

Document Title**2Mx16 bit Uni-Transistor Random Access Memory**Revision History

<u>Revision No.</u>	<u>History</u>	<u>Draft Date</u>	<u>Remark</u>
0.0	Initial Draft - Design target	September 4, 2000	Advance
0.1	Revised - Change package type from FBGA to TBGA. - Improve operating current from 30mA to 25mA. - Change input and output reference voltage from 1.1V to 1.5V at AC test condition. - Expand max operating voltage from 3.0V to 3.3V. - Expand max operating temperature from 70°C to 85°C. - Release speed from 70/85ns to 100ns. - Release standby current form 170μA to 200μA. - Add Power up timing diagram. - Add AC characteristics for continuous write.	February 9, 2001	Preliminary
1.0	Finalize - Release standby current form 200μA to 250μA. - Release deep power down current form 10μA to 20μA. - Release t _{wc} for continuous write operation from 100ns to 110ns. - Release t _{cw} for continuous write operation from 90ns to 100ns. - Release t _{aw} for continuous write operation from 90ns to 100ns. - Release t _{bw} for continuous write operation from 90ns to 100ns. - Release t _{wP} for continuous write operation from 90ns to 100ns.	March 30, 2001	Final
2.0	Revised - Add product list	April 16, 2001	Final
3.0	Revised - Improve standby current from 250μA to 150μA.	May 28, 2001	Final

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2M x 16 bit Uni-Transistor CMOS RAM**FEATURES**

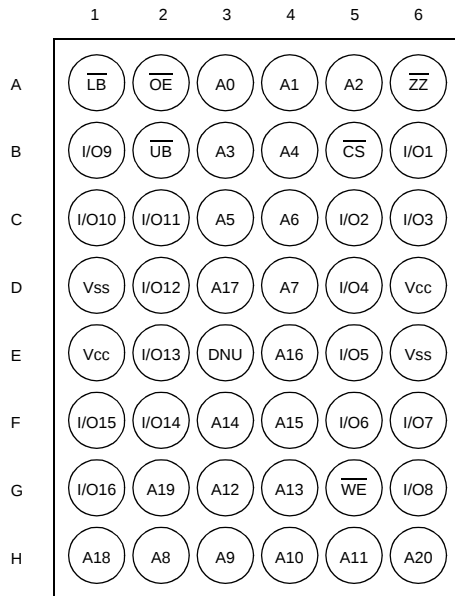
- Process Technology: CMOS
- Organization: 2M x16 bit
- Power Supply Voltage: 2.7~3.3V
- Three state output status
- Deep Power Down: Memory cell data hold invalid
- Package Type: 48-TBGA-9.00x12.00
- Compatible with Low Power SRAM

GENERAL DESCRIPTION

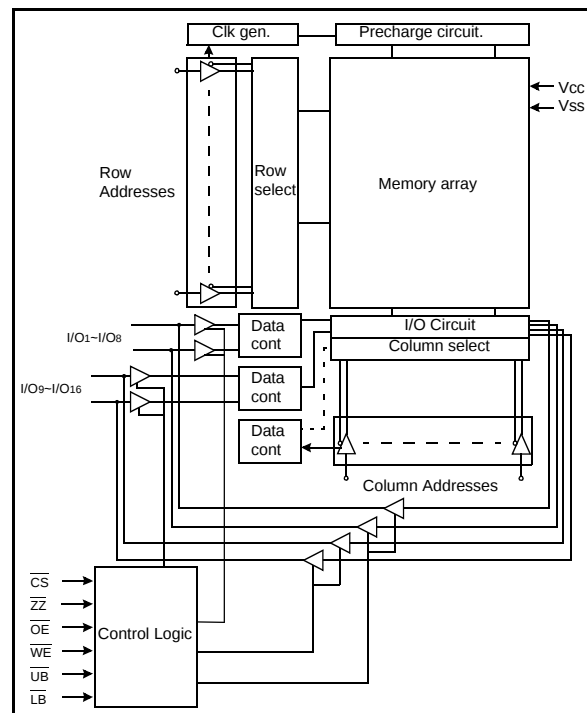
The K1S321615M is fabricated by SAMSUNG's advanced CMOS technology using one transistor memory cell. The device support, extended temperature range and 48 ball Chip Scale Package for user flexibility of system design. The device also supports deep power down mode for low standby current.

