## Document Title

**512K x16 bit Super Low Power and Low Voltage Full CMOS Static RAM**

## Revision History

| Revision No. | History | Draft Date | Remark |
|---|---|---|---|
| 0.0 | Initial draft | July 30, 2003 | Preliminary |

## *512K x 16 bit Super Low Power and Low Voltage Full CMOS Static RAM*

### FEATURES

- Process Technology: Full CMOS
- Organization: 512K x16
- Power Supply Voltage: 2.7~3.6V
- Low Data Retention Voltage: 1.5V(Min)
- Three State Outputs
- Package Type: 48-FBGA-6.00x7.00

### GENERAL DESCRIPTION

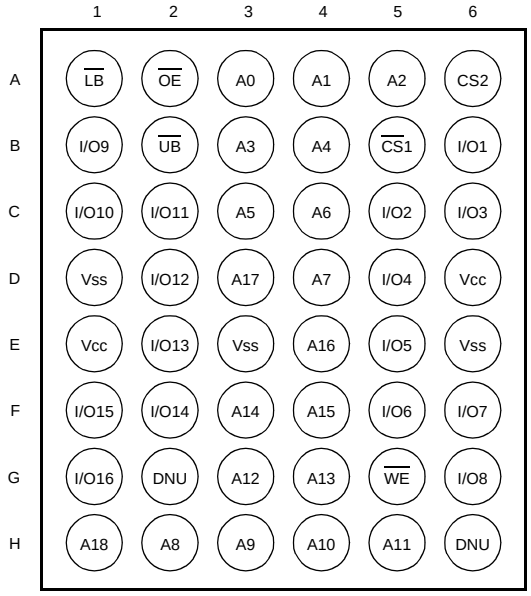
The K6F8016T6C families are fabricated by SAMSUNG′s advanced full CMOS process technology. The families support industrial operating temperature ranges and have chip scale package for user flexibility of system design. The families also support low data retention voltage for battery back-up operation 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) | |
| K6F8016T6C-F | Industrial(-40~85°C) | 2.7~3.6V | 55[1]/70ns | 4μA[2] | 4mA | 48-FBGA-6.00x7.00 |

1. The parameter is measured with 30pF test load.
2. Typical values are measured at $V_{CC}$=3.3V, TA=25°C and not 100% tested

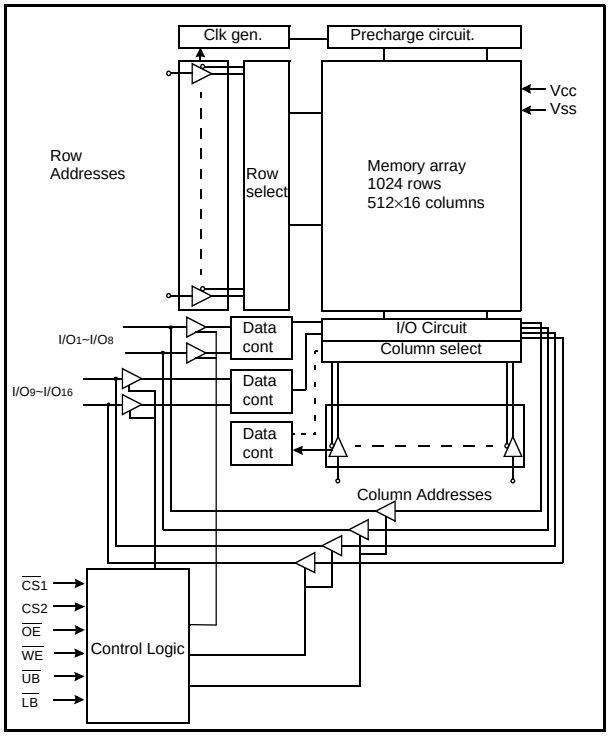
### PIN DESCRIPTION




**48 ball FBGA - Top View(Ball Down)**

| Name | Function | Name | Function |
|---|---|---|---|
| $\overline{CS_1}$, $CS_2$ | Chip Select Inputs | Vcc | Power |
| $\overline{OE}$ | Output Enable Input | Vss | Ground |
| $\overline{WE}$ | Write Enable Input | $\overline{UB}$ | Upper Byte($I/O_{9\sim16}$) |
| $A_0$~$A_{18}$ | Address Inputs | $\overline{LB}$ | Lower Byte($I/O_{1\sim8}$) |
| $I/O_1$~$I/O_{16}$ | Data Inputs/Outputs | DNU | Do Not Use |

