SDRAM Registered Module

168pin Registered Module based on 256Mb E-die
with 72-bit ECC

Revision 1.4

May 2004

Revision History

Revision 0.0 (June, 2003)

- First release

Revision 1.0 (June, 2003)

- Revision 1.0 release.

Revision 1.1 (September, 2003)

- Corrected typo.

Revision 1.2 (February, 2004)

- Corrected typo.

Revision 1.3 (March. 2004)

- Modified DC Characteristics Notes.

Revision 1.4 (May, 2004)

- Added Note 5. sentense of tRDL parameter

168Pin Registered DIMM based on 256Mb E-die (x4, x8)

Ordering Information

Part Number	Density	Organization	Component Composition	Component Package	Height
M390S3253ET1-C7A	256MB	32Mx72	32Mx8(K4S560832E) * 9EA	54-TSOP(II)	1,500mil
M390S3253ETU-C7A	256MB	32Mx72	32Mx8(K4S560832E) * 9EA		1,200mil
M390S6450ET1-C7A	512MB	64Mx72	64Mx4(K4S560432E) * 18EA		1,700mil
M390S6450ETU-C7A	512MB	64Mx72	64Mx4(K4S560432E) * 18EA		1,200mil
M390S6453ET1-C7A	512MB	64Mx72	32Mx8(K4S560832E) * 18EA		1,700mil
M390S2858ET1-C7A	1GB	128Mx72	st.128Mx4(K4S510632E) * 18EA		1,700mil
M390S2858ETU-C7A	1GB	128Mx72	st.128Mx4(K4S510632E) * 18EA		1,200mil

Operating Frequencies

	7A	
	@CL3	@CL2
Maximum Clock Frequency	133MHz(7.5ns)	100MHz(10ns)
CL-tRCD-tRP(clock)	3 - 3 - 3	2 - 2 - 2

Feature

- Burst mode operation
- Auto & self refresh capability (8192 Cycles/64ms)
- LVTTL compatible inputs and outputs
- Single 3.3V ± 0.3V power supply
- MRS cycle with address key programs Latency (Access from column address)
  Burst length (1, 2, 4, 8 & Full page)
  Data scramble (Sequential & Interleave)
- All inputs are sampled at the positive going edge of the system clock
- Serial presence detect with EEPROM

PIN CONFIGURATIONS (Front side/back side)

Pin	Front	Pin	Front	Pin	Front	Pin	Back	Pin	Back	Pin	Back
1	VSS	29	DQM1	57	DQ18	85	VSS	113	DQM5	141	DQ50
2	DQ0	30	**CS0	58	DQ19	86	DQ32	114	**CS1	142	DQ51
3	DQ1	31	DU	59	VDD	87	DQ33	115	RAS	143	VDD
4	DQ2	32	VSS	60	DQ20	88	DQ34	116	VSS	144	DQ52
5	DQ3	33	A0	61	NC	89	DQ35	117	A1	145	NC
6	VDD	34	A2	62	*VREF	90	VDD	118	A3	146	*VREF
7	DQ4	35	A4	63	**CKE1	91	DQ36	119	A5	147	REGE
8	DQ5	36	A6	64	VSS	92	DQ37	120	A7	148	VSS
9	DQ6	37	A8	65	DQ21	93	DQ38	121	A9	149	DQ53
10	DQ7	38	A10/AP	66	DQ22	94	DQ39	122	BA0	150	DQ54
11	DQ8	39	BA1	67	DQ23	95	DQ40	123	A11	151	DQ55
12	VSS	40	VDD	68	VSS	96	VSS	124	VDD	152	VSS
13	DQ9	41	VDD	69	DQ24	97	DQ41	125	**CLK1	153	DQ56
14	DQ10	42	**CLK0	70	DQ25	98	DQ42	126	A12	154	DQ57
15	DQ11	43	VSS	71	DQ26	99	DQ43	127	VSS	155	DQ58
16	DQ12	44	DU	72	DQ27	100	DQ44	128	**CKE0	156	DQ59
17	DQ13	45	**CS2	73	VDD	101	DQ45	129	**CS3	157	VDD
18	VDD	46	DQM2	74	DQ28	102	VDD	130	DQM6	158	DQ60
19	DQ14	47	DQM3	75	DQ29	103	DQ46	131	DQM7	159	DQ61
20	DQ15	48	DU	76	DQ30	104	DQ47	132	*A13	160	DQ62
21	CB0	49	VDD	77	DQ31	105	CB4	133	VDD	161	DQ63
22	CB1	50	NC	78	VSS	106	CB5	134	NC	162	VSS
23	VSS	51	NC	79	**CLK2	107	VSS	135	NC	163	**CLK3
24	NC	52	CB2	80	NC	108	NC	136	CB6	164	NC
25	NC	53	CB3	81	NC	109	NC	137	CB7	165	SA0
26	VDD	54	VSS	82	SDA	110	VDD	138	VSS	166	SA1
27	WE	55	DQ16	83	SCL	111	CAS	139	DQ48	167	SA2
28	DQM0	56	DQ17	84	VDD	112	DQM4	140	DQ49	168	VDD

Note : 1. * These pins are not used in this module.
2. Pins 82,83,165,166,167 should be NC in the system which does not support SPD.
3. ** About these pins, Refer to the Block Diagram of each.