PRODUCT FAMILY

Product Family	Operating Temp.	Vcc Range	Speed (trc)	Power Dissipation			PKG Type
				Standby (Isb1, Max.)	Deep power down(Isbd, Max.)	Operating (Icc2, Max.)	
K1S321615M-E	Extended(-25~85°C)	2.7~3.3V	100ns	150µA	20µA	25mA	48-TBGA-9.00x12.00

PIN DESCRIPTION

48-TBGA: Top View(Ball Down)

FUNCTIONAL BLOCK DIAGRAM

Name	Function	Name	Function
CS	Chip Select Input	Vcc	Power
ZZ	Deep Power Down	Vss	Ground
OE	Output Enable Input	UB	Upper Byte(I/O9~16)
WE	Write Enable Input	LB	Lower Byte(I/O1~8)
A0~A20	Address Inputs	DNU	Do Not Use ¹⁾
I/O1~I/O16	Data Inputs/Outputs		

1) Reserved for future user

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POWER UP SEQUENCE

1. Apply power.
2. Maintain stable power(V_{CC} min.=2.7V) for a minimum 200 μ s with $\overline{CS}$ =high.
3. Issue read operation at least twice.

FUNCTIONAL DESCRIPTION

$\overline{CS}$	$\overline{ZZ}$	$\overline{OE}$	$\overline{WE}$	$\overline{LB}$	$\overline{UB}$	I/O ₁₋₈	I/O ₉₋₁₆	Mode	Power
H	H	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	Deep Power Down
L	H	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

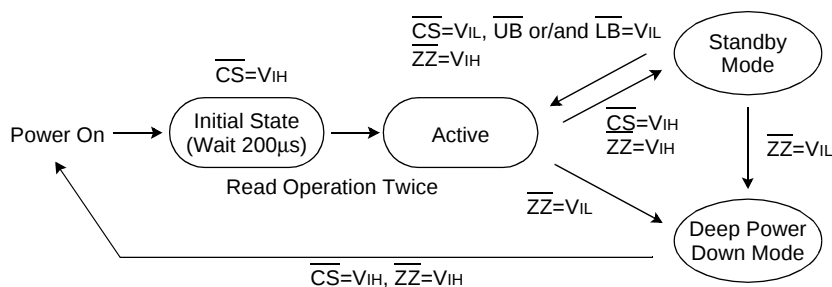
1. X means dont care.(Must be low or high state)

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	V
Voltage on Vcc supply relative to Vss	V _{CC}	-0.2 to 3.6V	V
Power Dissipation	P _D	1.0	W
Storage temperature	T _{STG}	-65 to 150	°C
Operating Temperature	T _A	-25 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 longer than 1seconds may affect reliability.

STANDBY MODE STATE MACHINES



STANDBY MODE CHARACTERISTIC

Power Mode	Memory Cell Data	Standby Current(mA)	Wait Time(ms)
Standby	Valid	150	0
Deep Power Down	Invaidd	20	200

PRODUCT LIST

Extended Temperature Products(-25~85°C)	
Part Name	Function
K1S321615M-EE10	48-TBGA with 48 ball, 100ns, 3.0V

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

1. T_A=-25 to 85°C, otherwise specified.

2. Overshoot: V_{CC}+1.0V in case of pulse width ≤20ns.

3. Undershoot: -1.0V 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}	$\overline{CS}=V_{IH}$, $\overline{ZZ}=V_{IH}$, $\overline{OE}=V_{IH}$ or $\overline{WE}=V_{IL}$, V _{IO} =V _{SS} to V _{CC}	-1	-	1	μA
Average operating current	I _{CC1}	Cycle time=1μs, 100% duty, I _{IO} =0mA, $\overline{CS} \leq 0.2V$, $\overline{ZZ} \geq V_{CC}-0.2V$, V _{IN} ≤0.2V or V _{IN} ≥V _{CC} -0.2V	-	2	5	mA
	I _{CC2}	Cycle time=Min, I _{IO} =0mA, 100% duty, $\overline{CS}=V_{IL}$, $\overline{ZZ}=V_{IH}$, V _{IN} =V _{IL} or V _{IH}	-	18	25	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}	$\overline{CS} \geq V_{CC}-0.2V$, $\overline{ZZ} \geq V_{CC}-0.2V$, Other inputs=V _{SS} to V _{CC}	-	120	150	μA
Deep Power Down	I _{SD}	$\overline{ZZ} \leq 0.2V$, Other inputs=V _{SS} to V _{CC}	-	5	20	μA

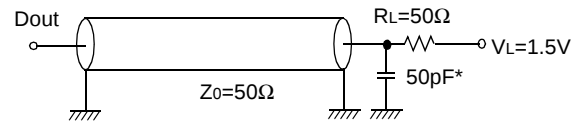
1. Typical values are tested at V_{CC}=3.0V, T_A=25°C and not guaranteed.