### FUNCTIONAL BLOCK DIAGRAM



## PRODUCT LIST

| Industrial Temperature Products(-40~85°C) | |
|---|---|
| **Part Name** | **Function** |
| K6F8016T6C-FF55<br>K6F8016T6C-FF70 | 48-FBGA, 55ns, 3.0V/3.3V<br>48-FBGA, 70ns, 3.0V/3.3V |

## FUNCTIONAL DESCRIPTION

| $\overline{CS_1}$ | $CS_2$ | $\overline{OE}$ | $\overline{WE}$ | $\overline{LB}$ | $\overline{UB}$ | $I/O_{1\sim8}$ | $I/O_{9\sim16}$ | 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 RATINGS[1]

| Item | Symbol | Ratings | Unit |
|---|---|---|---|
| Voltage on any pin relative to Vss | $V_{IN}$, $V_{OUT}$ | -0.3 to $V_{CC}$+0.3V(Max. 4.2V) | V |
| Voltage on Vcc supply relative to Vss | $V_{CC}$ | -0.3 to 4.2 | 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 be used under recommended operating condition. Exposure to absolute maximum rating conditions over 1 second may affect reliability.

## RECOMMENDED DC OPERATING CONDITIONS[1)]

| Item | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Supply voltage | Vcc | 2.7 | 3.0/3.3 | 3.6 | V |
| Ground | Vss | 0 | 0 | 0 | V |
| Input high voltage | $V_{IH}$ | 2.2 | - | Vcc+0.3[2)] | V |
| Input low voltage | $V_{IL}$ | -0.3[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.

## CAPACITANCE[1)] (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 CHARACTERISTIC

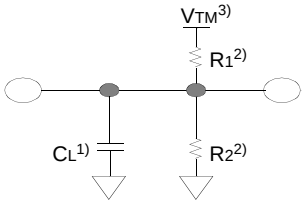
| Item | Symbol | Test Conditions | | Min | Typ[1)] | Max | Unit |
|---|---|---|---|---|---|---|---|
| Input leakage current | $I_{LI}$ | $V_{IN}$=Vss to Vcc | | -1 | - | 1 | µA |
| Output leakage current | $I_{LO}$ | $\overline{CS_1}$=$V_{IH}$ or $CS_2$=$V_{IL}$ or $\overline{OE}$=$V_{IH}$ or $\overline{WE}$=$V_{IL}$ or $\overline{LB}$=$\overline{UB}$=$V_{IH}$, $V_{IO}$=Vss to Vcc | | -1 | - | 1 | µA |
| Average operating current | $I_{CC1}$ | Cycle time=1µs, 100%duty, $I_{IO}$=0mA, $\overline{CS_1}$≤0.2V, $\overline{LB}$≤0.2V or/and $\overline{UB}$≤0.2V, $CS_2$≥Vcc-0.2V, $V_{IN}$≤0.2V or $V_{IN}$≥Vcc-0.2V | | - | - | 4 | mA |
| | $I_{CC2}$ | Cycle time=Min, $I_{IO}$=0mA, 100% duty, $\overline{CS_1}$=$V_{IL}$, $CS_2$=$V_{IH}$, $\overline{LB}$=$V_{IL}$ or/and $\overline{UB}$=$V_{IL}$, $V_{IN}$=$V_{IL}$ or $V_{IH}$ | 70ns | - | - | 22 | mA |
| | | | 55ns | - | - | 28 | |
| 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~Vcc<br>1) $\overline{CS_1}$≥Vcc-0.2V, $CS_2$≥Vcc-0.2V($\overline{CS_1}$ controlled) or<br>2) 0V≤$CS_2$≤0.2V($CS_2$ controlled) | | - | 4 | 15 | µA |

