

**Document Title****512K x8 bit Super Low Power and Low Voltage Full CMOS Static RAM****Revision History**

| <b><u>Revision No.</u></b> | <b><u>History</u></b> | <b><u>Draft Date</u></b> | <b><u>Remark</u></b> |
|----------------------------|-----------------------|--------------------------|----------------------|
| 0.0                        | Initial Draft         | October 25, 2000         | Preliminary          |
| 1.0                        | Finalize              | March 12, 2001           | Final                |

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## 512K x 8 bit Super Low Power and Low Voltage Full CMOS Static RAM

### FEATURES

- Process Technology: Full CMOS
- Organization: 512K x8 bit
- Power Supply Voltage: 2.7~3.3V
- Low Data Retention Voltage: 1.5V(Min)
- Three State Outputs
- Package Type: 48(36)-TBGA-6.00x7.00

### GENERAL DESCRIPTION

The K6F4008U2E families are fabricated by SAMSUNG's advanced full CMOS process technology. The families support industrial temperature range and Chip Scale Package for user flexibility of system design. The families also supports low data retention voltage for battery back-up operation with low data retention current.

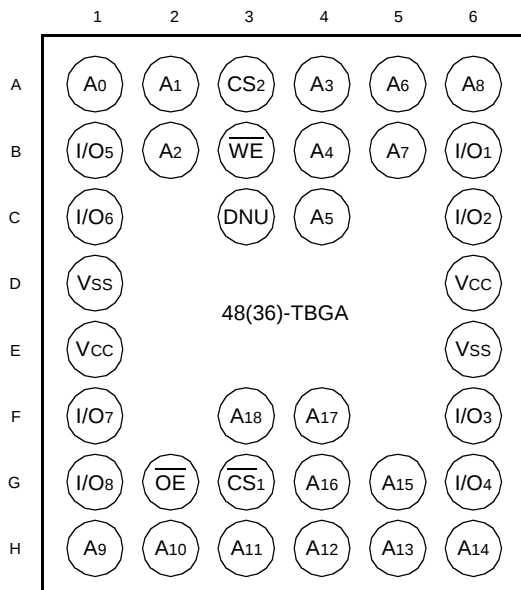
### PRODUCT FAMILY

| Product Family | Operating Temperature | Vcc Range | Speed                  | Power Dissipation    |                       | PKG Type              |
|----------------|-----------------------|-----------|------------------------|----------------------|-----------------------|-----------------------|
|                |                       |           |                        | Standby (Isb1, Typ.) | Operating (Icc1, Max) |                       |
| K6F4008U2E-F   | Industrial(-40~85°C)  | 2.7~3.3V  | 55 <sup>1)</sup> /70ns | 1.0μA <sup>2)</sup>  | 2mA                   | 48(36)-TBGA-6.00x7.00 |

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

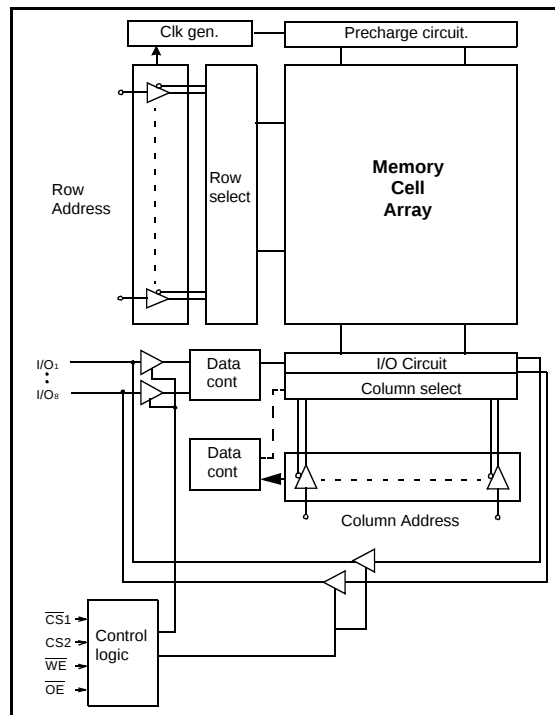
2. Typical value are at Vcc=3.0V, TA=25°C and not 100% tested.