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): $C_L=50\text{pF}$ 

* Include scope and jig capacitance

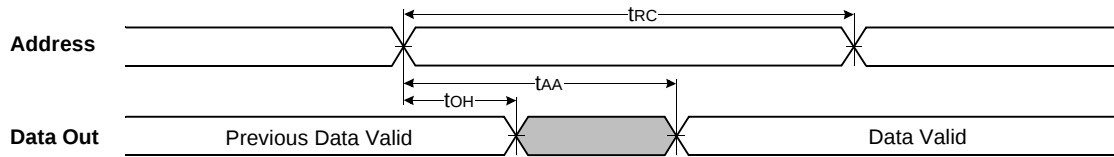
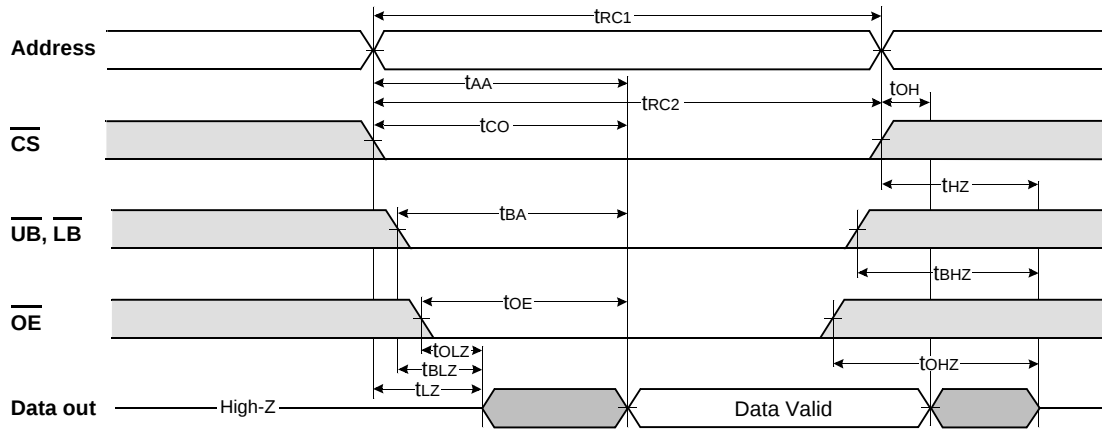
AC CHARACTERISTICS($V_{CC}=2.7\sim 3.3\text{V}$, $T_A=-25$ to 85°C)

Parameter List		Symbol	Speed Bins				Units
			100ns ¹⁾		100ns ²⁾		
			Min	Max	Min	Max	
Read	Read Cycle Time	t _{RC}	100	-	100	-	ns
	Address Access Time	t _{AA}	-	100	-	100	ns
	Chip Select to Output	t _{CO}	-	100	-	100	ns
	Output Enable to Valid Output	t _{OE}	-	50	-	50	ns
	$\overline{\text{UB}}$, $\overline{\text{LB}}$ Access Time	t _{BA}	-	100	-	100	ns
	Chip Select to Low-Z Output	t _{LZ}	10	-	10	-	ns
	$\overline{\text{UB}}$, $\overline{\text{LB}}$ 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	25	0	25	ns
	$\overline{\text{UB}}$, $\overline{\text{LB}}$ Disable to High-Z Output	t _{BHZ}	0	25	0	25	ns
	Output Disable to High-Z Output	t _{OHZ}	0	25	0	25	ns
	Output Hold from Address Change	t _{OH}	5	-	5	-	ns
Write	Write Cycle Time	t _{WC}	100	-	110	-	ns
	Chip Select to End of Write	t _{CW}	80	-	100	-	ns
	Address Set-up Time	t _{AS}	0	-	0	-	ns
	Address Valid to End of Write	t _{AW}	80	-	100	-	ns
	$\overline{\text{UB}}$, $\overline{\text{LB}}$ Valid to End of Write	t _{BW}	80	-	100	-	ns
	Write Pulse Width	t _{WP}	70	-	100	-	ns
	Write Recovery Time	t _{WR}	0	-	0	-	ns
	Write to Output High-Z	t _{WHZ}	0	30	0	30	ns
	Data to Write Time Overlap	t _{DW}	40	-	40	-	ns
	Data Hold from Write Time	t _{DH}	0	-	0	-	ns
	End Write to Output Low-Z	t _{OW}	5	-	5	-	ns