1. Typical values are measured at $V_{CC}$=3.3V, $T_A$=25°C and not 100% tested.

## AC OPERATING CONDITIONS

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

Input pulse level: 0.4 to 2.2V
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. $R_1$=3070Ω, $R_2$=3150Ω
3. $V_{TM}$=2.8V

## AC CHARACTERISTICS ($V_{CC}$=2.7~3.3V, Industrial product: $T_A$=-40 to 85°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 |
| | $\overline{UB}$, $\overline{LB}$ Access Time | $t_{BA}$ | - | 55 | - | 70 | ns |
| | Chip Select to Low-Z Output | $t_{LZ}$ | 10 | - | 10 | - | ns |
| | $\overline{UB}$, $\overline{LB}$ Enable to Low-Z Output | $t_{BLZ}$ | 10 | - | 10 | - | ns |
| | Output Enable to Low-Z Output | $t_{OLZ}$ | 5 | - | 5 | - | ns |
| | Chip Disable to High-Z Output | $t_{HZ}$ | 0 | 20 | 0 | 25 | ns |
| | $\overline{UB}$, $\overline{LB}$ Disable to High-Z Output | $t_{BHZ}$ | 0 | 20 | 0 | 25 | ns |
| | Output Disable to High-Z Output | $t_{OHZ}$ | 0 | 20 | 0 | 25 | ns |
| | Output Hold from Address Change | $t_{OH}$ | 10 | - | 10 | - | 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 |
| | $\overline{UB}$, $\overline{LB}$ Valid to End of Write | $t_{BW}$ | 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 |

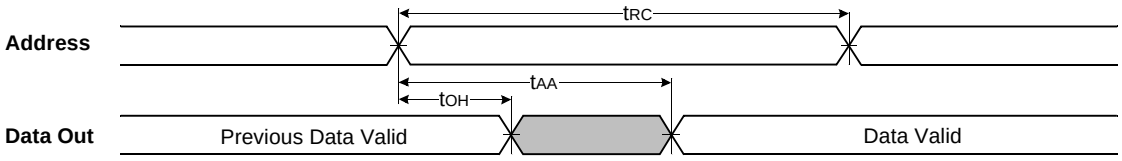
## DATA RETENTION CHARACTERISTICS

| Item | Symbol | Test Condition | Min | Typ2) | Max | Unit |
|---|---|---|---|---|---|---|
| Vcc for data retention | $V_{DR}$ | $\overline{CS_1}$≥Vcc-0.2V1) | 1.5 | - | 3.6 | V |
| Data retention current | $I_{DR}$ | Vcc=1.5V, $\overline{CS_1}$≥Vcc-0.2V1) | - | 1.0 | 6 | µA |
| Data retention set-up time | $t_{SDR}$ | See data retention waveform | 0 | - | - | ns |
| Recovery time | $t_{RDR}$ | | tRC | - | - | |