Pin Description

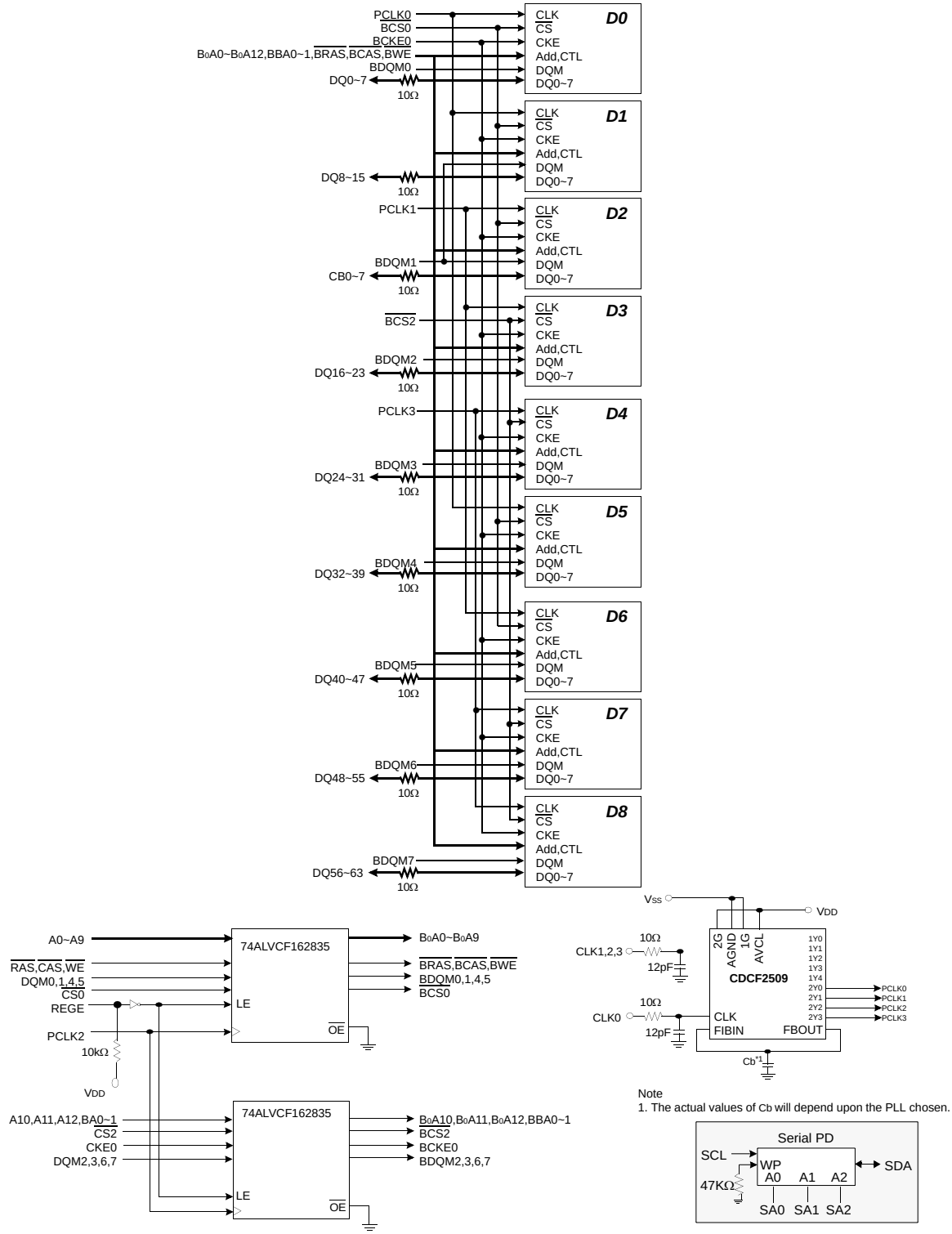
Pin Name	Function	Pin Name	Function
A0 ~ A12	Address input (Multiplexed)	DQM0 ~ 7	DQM
BA0 ~ BA1	Select bank	VDD	Power supply (3.3V)
DQ0 ~ DQ63	Data input/output	VSS	Ground
CB0 ~ CB7	Check bit (Data-in/data-out)	*VREF	Power supply for reference
CLK0 ~ 3	Clock input	REGE	Register enable
CKE0, CKE1	Clock enable input	SDA	Serial data I/O
CS0 ~ CS3	Chip select input	SCL	Serial clock
RAS	Row address strobe	SA0 ~ 2	Address in EEPROM
CAS	Colume address strobe	DU	Don't use
WE	Write enable	NC	No connection

PIN CONFIGURATION DESCRIPTION

Pin	Name	Input Function
CLK	*System clock*	Active on the positive going edge to sample all inputs.
$\overline{CS}$	*Chip select*	Disables or enables device operation by masking or enabling all inputs except CLK, CKE and DQM
CKE	*Clock enable*	Masks system clock to freeze operation from the next clock cycle. CKE should be enabled at least one cycle prior to new command. Disable input buffers for power down in standby. CKE should be enabled 1CLK+tss prior to valid command.
A0 ~ A12	*Address*	Row/column addresses are multiplexed on the same pins. Row address : RA0 ~ RA12 Column address : (x4 : CA0 ~ CA9, CA11), (x8 : CA0 ~ CA9)
BA0 ~ BA1	*Bank select address*	Selects bank to be activated during row address latch time. Selects bank for read/write during column address latch time.
$\overline{RAS}$	*Row address strobe*	Latches row addresses on the positive going edge of the CLK with $\overline{RAS}$ low. Enables row access & precharge.
$\overline{CAS}$	*Column address strobe*	Latches column addresses on the positive going edge of the CLK with $\overline{CAS}$ low. Enables column access.
$\overline{WE}$	*Write enable*	Enables write operation and row precharge. Latches data in starting from $\overline{CAS}$, $\overline{WE}$ active.
DQM0 ~ 7	*Data input/output mask*	Makes data output Hi-Z, t_{SHZ} after the clock and masks the output. Blocks data input when DQM active. (Byte masking)
REGE	*Register enable*	The device operates in the transparent mode when REGE is low. When REGE is high, the device operates in the registered mode. In registered mode, the Address and control inputs are latched if CLK is held at a high or low logic level. the inputs are stored in the latch/flip-flop on the rising edge of CLK. REGE is tied to V_{DD} through 10K ohm Resistor on PCB. So if REGE of module is floating, this module will be operated as registered mode.
DQ0 ~ 63	*Data input/output*	Data inputs/outputs are multiplexed on the same pins.
CB0 ~ 7	*Check bit*	Check bits for ECC.
V_{DD}/V_{SS}	*Power supply/ground*	Power and ground for the input buffers and the core logic.