1. The characteristics which is restricted for continuous write operation over 20 times, please refer to technical note.

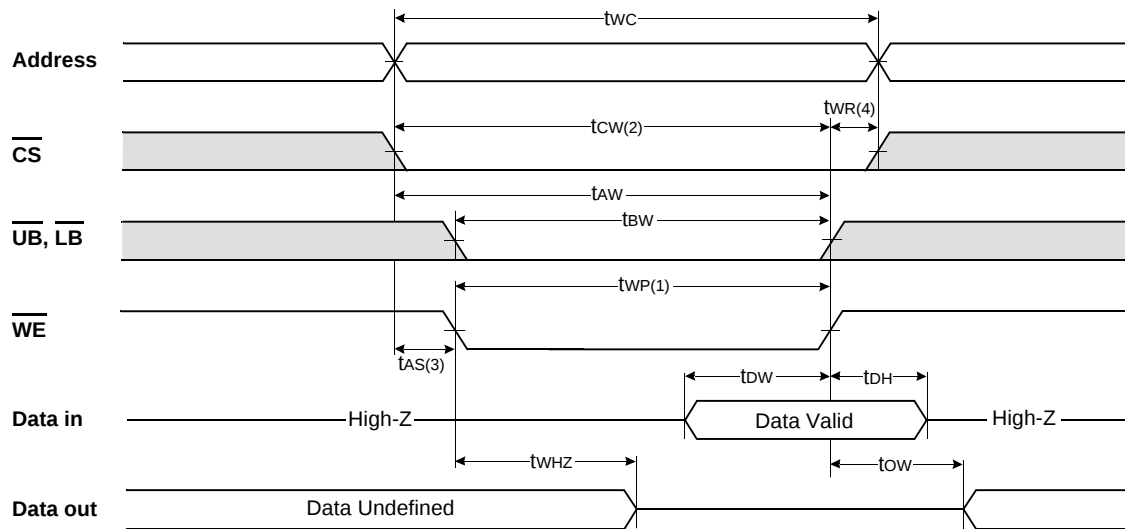
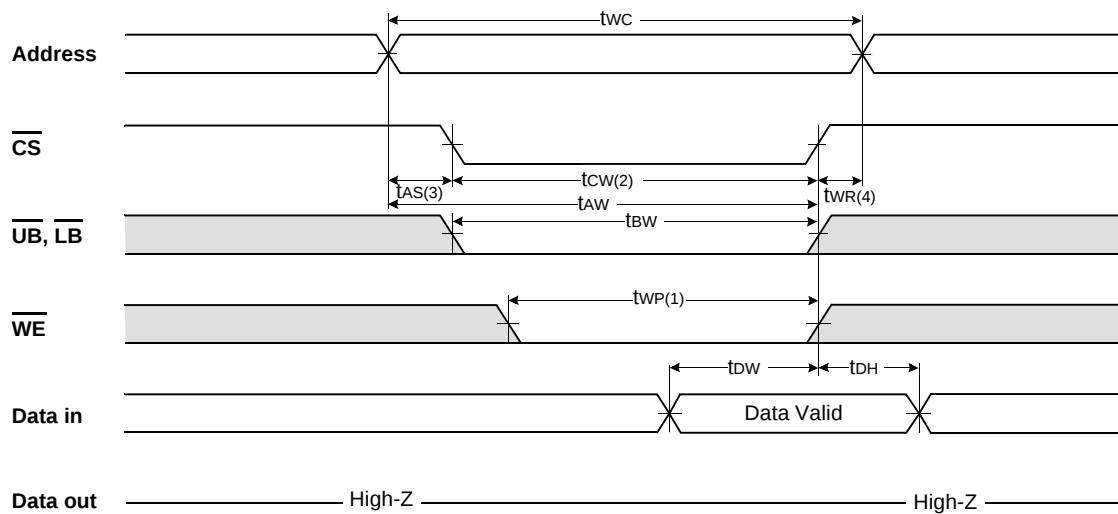
2. The characteristics for continuous write operation.

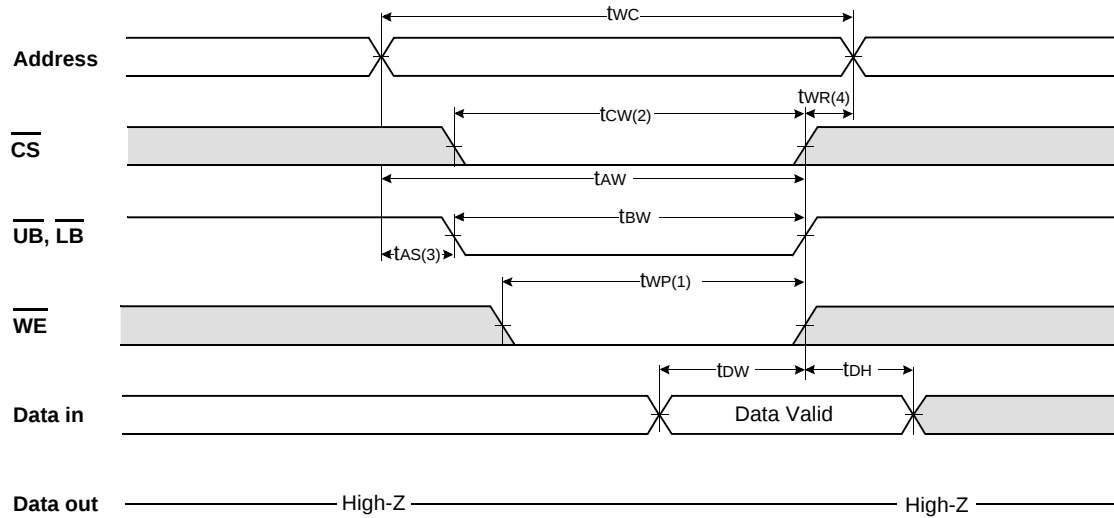
TIMING DIAGRAMS

TIMING WAVEFORM OF READ CYCLE(1) (Address Controlled, $\overline{CS}=\overline{OE}=V_{IL}$, $\overline{ZZ}=\overline{WE}=V_{IH}$, $\overline{UB}$ or/and $\overline{LB}=V_{IL}$)TIMING WAVEFORM OF READ CYCLE(2) ($\overline{ZZ}=\overline{WE}=V_{IH}$)