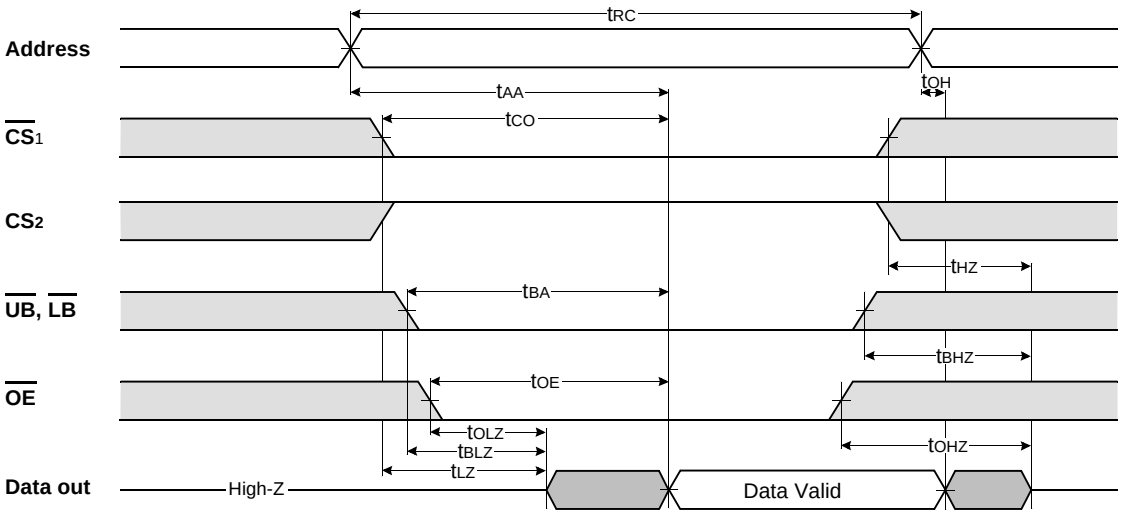
1. 1) $\overline{CS_1}$≥Vcc-0.2V, $CS_2$≥Vcc-0.2V($\overline{CS_1}$ controlled) or
   2) 0≤$CS_2$≤0.2V($CS_2$ controlled)
2. Typical values are measured at $T_A$=25°C and not 100% tested.

## TIMING DIAGRAMS

### TIMING WAVEFORM OF READ CYCLE(1) (Address Controlled, $\overline{CS_1}$=$\overline{OE}$=$V_{IL}$, $CS_2$=$\overline{WE}$=$V_{IH}$, $\overline{UB}$ or/and $\overline{LB}$=$V_{IL}$)