### PIN DESCRIPTION



| Name     | Function            | Name      | Function            |
|----------|---------------------|-----------|---------------------|
| CS1, CS2 | Chip Select Inputs  | I/O1~I/O8 | Data Inputs/Outputs |
| OE       | Output Enable Input | Vcc       | Power               |
| WE       | Write Enable Input  | Vss       | Ground              |
| A0~A18   | Address Inputs      | DNU       | Do Not Use          |

### FUNCTIONAL BLOCK DIAGRAM



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## PRODUCT LIST

| Industrial Temperature Products(-40~85°C) |                                                    |
|-------------------------------------------|----------------------------------------------------|
| Part Name                                 | Function                                           |
| K6F4008U2E-EF55<br>K6F4008U2E-EF70        | 48(36)-TBGA, 55ns, 3.0V<br>48(36)-TBGA, 70ns, 3.0V |

## FUNCTIONAL DESCRIPTION

| CS <sub>1</sub> | CS <sub>2</sub> | OE              | WE              | I/O    | Mode            | Power   |
|-----------------|-----------------|-----------------|-----------------|--------|-----------------|---------|
| H               | X <sup>1)</sup> | X <sup>1)</sup> | X <sup>1)</sup> | High-Z | Deselected      | Standby |
| X <sup>1)</sup> | L               | X <sup>1)</sup> | X <sup>1)</sup> | High-Z | Deselected      | Standby |
| L               | H               | H               | H               | High-Z | Output Disabled | Active  |
| L               | H               | L               | H               | Dout   | Read            | Active  |
| L               | H               | X <sup>1)</sup> | L               | Din    | Write           | Active  |

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

ABSOLUTE MAXIMUM RATINGS<sup>1)</sup>

| Item                                                          | Symbol                             | Ratings                                  | Unit |
|---------------------------------------------------------------|------------------------------------|------------------------------------------|------|
| Voltage on any pin relative to V <sub>ss</sub>                | V <sub>IN</sub> , V <sub>OUT</sub> | -0.5 to V <sub>CC</sub> +0.3V(Max. 3.6V) | V    |
| Voltage on V <sub>CC</sub> supply relative to V <sub>ss</sub> | V <sub>CC</sub>                    | -0.3 to 3.6                              | V    |
| Power Dissipation                                             | P <sub>D</sub>                     | 1.0                                      | W    |
| Storage temperature                                           | T <sub>STG</sub>                   | -65 to 150                               | °C   |
| Operating Temperature                                         | T <sub>A</sub>                     | -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 CONDITIONS<sup>1)</sup>

| Item               | Symbol          | Min                | Typ | Max                                | Unit |
|--------------------|-----------------|--------------------|-----|------------------------------------|------|
| Supply voltage     | V <sub>CC</sub> | 2.7                | 3.0 | 3.3                                | V    |
| Ground             | V <sub>SS</sub> | 0                  | 0   | 0                                  | V    |
| Input high voltage | V <sub>IH</sub> | 2.2                | -   | V <sub>CC</sub> +0.3 <sup>2)</sup> | V    |
| Input low voltage  | V <sub>IL</sub> | -0.3 <sup>3)</sup> | -   | 0.6                                | V    |

Note:

1. T<sub>A</sub>= -40 to 85°C, otherwise specified.
2. Overshoot: V<sub>CC</sub>+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<sup>1)</sup> (f=1MHz, T<sub>A</sub>=25°C)

| Item                     | Symbol          | Test Condition      | Min | Max | Unit |
|--------------------------|-----------------|---------------------|-----|-----|------|
| Input capacitance        | C <sub>IN</sub> | V <sub>IN</sub> =0V | -   | 8   | pF   |
| Input/Output capacitance | C <sub>IO</sub> | V <sub>IO</sub> =0V | -   | 10  | pF   |