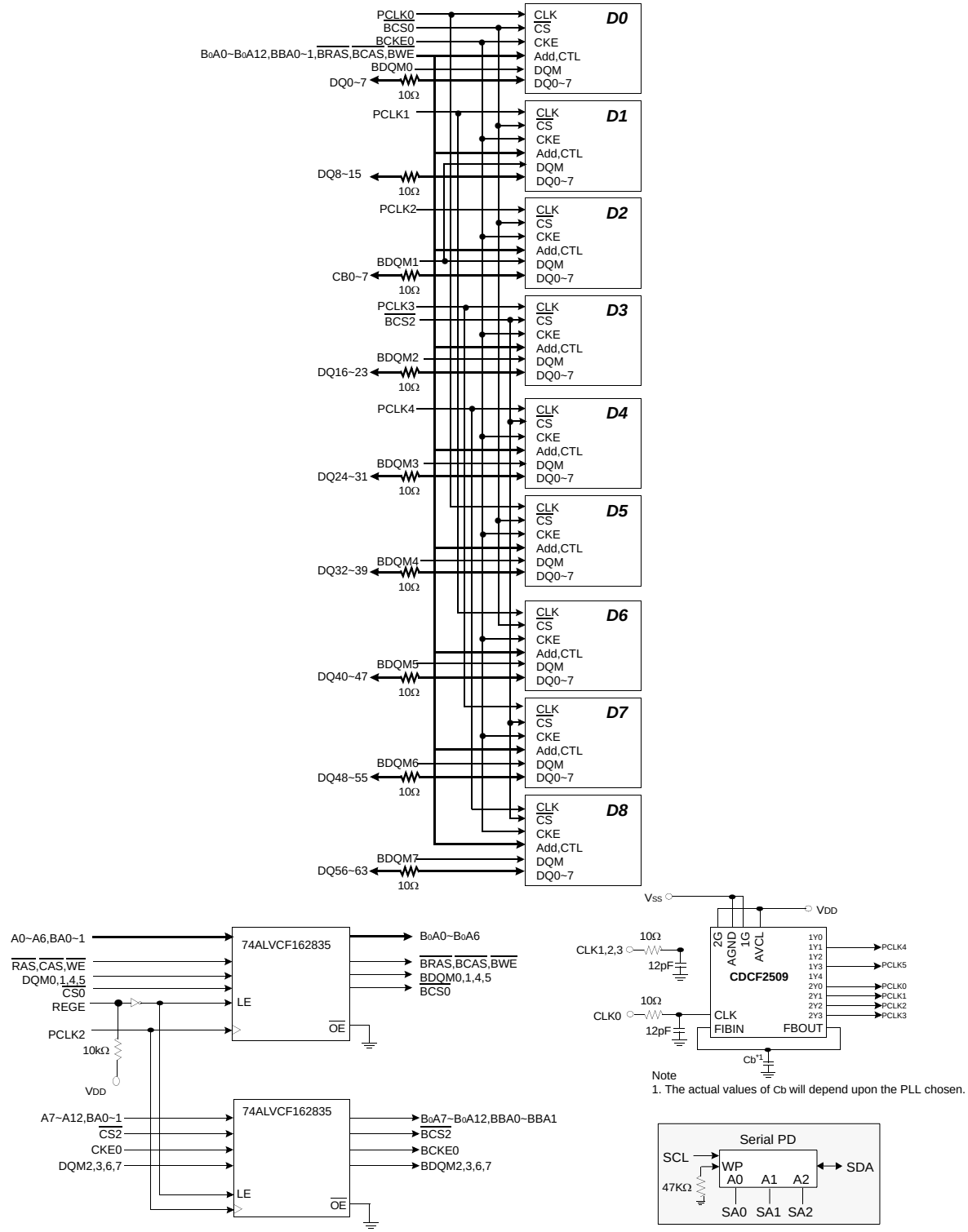
256MB, 32Mx72 ECC Module (M390S3253ET1) (Populated as 1 bank of x8 SDRAM Module)

FUNCTIONAL BLOCK DIAGRAM



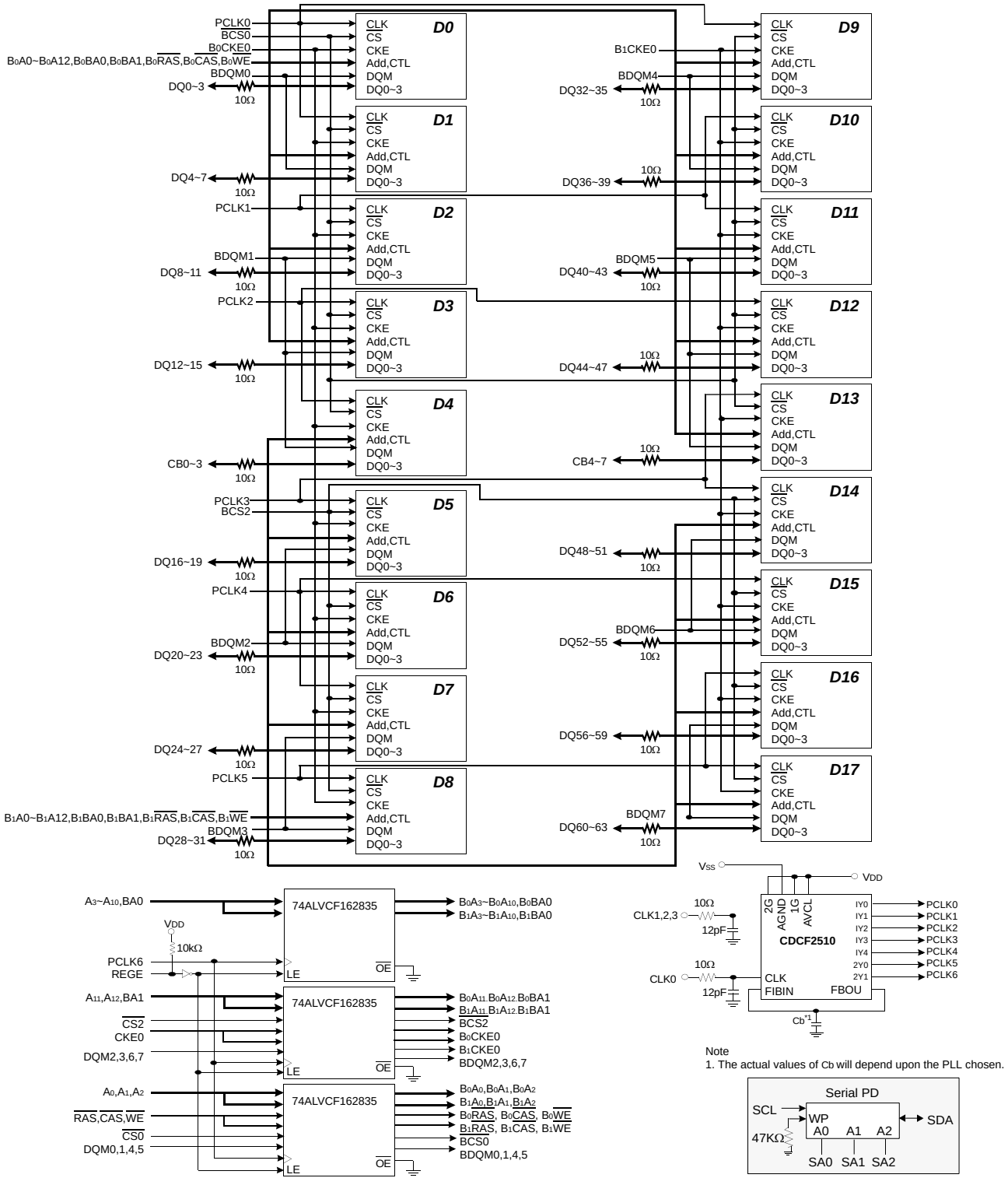
256MB, 32Mx72 ECC Module (M390S3253ETU) (Populated as 1 bank of x8 SDRAM Module)