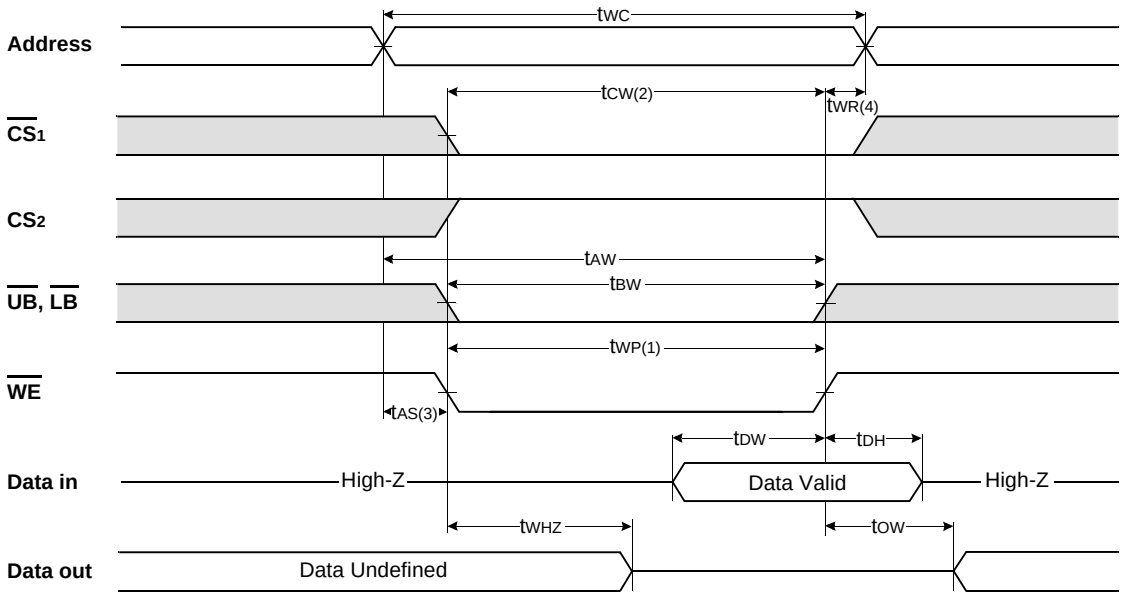

### TIMING WAVEFORM OF READ CYCLE(2) ($\overline{WE}$=$V_{IH}$)



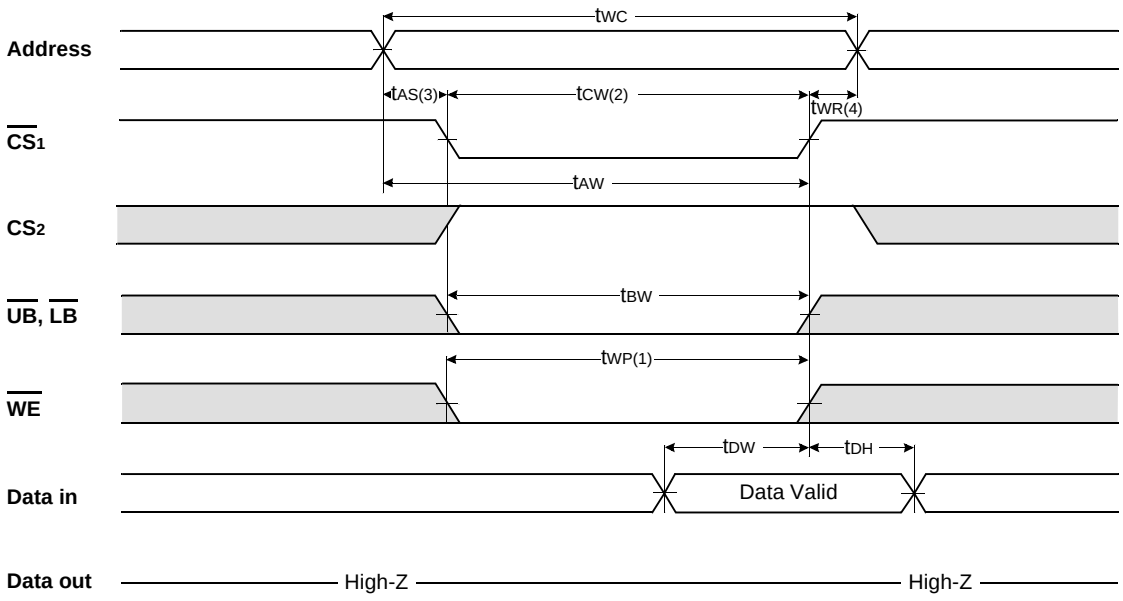

**NOTES (**READ CYCLE)

1. $t_{HZ}$ and $t_{OHZ}$ 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, $t_{HZ}$(Max.) is less than $t_{LZ}$(Min.) both for a given device and from device to device interconnection.

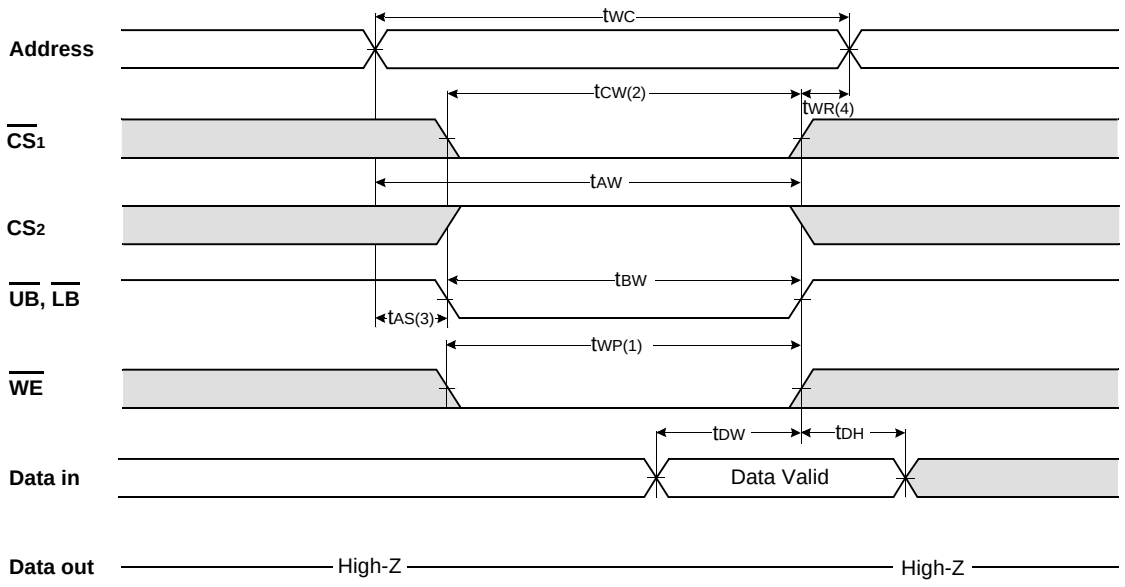
**TIMING WAVEFORM OF WRITE CYCLE(1)** ($\overline{WE}$ Controlled)