(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.
3. The minimum read cycle(t_{RC}) is determined later one of the t_{RC1} and t_{RC2} .

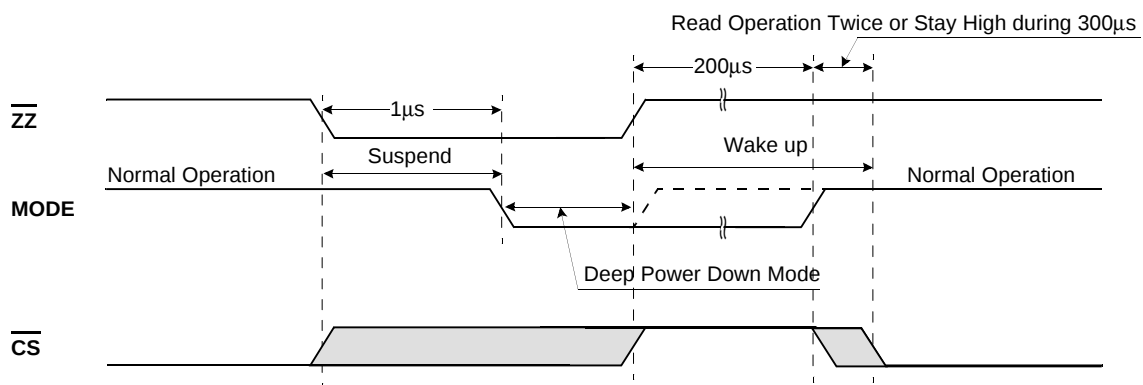
TIMING WAVEFORM OF WRITE CYCLE(1)($\overline{WE}$ Controlled, $\overline{ZZ}=V_{IH}$)TIMING WAVEFORM OF WRITE CYCLE(2)($\overline{CS}$ Controlled, $\overline{ZZ}=V_{IH}$)

TIMING WAVEFORM OF WRITE CYCLE(3)($\overline{UB}$, $\overline{LB}$ Controlled, $\overline{ZZ}=V_{IH}$)

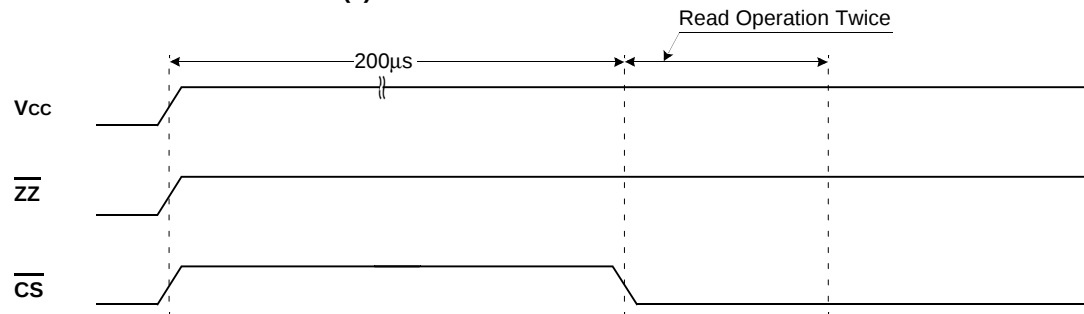
(WRITE CYCLE)

1. A write occurs during the overlap(t_{WP}) of low $\overline{CS}$ and low $\overline{WE}$. A write begins when $\overline{CS}$ 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 $\overline{CS}$ 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 $\overline{CS}$ 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} applied in case a write ends as $\overline{CS}$ or $\overline{WE}$ going high.