FUNCTIONAL BLOCK DIAGRAM



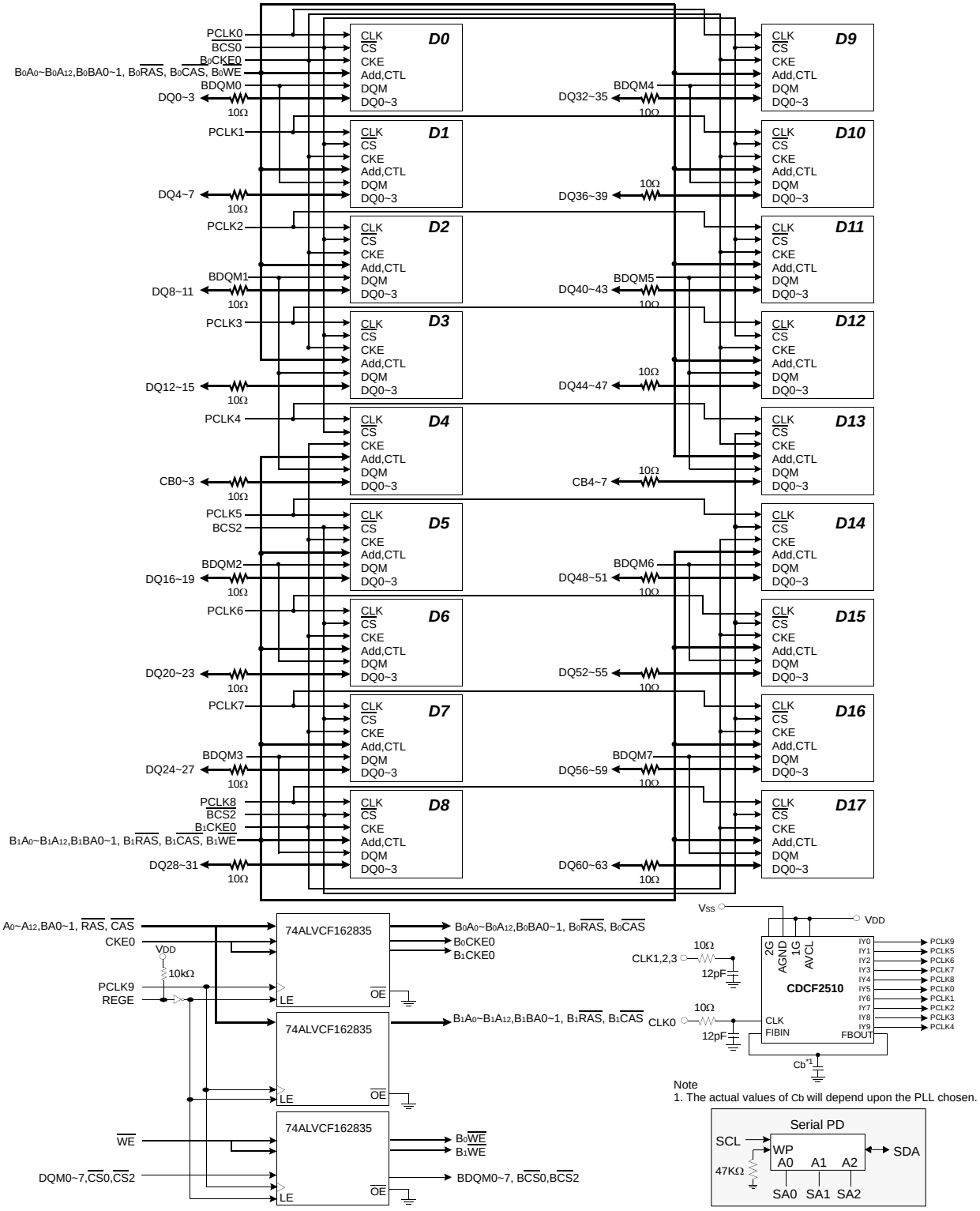
512MB 64Mx72 ECC Module (M390S6450ET1) (Populated as 1 bank of x4 SDRAM Module)

FUNCTIONAL BLOCK DIAGRAM



512MB 64Mx72 ECC Module (M390S6450ETU) (Populated as 1 bank of x4 SDRAM Module)

FUNCTIONAL BLOCK DIAGRAM



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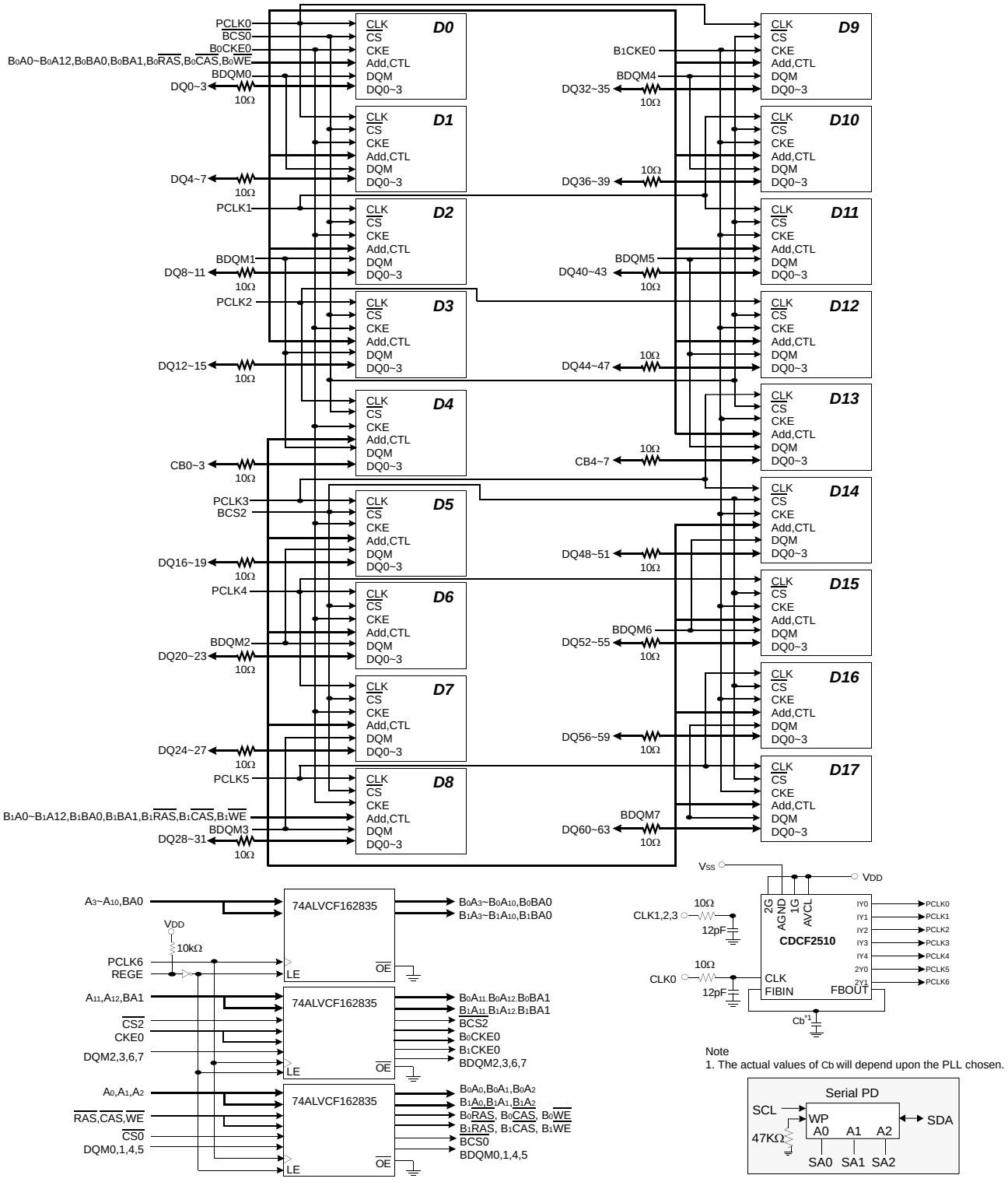
512MB, 64Mx72 ECC Module (M390S6453ET1) (Populated as 2 bank of x8 SDRAM Module)