**TIMING WAVEFORM OF WRITE CYCLE(2)** ($\overline{CS_1}$ Controlled)



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

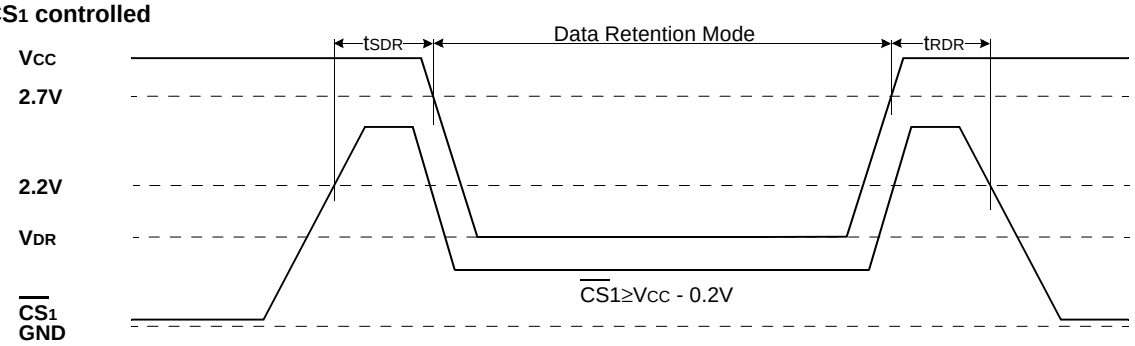



**NOTES** (WRITE CYCLE)

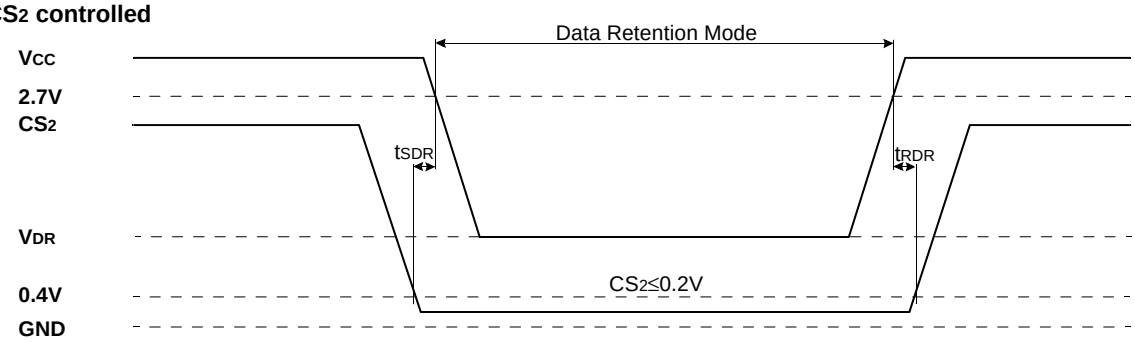
1. A write occurs during the overlap($t_{WP}$) of low $\overline{CS_1}$ and low $\overline{WE}$. A write begins when $\overline{CS_1}$ goes low and $\overline{WE}$ goes low with asserting UB or LB for single byte operation or simultaneously asserting UB and LB for double byte operation. A write ends at the earliest transition when $\overline{CS_1}$ 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 $\overline{CS_1}$ 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 $\overline{CS_1}$ or $\overline{WE}$ going high.