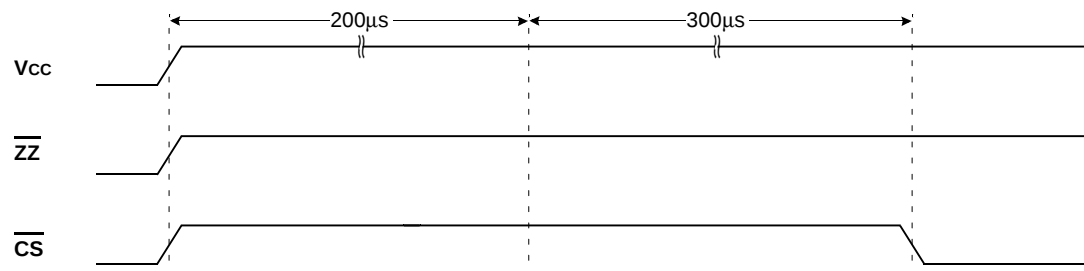
TIMING WAVEFORM OF DEEP POWER DOWN MODE



TIMING WAVEFORM OF POWER UP(1)



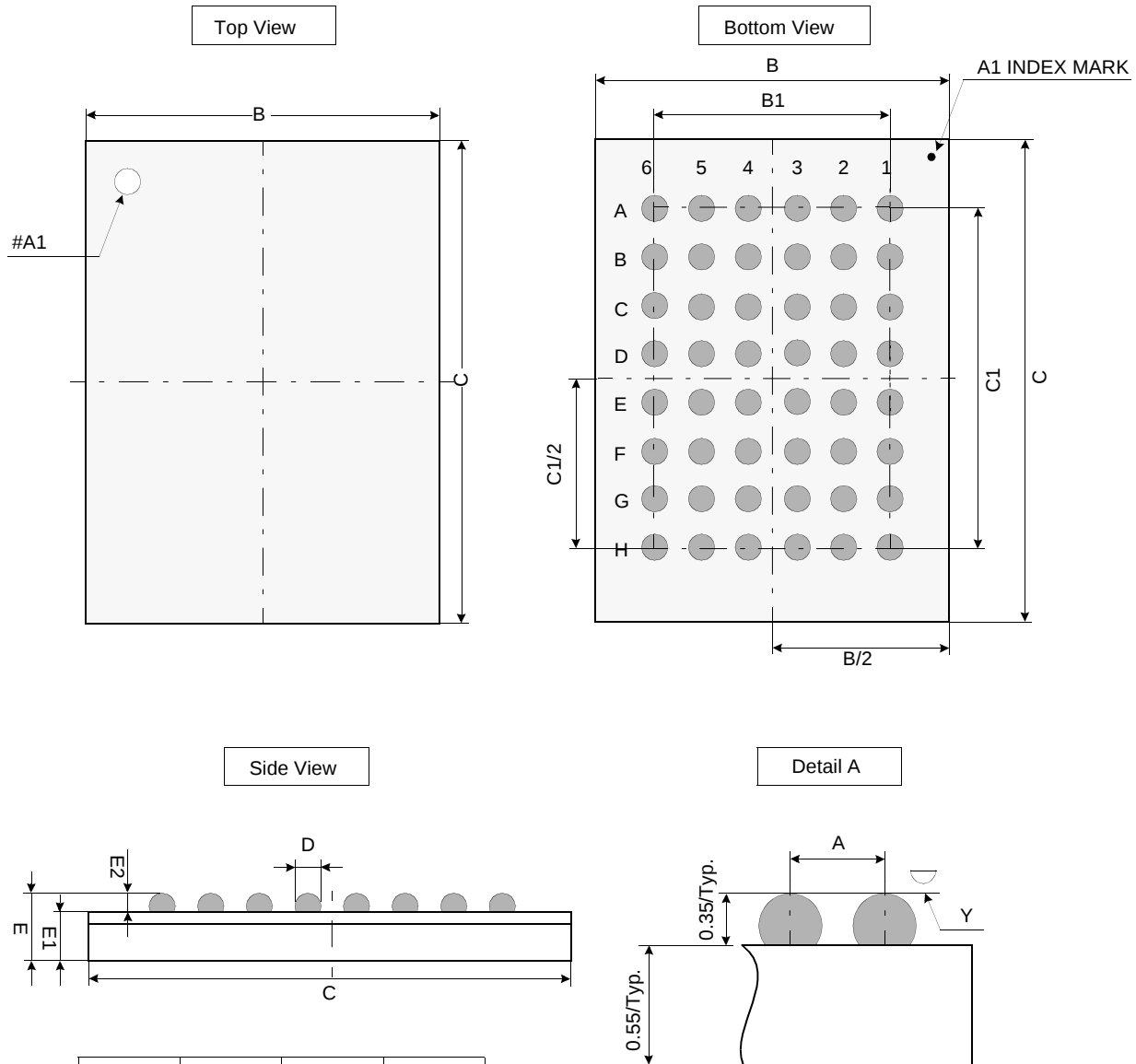
TIMING WAVEFORM OF POWER UP(2)(No Dummy Cycle)



PACKAGE DIMENSION

Unit: millimeters

48 TAPE BALL GRID ARRAY(0.75mm ball pitch)



	Min	Typ	Max
A	-	0.75	-
B	8.90	9.00	9.10
B1	-	3.75	-
C	11.90	12.00	12.10
C1	-	5.25	-
D	0.40	0.45	0.50
E	-	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)

TECHNICAL NOTE

U_tRAM USAGE AND TIMING

INTRODUCTION

U_tRAM is based on single-transistor DRAM cells. As with any other DRAM, the data in these cells must be periodically refreshed to prevent data loss. What makes the U_tRAM unique is that it offers a true SRAM style interface that hides all refresh operations from the memory controller.