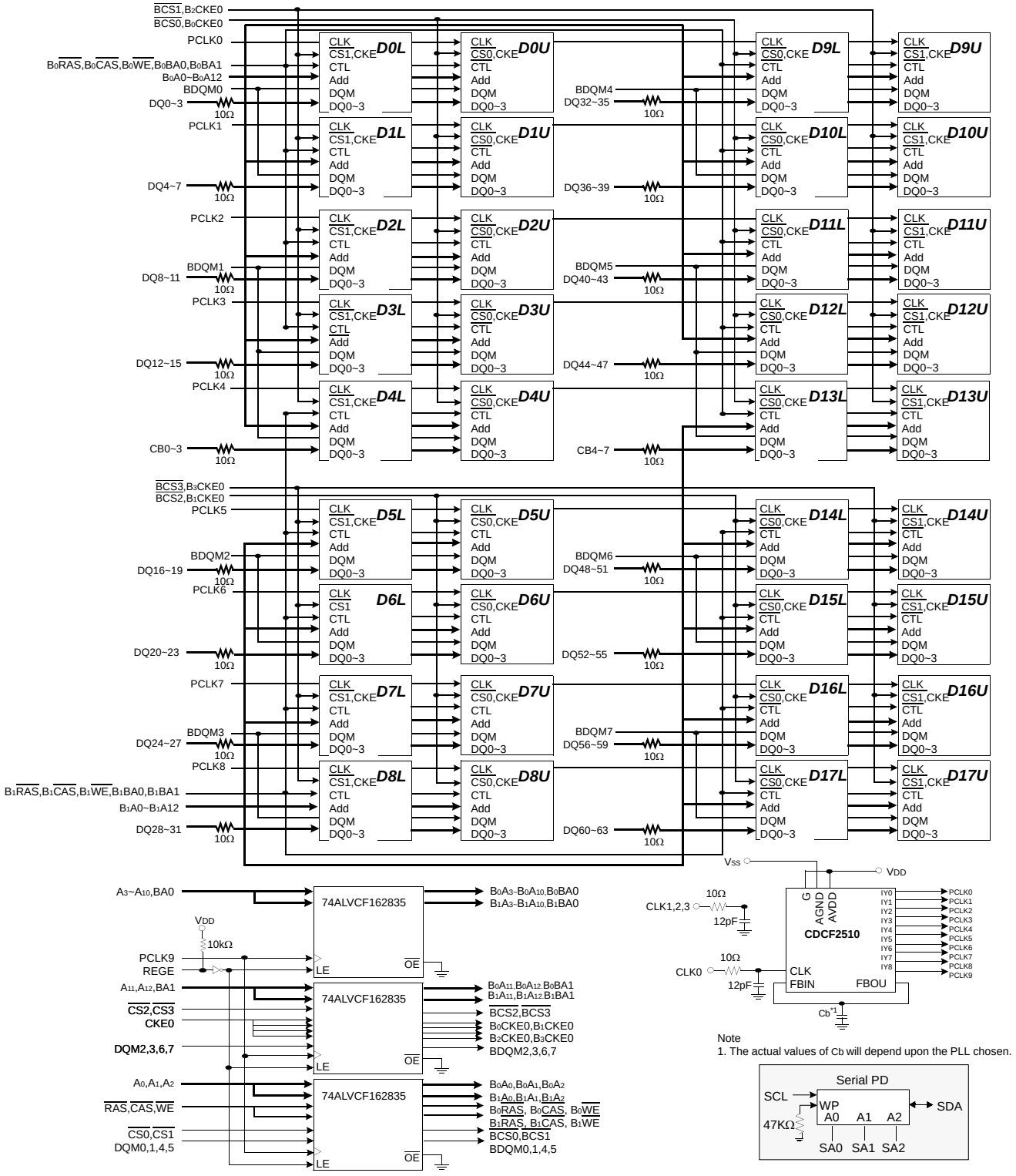
FUNCTIONAL BLOCK DIAGRAM



Note
1. The actual values of Cb will depend upon the PLL chosen.

