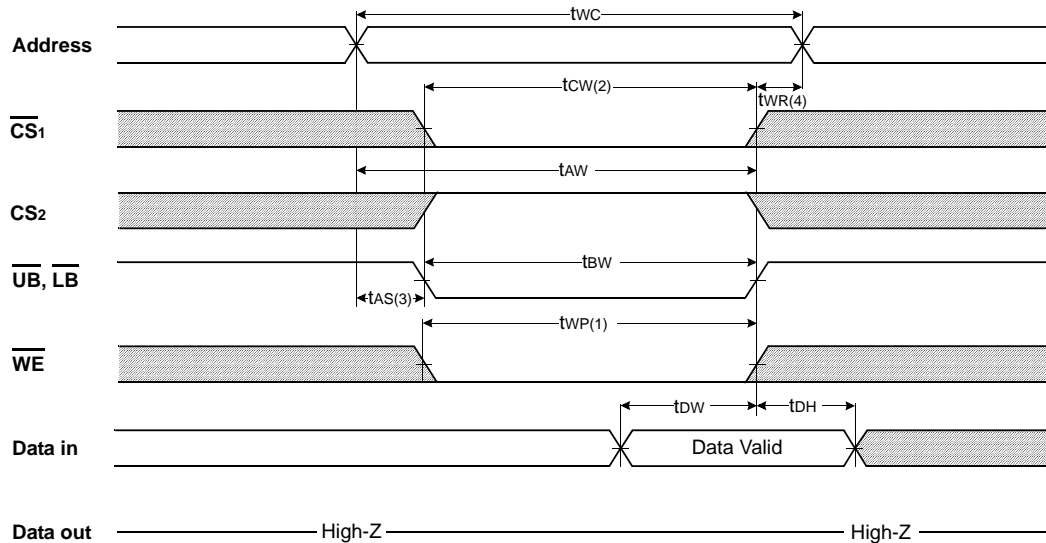
TIMING WAVEFORM OF WRITE CYCLE(1) (\overline{WE} Controlled)



TIMING WAVEFORM OF WRITE CYCLE(2) (\overline{CS}_1 Controlled)



TIMING WAVEFORM OF WRITE CYCLE(3) (\overline{UB} , \overline{LB} Controlled)

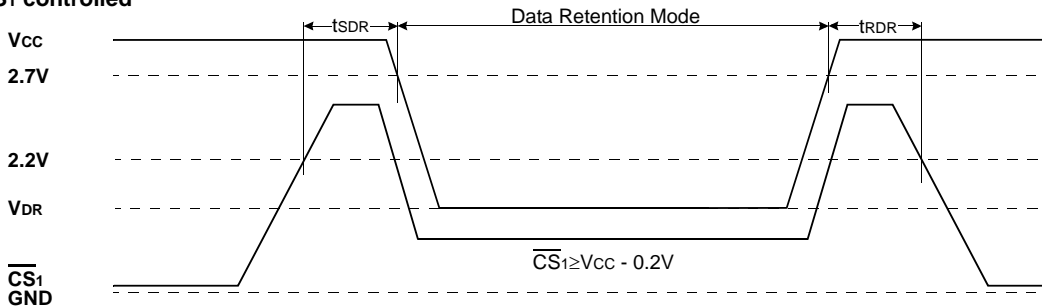


NOTES (WRITE CYCLE)

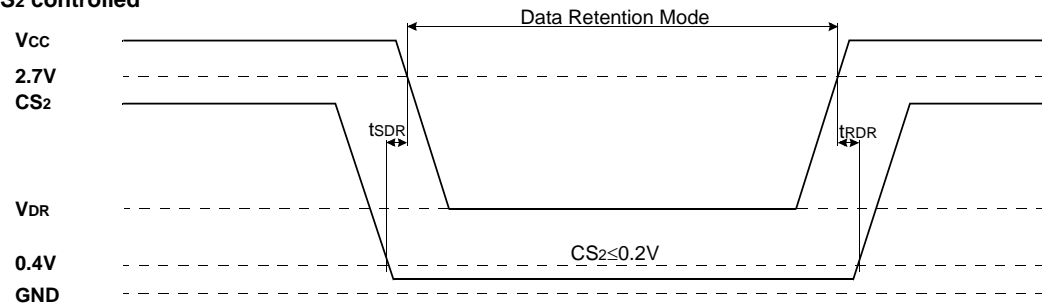
1. A write occurs during the overlap (t_{WP}) of low $\overline{CS1}$ and low \overline{WE} . A write begins when $\overline{CS1}$ goes low and \overline{WE} goes low with asserting \overline{UB} or \overline{LB} for single byte operation or simultaneously asserting \overline{UB} and \overline{LB} for double byte operation. A write ends at the earliest transition when $\overline{CS1}$ goes high and \overline{WE} goes high. The t_{WP} is measured from the beginning of write to the end of write.
2. t_{CW} is measured from the $\overline{CS1}$ going low to the end of write.
3. t_{AS} is measured from the address valid to the beginning of write.
4. t_{WR} is measured from the end of write to the address change. t_{WR} is applied in case a write ends with $\overline{CS1}$ or \overline{WE} going high.