## DATA RETENTION WAVE FORM

**$\overline{CS_1}$ controlled**




**$CS_2$ controlled**

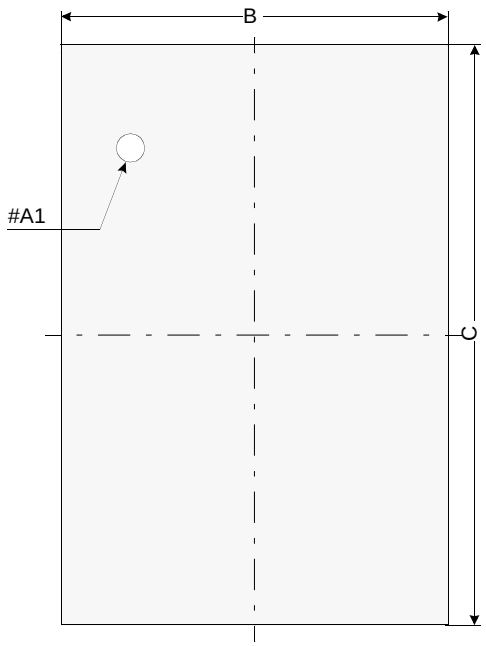


## PACKAGE DIMENSION

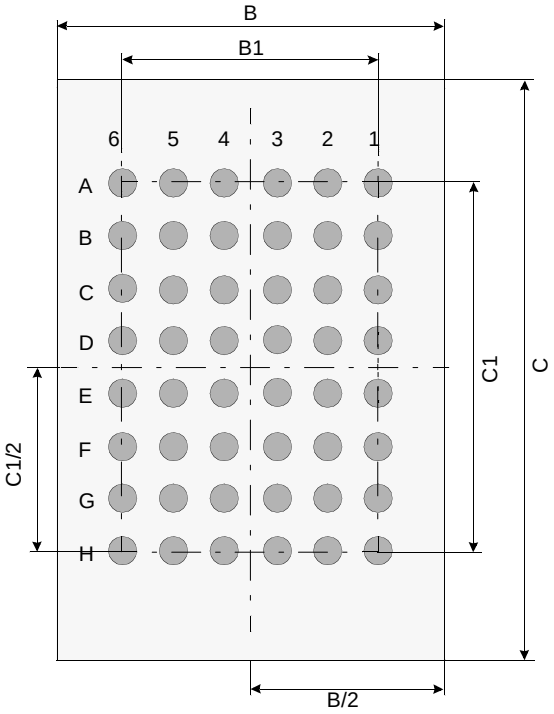
Unit: millimeters

**48 BALL FINE PITCH BALL GRID ARRAY(0.75mm ball pitch)**

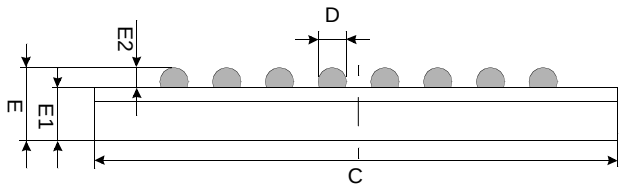
Top View



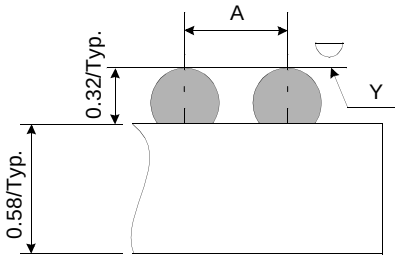

Bottom View




Side View




Detail A




| | 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 | 0.80 | 0.90 | 1.00 |
| E1 | - | 0.58 | - |
| E2 | 0.27 | 0.32 | 0.37 |
| Y | - | - | 0.08 |

Notes.

1. Ball counts: 48(8 row x 6 column)
2. Ball pitch: (x,y)=(0.75 x 0.75)(typ.)
3. All tolerence are ±0.050 unless specified beside figure.
4. Typ: Typical
5. Y is coplanarity: 0.08(Max)