1GB, 128Mx72 ECC Module (M390S2858ET1) (Populated as 2 bank of x4 SDRAM Module)

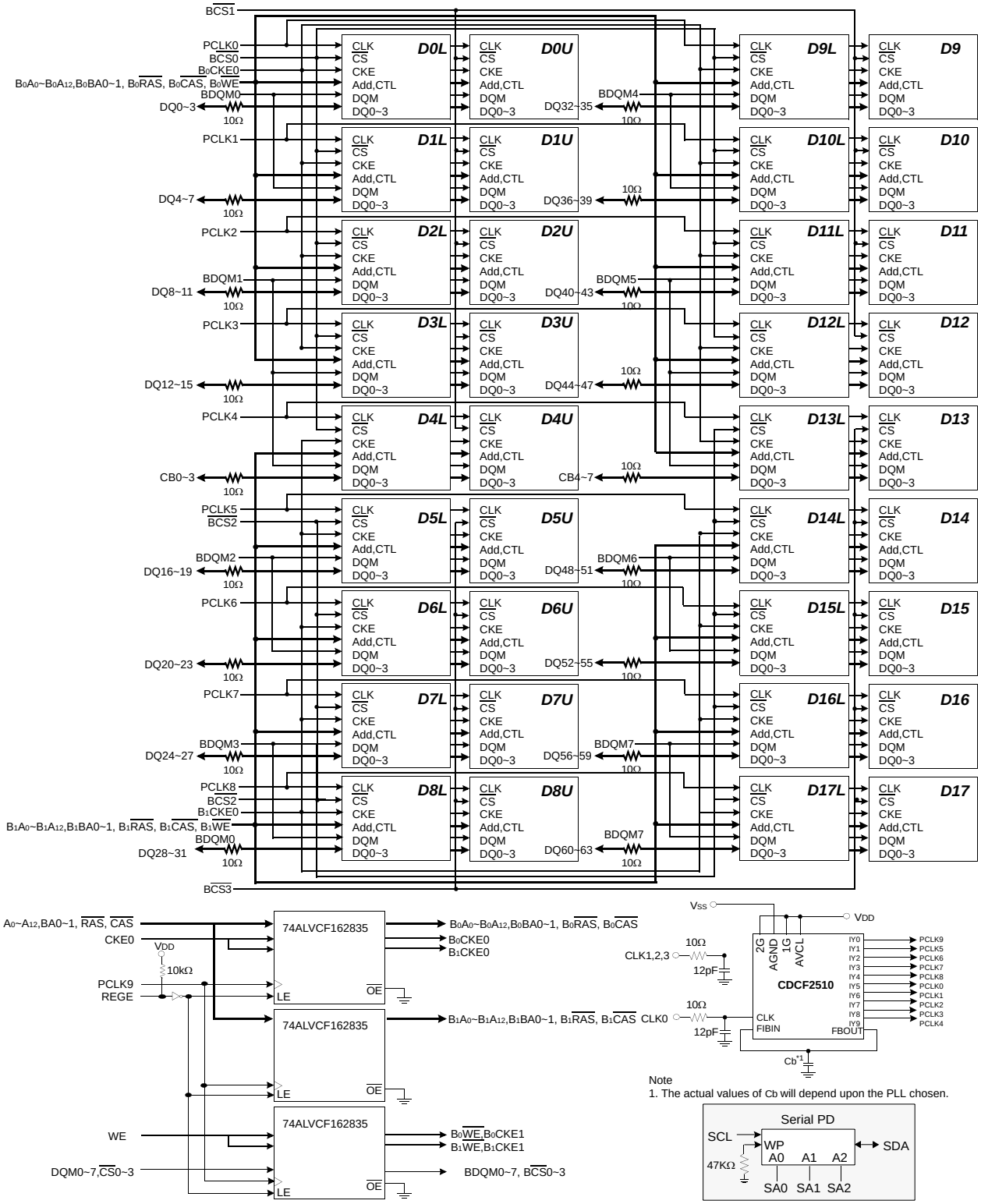
FUNCTIONAL BLOCK DIAGRAM



SAMSUNG ELECTRONICS

1GB, 128Mx72 ECC Module (M390S2858ETU) (Populated as 2 bank of x4 SDRAM Module)

FUNCTIONAL BLOCK DIAGRAM



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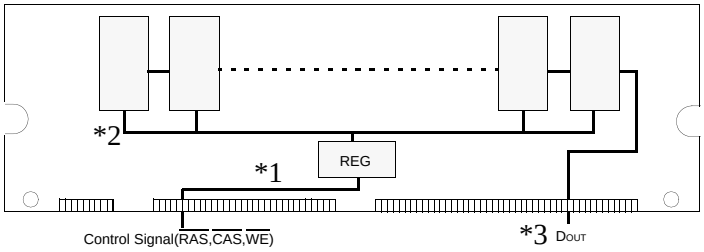
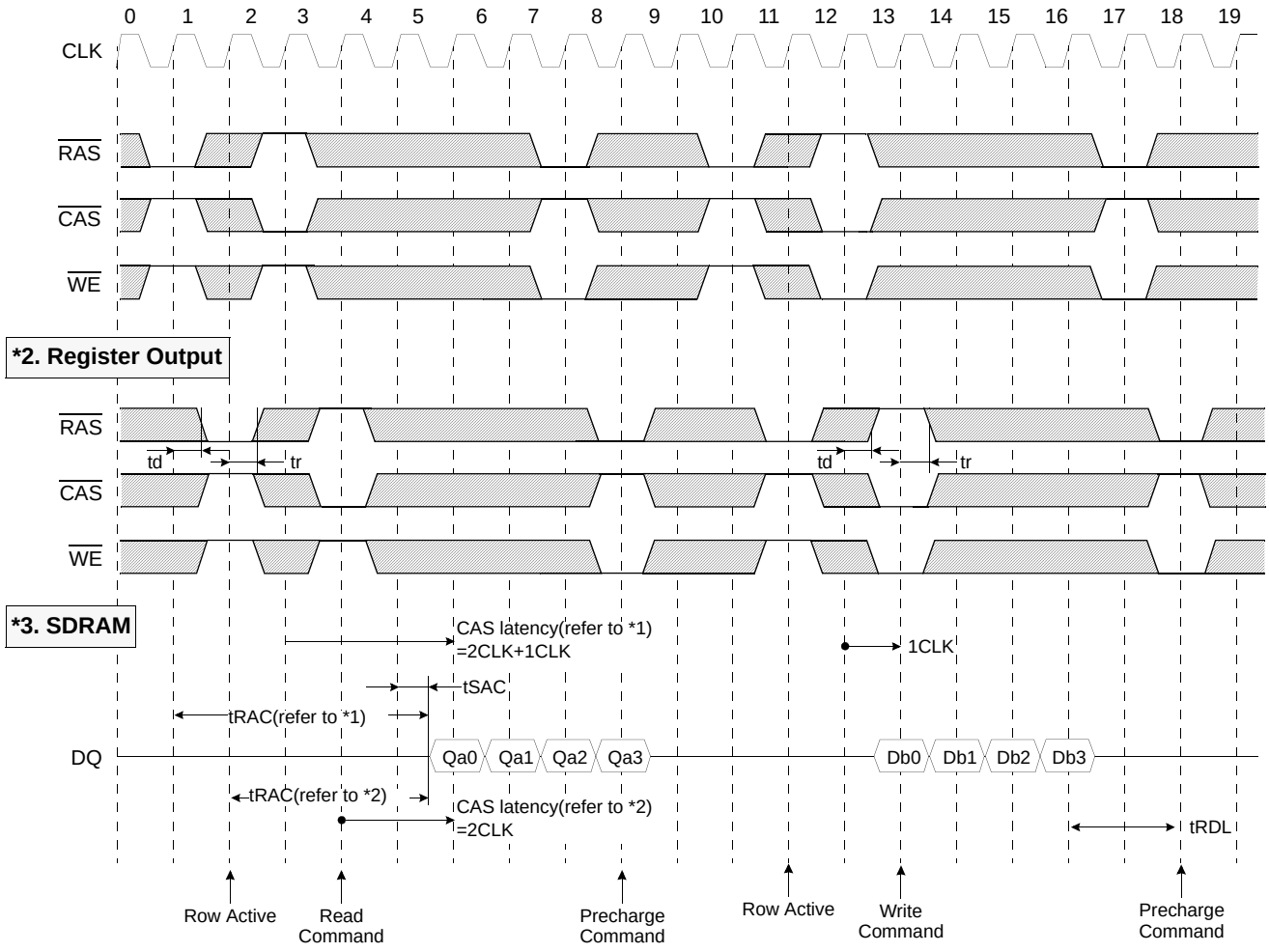
STANDARD TIMING DIAGRAM WITH PLL & REGISTER (CL=2, BL=4)