1. Capacitance is sampled, not 100% tested.

## DC AND OPERATING CHARACTERISTICS

| Item                      | Symbol           | Test Conditions                                                                                                                                                                                         |      | Min | Typ <sup>1)</sup> | Max | Unit |
|---------------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----|-------------------|-----|------|
| Input leakage current     | I <sub>LI</sub>  | V <sub>IN</sub> =V <sub>SS</sub> to V <sub>CC</sub>                                                                                                                                                     |      | -1  | -                 | 1   | μA   |
| Output leakage current    | I <sub>LO</sub>  | $\overline{CS}_1$ =V <sub>IH</sub> , CS <sub>2</sub> =V <sub>IL</sub> or $\overline{OE}$ =V <sub>IH</sub> or $\overline{WE}$ =V <sub>IL</sub> , V <sub>IO</sub> =V <sub>SS</sub> to V <sub>CC</sub>     |      | -1  | -                 | 1   | μA   |
| Average operating current | I <sub>CC1</sub> | Cycle time=1μs, 100%duty, I <sub>IO</sub> =0mA, $\overline{CS}_1$ ≤0.2V, CS <sub>2</sub> ≥V <sub>CC</sub> -0.2V, V <sub>IN</sub> ≤0.2V or V <sub>IN</sub> ≥V <sub>CC</sub> -0.2V                        |      | -   | -                 | 2   | mA   |
|                           | I <sub>CC2</sub> | Cycle time=Min, I <sub>IO</sub> =0mA, 100% duty, $\overline{CS}_1$ =V <sub>IL</sub> , CS <sub>2</sub> =V <sub>IH</sub> , V <sub>IN</sub> =V <sub>IL</sub> or V <sub>IH</sub>                            | 70ns | -   | -                 | 15  | mA   |
|                           |                  |                                                                                                                                                                                                         | 55ns | -   | -                 | 20  |      |
| Output low voltage        | V <sub>OL</sub>  | I <sub>OL</sub> = 2.1mA                                                                                                                                                                                 |      | -   | -                 | 0.4 | V    |
| Output high voltage       | V <sub>OH</sub>  | I <sub>OH</sub> = -1.0mA                                                                                                                                                                                |      | 2.4 | -                 | -   | V    |
| Standby Current (CMOS)    | I <sub>SB1</sub> | $\overline{CS}_1$ ≥V <sub>CC</sub> -0.2V, CS <sub>2</sub> ≥V <sub>CC</sub> -0.2V( $\overline{CS}_1$ controlled) or 0V≤CS <sub>2</sub> ≤0.2V(CS <sub>2</sub> controlled), Other inputs=0-V <sub>CC</sub> |      | -   | 1                 | 12  | μA   |

1. Typical value are measured at V<sub>CC</sub>=3.0V, T<sub>A</sub>=25°C, and not 100% tested.

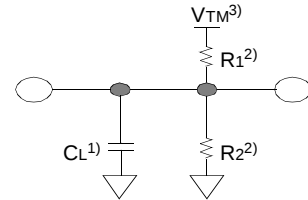
## AC OPERATING CONDITIONS

## TEST CONDITIONS (Test Load and Test 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):  $C_L = 100\text{pF} + 1\text{TTL}$  $C_L = 30\text{pF} + 1\text{TTL}$ 

1. Including scope and jig capacitance

2.  $R_1 = 3070\Omega$ ,  $R_2 = 3150\Omega$ 3.  $V_{TM} = 2.8\text{V}$ AC CHARACTERISTICS ( $V_{CC} = 2.7 \sim 3.3\text{V}$ , Industrial product:  $T_A = -40$  to  $85^\circ\text{C}$ )