START WITH A DRAM TECHNOLOGY

The key to the U_tRAM is its high speed and low power. This speed comes from the use of many small blocks, often just 32Kbits each, to create U_tRAM arrays. The small blocks have short word lines with little capacitance, eliminating a major source of operating current in conventional DRAM blocks.

Each independent macro-cell on a U_tRAM device consists of a number of these blocks. Each chip has one or more macro.

The address decoding logic is also fast. U_tRAM perform a complete read operation in every t_{RC}, but U_tRAM needs power up sequence like a DRAM.

Power Up Sequence and Diagram

1. Apply power.
2. Maintain stable power for a minimum 200μs with $\overline{CS}=V_{IH}$.
3. Issue read operation at least 2 times.

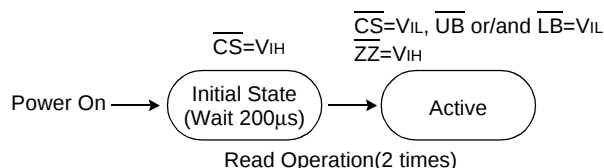


Figure 1.

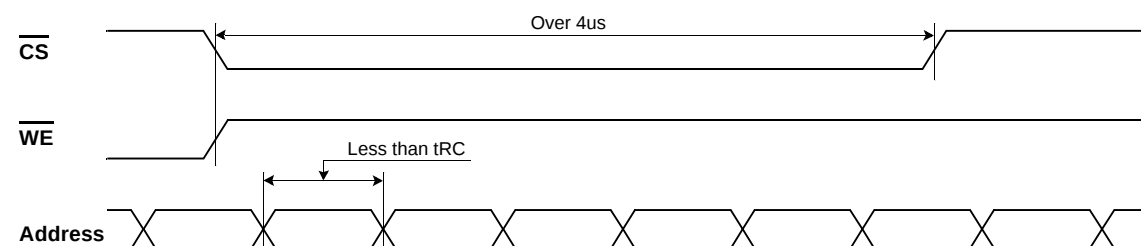
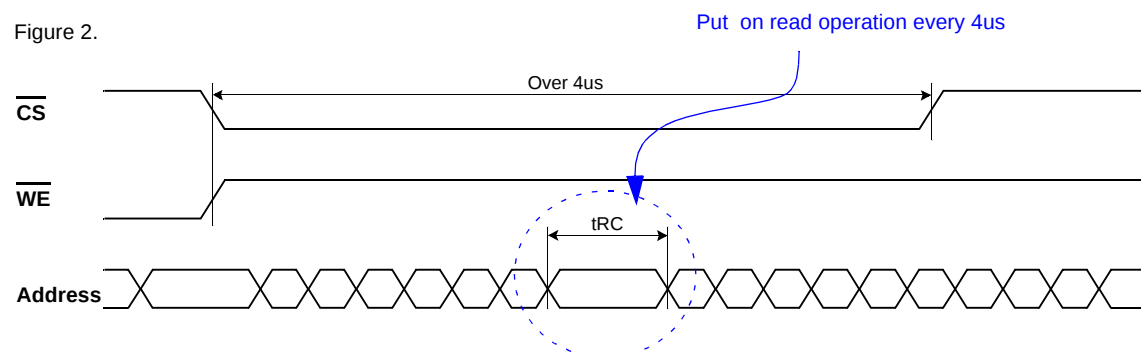


Figure 2.



DESIGN ACHIEVES SRAM SPECIFIC OPERATIONS

The U_tRAM design works just like an SRAM, with no wait states or other overhead for precharging or refreshing its internal DRAM cells. SAMSUNG Electronics(SAMSUNG) hides these operations with advanced design. Precharging takes place during every access, overlapped with the end of the cycle and the decoding portion of the next cycle.

Hiding refresh is more difficult. Every row in every block must be refreshed at least once during the refresh interval to prevent data loss. SAMSUNG provides an internal refresh controller for devices. When all accesses during a refresh interval are directed to one macro-cell, as can happen in signal processing applications, a more sophisticated approach is required to hide refresh. The pseudo SRAM, sometimes used on these applications, which is required a memory controller that can hold off accesses when a refresh operation is needed. SAMSUNG unique qualitative advantage over these parts(in addition to quantitative improvements in access speed and power consumption) is that the U_tRAM never needs to hold off accesses, and indeed it has no hold off signal. The circuitry that gives SAMSUNG this advantage is fairly simple but has not previously been disclosed.