***1. Register Input**



***2. Register Output**

***3. SDRAM**

td, tr = Delay of register

Notes : 1. In case of module timing, command cycles delayed 1CLK with respect to external input timing at the address and input signal because of the buffering in register. Therefore, Input/Output signals of read/write function should be issued 1CLK earlier as compared to Unbuffered DIMMs.

2. DIN is to be issued 1clock after write command in external timing because DIN is issued directly to module.

: Don't care

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Voltage on any pin relative to Vss	V_{IN}, V_{OUT}	-1.0 ~ 4.6	V
Voltage on V_{DD} supply relative to Vss	V_{DD}, V_{DDQ}	-1.0 ~ 4.6	V
Storage temperature	T_{STG}	-55 ~ +150	°C
Power dissipation	P_D	1.0 * # of component	W
Short circuit current	I_{OS}	50	mA

Note : Permanent device damage may occur if "ABSOLUTE MAXIMUM RATINGS" are exceeded.
Functional operation should be restricted to recommended operating condition.
Exposure to higher than recommended voltage for extended periods of time could affect device reliability.

DC OPERATING CONDITIONS AND CHARACTERISTICS

Recommended operating conditions (Voltage referenced to V_{SS} = 0V, T_A = 0 to 70°C)

Parameter	Symbol	Min	Typ	Max	Unit	Note
Supply voltage	V_{DD}	3.0	3.3	3.6	V	
Input high voltage	V_{IH}	2.0	3.0	V_{DDQ}+0.3	V	1
Input low voltage	V_{IL}	-0.3	0	0.8	V	2
Output high voltage	V_{OH}	2.4	-	-	V	I_{OH} = -2mA
Output low voltage	V_{OL}	-	-	0.4	V	I_{OL} = 2mA
Input leakage current	I_{LI}	-10	-	10	uA	3

Notes : 1. V_{IH} (max) = 5.6V AC.The overshoot voltage duration is ≤ 3ns.
2. V_{IL} (min) = -2.0V AC. The undershoot voltage duration is ≤ 3ns.
3. Any input 0V ≤ V_{IN} ≤ V_{DDQ}.
Input leakage currents include Hi-Z output leakage for all bi-directional buffers with Tri-State outputs.

CAPACITANCE(Max.) (V_{DD} = 3.3V, T_A = 23°C, f = 1MHz, V_{REF} = 1.4V ± 200 mV)

Parameter	Symbol	M390S3253ET1 M390S3253ETU	M390S6450ET1 M390S6450ETU	M390S6453ET1	M390S2858ET1 M390S2858ETU	Unit
Input capacitance (A0 ~ A11)	C_{IN1}	15	15	19	15	pF
Input capacitance ($\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$)	C_{IN2}	15	15	19	15	pF
Input capacitance (CKE0)	C_{IN3}	15	15	33	15	pF
Input capacitance (CLK0)	C_{IN4}	23	20	12	20	pF
Input capacitance ($\overline{CS0}$, $\overline{CS2}$)	C_{IN5}	15	15	12	15	pF
Input capacitance (DQM0 ~ DQM7)	C_{IN6}	15	15	12	15	pF
Input capacitance (BA0 ~ BA1)	C_{IN7}	15	15	12	15	pF
Data input/output capacitance(DQ0~DQ63)	C_{OUT1}	16	16	19	22	pF
Data input/ouput capacitance (CB0~CB7)	C_{OUT2}	16	16	19	22	pF

DC CHARACTERISTICS

M390S3253ETU(1) (32M x 72, 256MB Module)

(Recommended operating condition unless otherwise noted, T_A = 0 to 70°C)

Parameter	Symbol	Test Condition	Version	Unit	Note
			7A		
Operating current (One bank active)	I_{CC1}	Burst length = 1 $t_{RC} \geq t_{RC}$(min) I_O = 0 mA	1,220	mA	1
Precharge standby current in power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	370	mA	
	I_{CC2PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	20		
Precharge standby current in non power-down mode	I_{CC2N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	530	mA	
	I_{CC2NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	95		
Active standby current in power-down mode	I_{CC3P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	405	mA	
	I_{CC3PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	60		
Active standby current in non power-down mode (One bank active)	I_{CC3N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	575	mA	
	I_{CC3NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	230	mA	
Operating current (Burst mode)	I_{CC4}	I_O = 0 mA Page burst 4Banks activated t_{CCD} = 2CLKs	1,400	mA	1
Refresh current	I_{CC5}	$t_{RC} \geq t_{RC}$(min)	2,120	mA	2
Self refresh current	I_{CC6}	CKE ≤ 0.2V	380	mA	

M390S6450ETU(1) (64M x 72, 512MB Module)

(Recommended operating condition unless otherwise noted, T_A = 0 to 70°C)

Parameter	Symbol	Test Condition	Version	Unit	Note
			7A		
Operating current (One bank active)	I_{CC1}	Burst length = 1 $t_{RC} \geq t_{RC}$(min) I_O = 0 mA	1,940	mA	1
Precharge standby current in power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	370	mA	
	I_{CC2PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	40		
Precharge standby current in non power-down mode	I_{CC2N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	710	mA	
	I_{CC2NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	185		
Active standby current in power-down mode	I_{CC3P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	460	mA	
	I_{CC3PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	110		
Active standby current in non power-down mode (One bank active)	I_{CC3N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	800	mA	
	I_{CC3NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	455	mA	
Operating current (Burst mode)	I_{CC4}	I_O = 0 mA Page burst 4Banks activated t_{CCD} = 2CLKs	2,300	mA	1
Refresh current	I_{CC5}	$t_{RC} \geq t_{RC}$(min)	3,740	mA	2
Self refresh current	I_{CC6}	CKE ≤ 0.2V	405	mA	