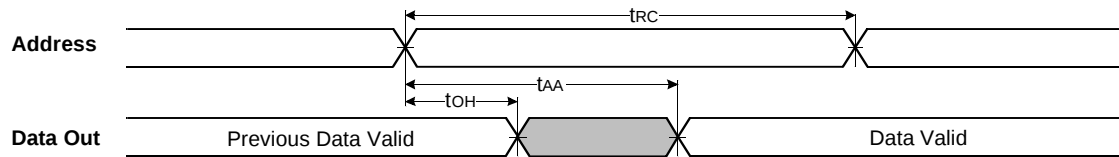
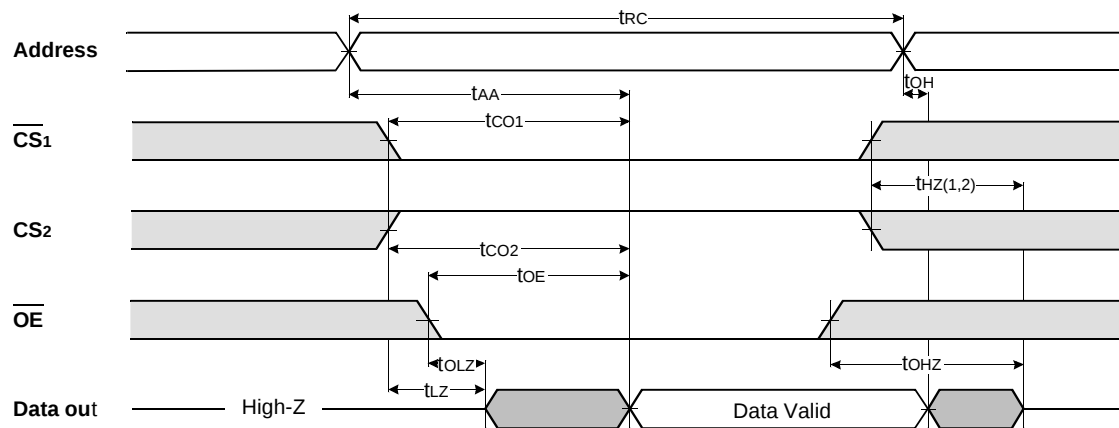
| Parameter List |                                 | Symbol           | Speed Bins |     |      |     | Units |
|----------------|---------------------------------|------------------|------------|-----|------|-----|-------|
|                |                                 |                  | 55ns       |     | 70ns |     |       |
|                |                                 |                  | Min        | Max | Min  | Max |       |
| Read           | Read Cycle Time                 | t <sub>RC</sub>  | 55         | -   | 70   | -   | ns    |
|                | Address Access Time             | t <sub>AA</sub>  | -          | 55  | -    | 70  | ns    |
|                | Chip Select to Output           | t <sub>CO</sub>  | -          | 55  | -    | 70  | ns    |
|                | Output Enable to Valid Output   | t <sub>OE</sub>  | -          | 25  | -    | 35  | ns    |
|                | Chip Select to Low-Z Output     | t <sub>LZ</sub>  | 10         | -   | 10   | -   | ns    |
|                | Output Enable to Low-Z Output   | t <sub>OLZ</sub> | 5          | -   | 5    | -   | ns    |
|                | Chip Disable to High-Z Output   | t <sub>HZ</sub>  | 0          | 20  | 0    | 25  | ns    |
|                | Output Disable to High-Z Output | t <sub>OHZ</sub> | 0          | 20  | 0    | 25  | ns    |
|                | Output Hold from Address Change | t <sub>OH</sub>  | 10         | -   | 10   | -   | ns    |
| Write          | Write Cycle Time                | t <sub>WC</sub>  | 55         | -   | 70   | -   | ns    |
|                | Chip Select to End of Write     | t <sub>CW</sub>  | 45         | -   | 60   | -   | ns    |
|                | Address Set-up Time             | t <sub>AS</sub>  | 0          | -   | 0    | -   | ns    |
|                | Address Valid to End of Write   | t <sub>AW</sub>  | 45         | -   | 60   | -   | ns    |
|                | Write Pulse Width               | t <sub>WP</sub>  | 40         | -   | 50   | -   | ns    |
|                | Write Recovery Time             | t <sub>WR</sub>  | 0          | -   | 0    | -   | ns    |
|                | Write to Output High-Z          | t <sub>WHZ</sub> | 0          | 20  | 0    | 20  | ns    |
|                | Data to Write Time Overlap      | t <sub>DW</sub>  | 25         | -   | 30   | -   | ns    |
|                | Data Hold from Write Time       | t <sub>DH</sub>  | 0          | -   | 0    | -   | ns    |
|                | End Write to Output Low-Z       | t <sub>OW</sub>  | 5          | -   | 5    | -   | ns    |