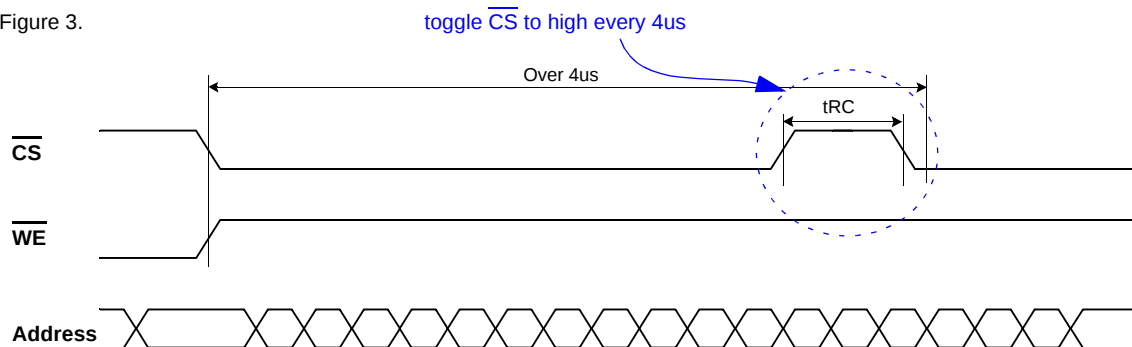
AVOID TIMING

Following figures are show you a abnormal timing which is not supported on U_tRAM and their solution.

At read operation, if your system have a timing which sustain invalid states over 4us at read mode like Figure 1. There are some guide line for proper operation of U_tRAM.

When your system have multiple invalid address signal shorter than t_{RC} on the timing which showed in Figure 1, U_tRAM need a normal read timing during that cycle(Figure 2) or toggle the CS to high about t_{RC}(Figure 3).

Figure 3.



Write operation have similar restricted operation with Read. If your system have a timing which sustain invalid states over 4us at write mode and system have continuous write signal with Min. tWC over 4us like Figure 4.

You must put read timing on the cycle(Figure 5) or toggle the $\overline{CS}$ to high about tRC(Figure 6).

Figure 4.

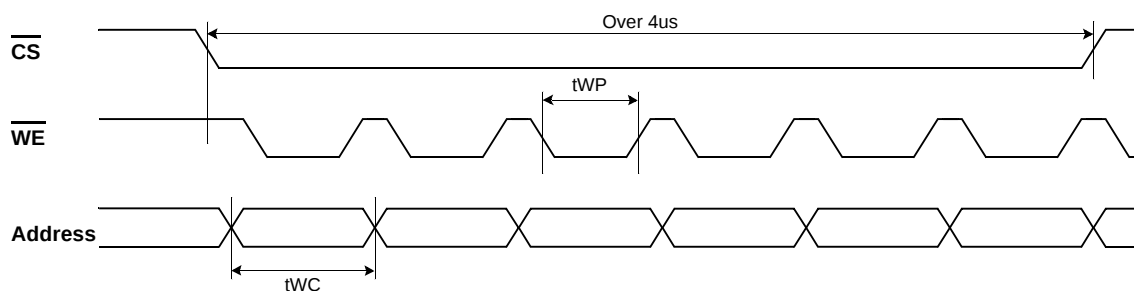


Figure 5.

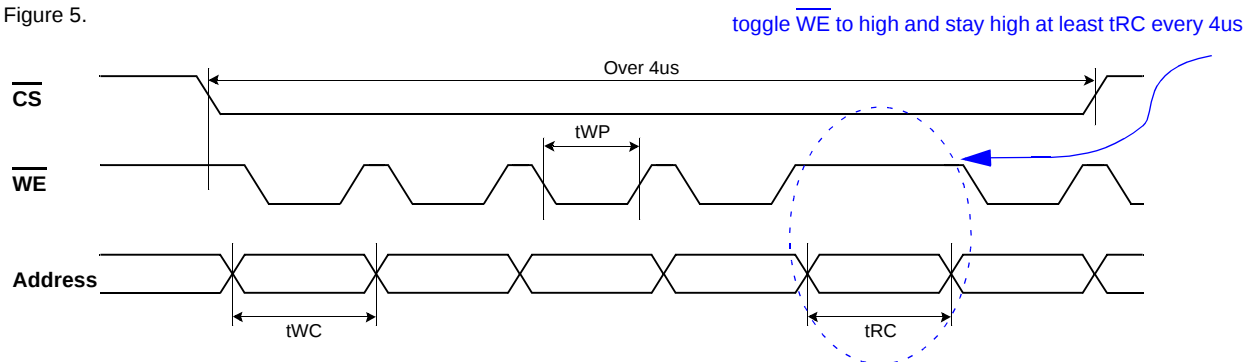


Figure 6.