DATA RETENTION WAVEFORM

$\overline{CS1}$ controlled



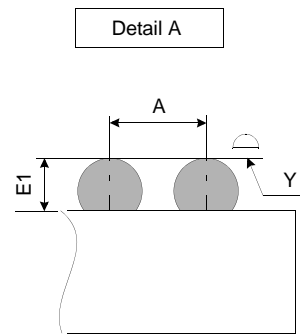
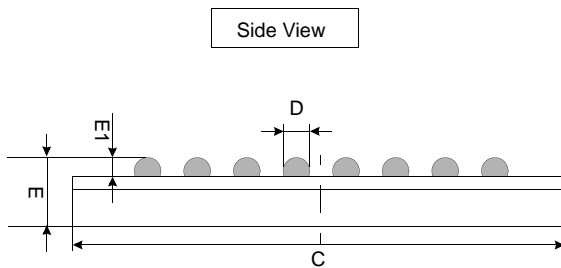
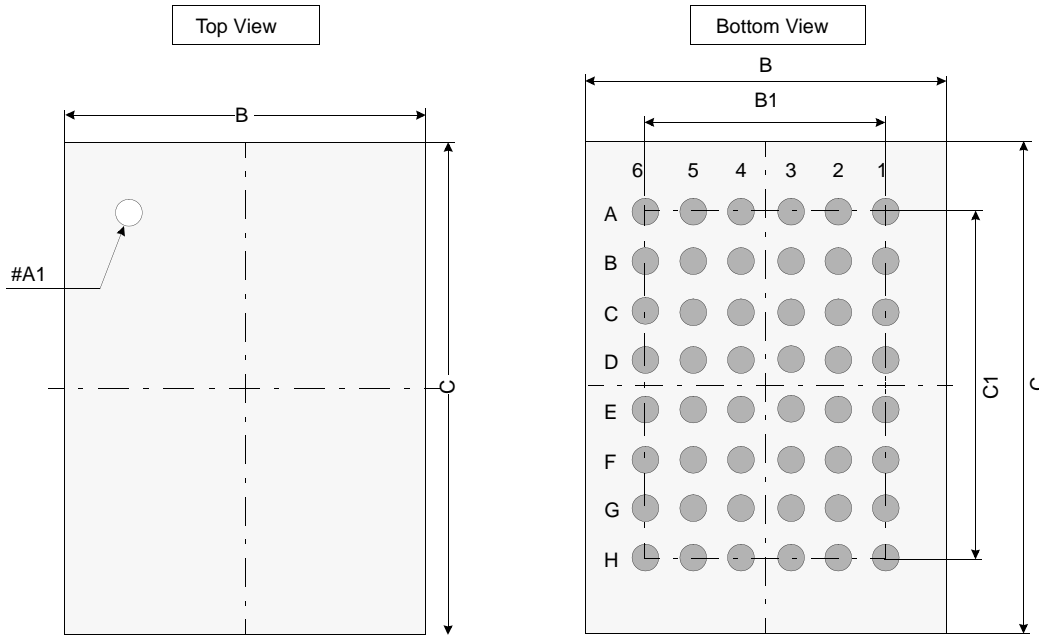
$CS2$ controlled



PACKAGE DIMENSION

Unit: millimeters

48 BALL FINE PITCH BGA(0.75mm ball pitch)



| | Min | Typ | Max |
|----|------|------|------|
| A | - | 0.75 | - |
| B | 5.90 | 6.00 | 6.10 |
| B1 | - | 3.75 | - |
| C | 6.90 | 7.00 | 7.10 |
| C1 | - | 5.25 | - |
| D | 0.40 | 0.45 | 0.50 |
| E | - | - | 1.00 |
| E1 | 0.25 | - | - |
| Y | - | - | 0.10 |

Notes.

1. Bump counts: 48(8 row x 6 column)
2. Bump pitch: (x,y)=(0.75 x 0.75)(typ.)
3. All tolerance are ± 0.050 unless specified beside figure.
4. Typ: Typical
5. Y is coplanarity: 0.10(Max)