## DATA RETENTION CHARACTERISTICS

| Item                               | Symbol           | Test Condition                                                                                       | Min             | Typ                | Max | Unit          |
|------------------------------------|------------------|------------------------------------------------------------------------------------------------------|-----------------|--------------------|-----|---------------|
| V <sub>CC</sub> for data retention | V <sub>DR</sub>  | $\overline{CS}_1 \geq V_{CC} - 0.2\text{V}^{(1)}$                                                    | 1.5             | -                  | 3.3 | V             |
| Data retention current             | I <sub>DR</sub>  | $V_{CC} = 1.5\text{V}$ , $\overline{CS}_1 \geq V_{CC} - 0.2\text{V}^{(1)}$ , $V_{IN} \geq 0\text{V}$ | -               | 0.5 <sup>(2)</sup> | 3   | $\mu\text{A}$ |
| Data retention set-up time         | t <sub>SDR</sub> | See data retention waveform                                                                          | 0               | -                  | -   | ns            |
| Recovery time                      | t <sub>RDR</sub> |                                                                                                      | t <sub>RC</sub> | -                  | -   |               |

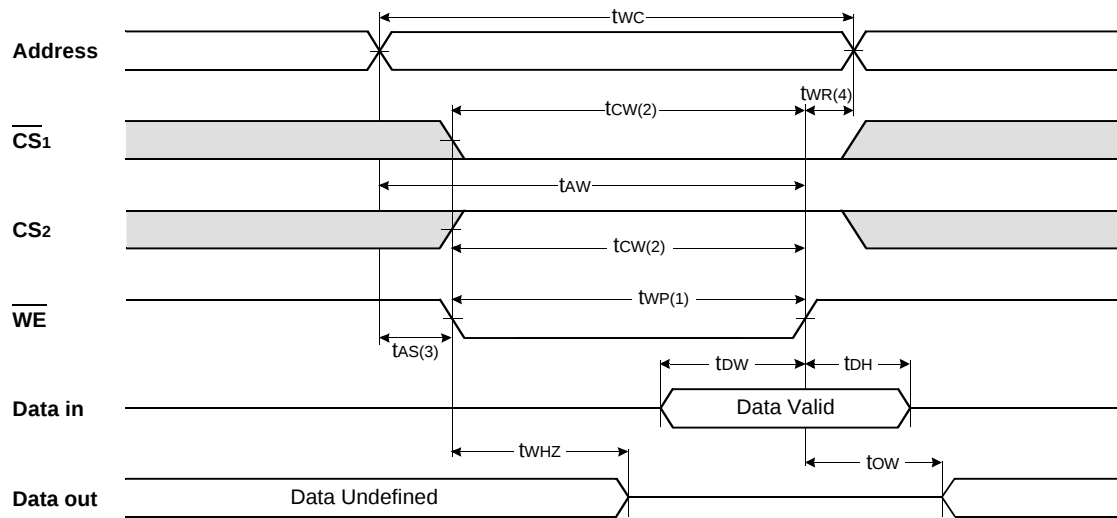
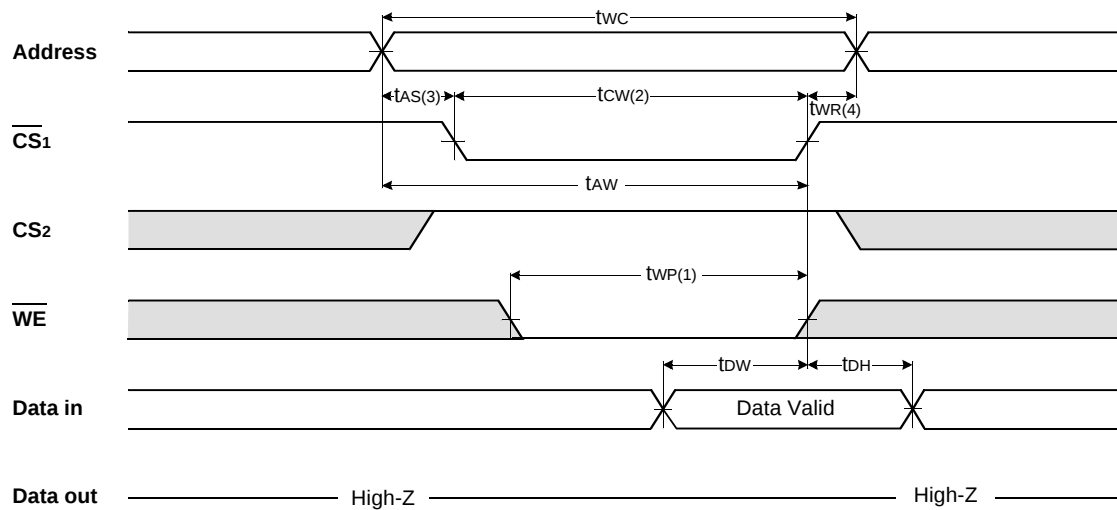
1.  $\overline{CS}_1 \geq V_{CC} - 0.2\text{V}$ ,  $\overline{CS}_2 \geq V_{CC} - 0.2\text{V}$  ( $\overline{CS}_1$  controlled) or  $0 \leq \overline{CS}_2 \leq 0.2\text{V}$  ( $\overline{CS}_2$  controlled).2. Typical value are measured at  $T_A = 25^\circ\text{C}$  and not 100% tested.

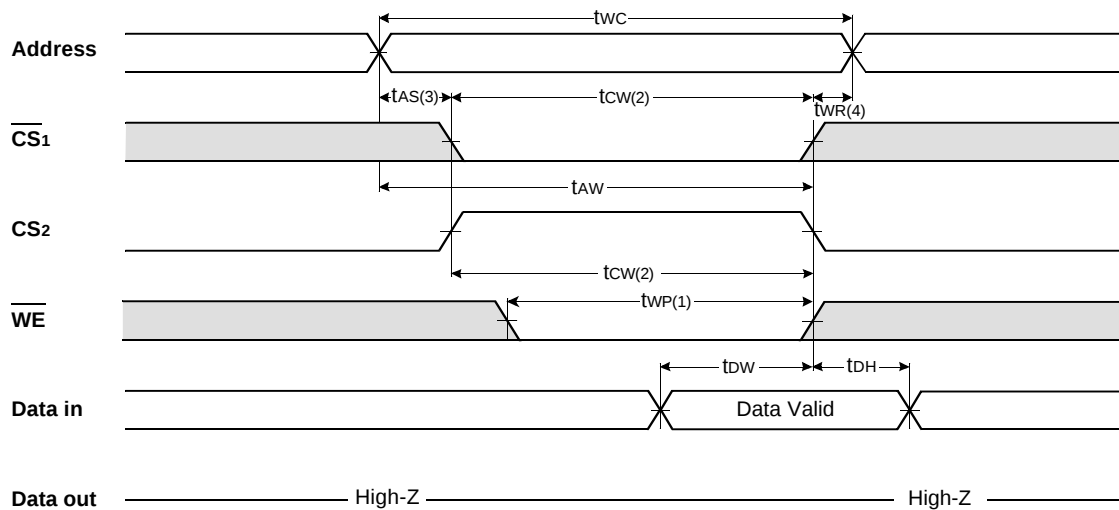
## TIMING DIAGRAMS

TIMING WAVEFORM OF READ CYCLE(1) (Address Controlled,  $\overline{CS_1}=\overline{OE}=V_{IL}$ ,  $CS_2=\overline{WE}=V_{IH}$ )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,  $t_{HZ}(\text{Max.})$  is less than  $t_{LZ}(\text{Min.})$  both for a given device and from device to device interconnection.

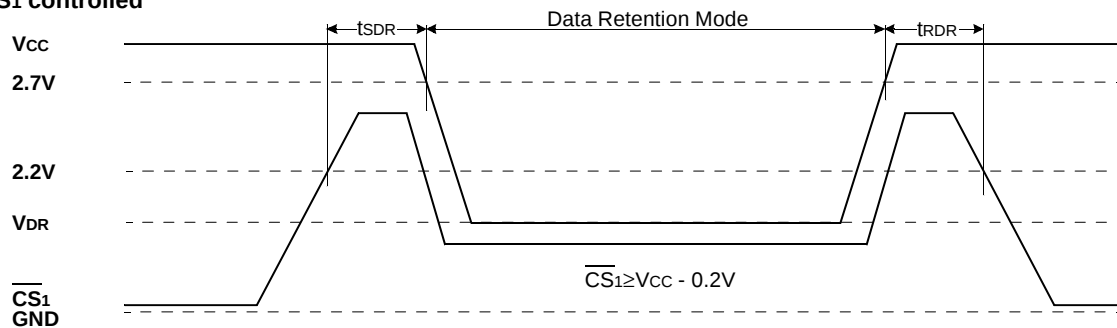
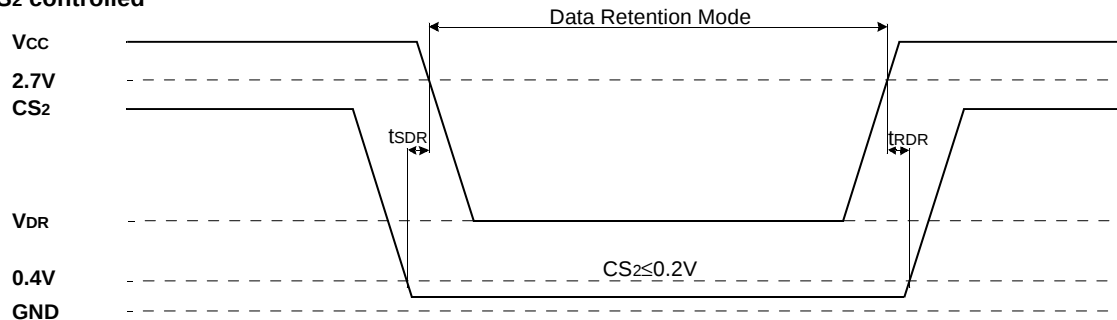
TIMING WAVEFORM OF WRITE CYCLE(1) ( $\overline{WE}$  Controlled)TIMING WAVEFORM OF WRITE CYCLE(2) ( $\overline{CS1}$  Controlled)

TIMING WAVEFORM OF WRITE CYCLE(3) (CS<sub>2</sub> Controlled)

## NOTES (WRITE CYCLE)

1. A write occurs during the overlap of a low  $\overline{CS_1}$ , a high  $CS_2$  and a low  $\overline{WE}$ . A write begins at the latest transition among  $\overline{CS_1}$  goes low,  $CS_2$  going high and  $\overline{WE}$  going low: A write ends at the earliest transition among  $CS_1$  going high,  $CS_2$  going low and  $\overline{WE}$  going high,  $t_{WP}$  is measured from the beginning of write to the end of write.
2.  $t_{CW}$  is measured from the  $CS_1$  going low or  $CS_2$  going high 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.  $t_{WR1}$  applied in case a write ends as  $\overline{CS_1}$  or  $\overline{WE}$  going high  $t_{WR2}$  applied in case a write ends as  $CS_2$  going to low.

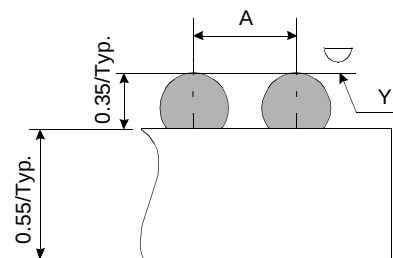
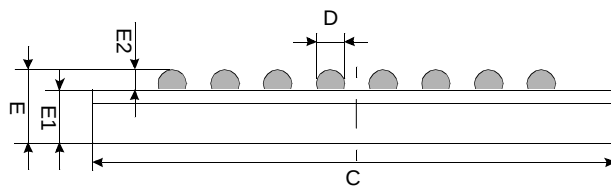
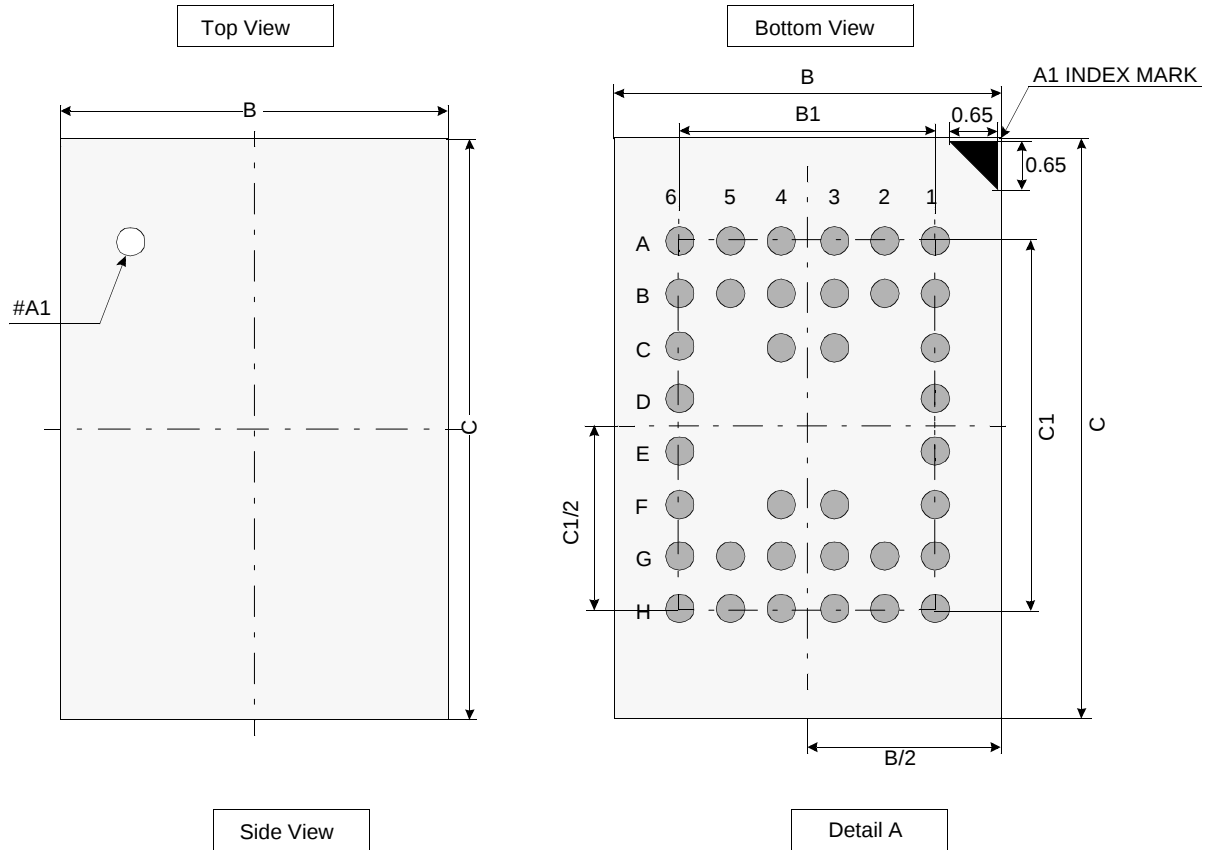
## DATA RETENTION WAVE FORM

CS<sub>1</sub> controlledCS<sub>2</sub> controlled

## PACKAGE DIMENSIONS

Units: millimeters

48(36) TAPE BALL GRID ARRAY(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  | 0.80 | 0.90 | 1.00 |
| E1 | -    | 0.55 | -    |
| E2 | 0.30 | 0.35 | 0.40 |
| Y  | -    | -    | 0.08 |

### 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 otherwise specified.
4. Typ: Typical
5. Y is coplanarity: 0.08(Max)