Notes : 1. Measured with outputs open.
2. Refresh period is 64ms.
3. Unless otherwise noted, input swing level is CMOS(V_{IH}/V_{IL}=V_{DDQ}/V_{SSQ})

DC CHARACTERISTICS

M390S6453ET1 (64M x 72, 512MB Module)

(Recommended operating condition unless otherwise noted, T_A = 0 to 70°C)

Parameter	Symbol	Test Condition	Version 7A	Unit	Note
Operating current (One bank active)	I_{CC1}	Burst length = 1 $t_{RC} \geq t_{RC}$(min) I_O = 0 mA	1,445	mA	1
Precharge standby current in power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	390	mA	
	I_{CC2PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	40		
Precharge standby current in non power-down mode	I_{CC2N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	710	mA	
	I_{CC2NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	185		
Active standby current in power-down mode	I_{CC3P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	460	mA	
	I_{CC3PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	110		
Active standby current in non power-down mode (One bank active)	I_{CC3N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	800	mA	
	I_{CC3NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	455	mA	
Operating current (Burst mode)	I_{CC4}	I_O = 0 mA Page burst 4Banks activated t_{CCD} = 2CLKs	1,625	mA	1
Refresh current	I_{CC5}	$t_{RC} \geq t_{RC}$(min)	2,345	mA	2
Self refresh current	I_{CC6}	CKE ≤ 0.2V	405	mA	

M390S2858ETU(1) (128M x 72, 1GB Module)

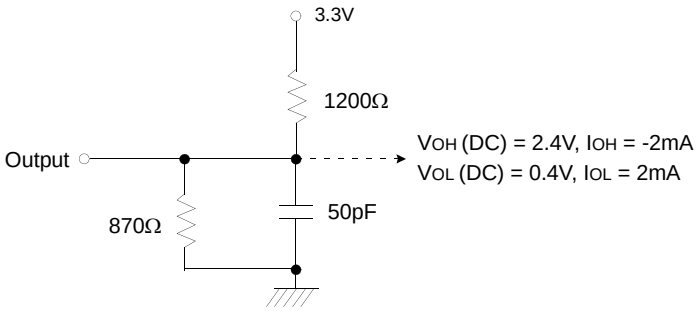
(Recommended operating condition unless otherwise noted, T_A = 0 to 70°C)

Parameter	Symbol	Test Condition	Version 7A	Unit	Note
Operating current (One bank active)	I_{CC1}	Burst length = 1 $t_{RC} \geq t_{RC}$(min) I_O = 0 mA	2,390	mA	1
Precharge standby current in power-down mode	I_{CC2P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	425	mA	
	I_{CC2PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	75		
Precharge standby current in non power-down mode	I_{CC2N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	1,070	mA	
	I_{CC2NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	365		
Active standby current in power-down mode	I_{CC3P}	CKE ≤ V_{IL}(max), t_{CC} = 10ns	570	mA	
	I_{CC3PS}	CKE & CLK ≤ V_{IL}(max), t_{CC} =∞	220		
Active standby current in non power-down mode (One bank active)	I_{CC3N}	CKE ≥ V_{IH}(min), $\overline{CS}$ ≥ V_{IH}(min), t_{CC} = 10ns Input signals are changed one time during 20ns	1,250	mA	
	I_{CC3NS}	CKE ≥ V_{IH}(min), CLK ≤ V_{IL}(max), t_{CC} =∞ Input signals are stable	905	mA	
Operating current (Burst mode)	I_{CC4}	I_O = 0 mA Page burst 4Banks activated t_{CCD} = 2CLKs	2,750	mA	1
Refresh current	I_{CC5}	$t_{RC} \geq t_{RC}$(min)	4,190	mA	2
Self refresh current	I_{CC6}	CKE ≤ 0.2V	460	mA	

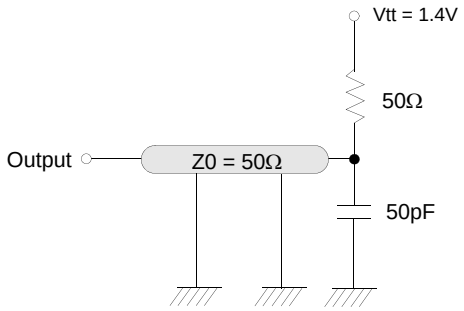
Notes : 1. Measured with outputs open.
2. Refresh period is 64ms.
3. Unless otherwise noted, input swing level is CMOS(V_{IH}/V_{IL}=V_{DDQ}/V_{SSQ})

AC OPERATING TEST CONDITIONS (V_{DD} = 3.3V ± 0.3V, T_A = 0 to 70°C)

Parameter	Value	Unit
AC input levels (Vih/Vil)	2.4/0.4	V
Input timing measurement reference level	1.4	V
Input rise and fall time	tr/tf = 1/1	ns
Output timing measurement reference level	1.4	V
Output load condition	See Fig. 2	



(Fig. 1) DC output load circuit



(Fig. 2) AC output load circuit

OPERATING AC PARAMETER

(AC operating conditions unless otherwise noted)

Parameter		Symbol	Version	Unit	Note
			7A		
Row active to row active delay		tRRD(min)	15	ns	1
$\overline{RAS}$ to $\overline{CAS}$ delay		tRCD(min)	20	ns	1
Row precharge time		tRP(min)	20	ns	1
Row active time		tRAS(min)	45	ns	1
		tRAS(max)	100	us	
Row cycle time		tRC(min)	65	ns	1
Last data in to row precharge		tRDL(min)	2	CLK	2,5
Last data in to Active delay		tDAL(min)	2 CLK + tRP	-	5
Last data in to new col. address delay		tCDL(min)	1	CLK	2
Last data in to burst stop		tBDL(min)	1	CLK	2
Col. address to col. address delay		tCCD(min)	1	CLK	3
Number of valid output data	CAS latency=3		2	ea	4
	CAS latency=2		1		

Notes : 1. The minimum number of clock cycles is determined by dividing the minimum time required with clock cycle time and then rounding off to the next higher integer.
2. Minimum delay is required to complete write.
3. All parts allow every cycle column address change.
4. In case of row precharge interrupt, auto precharge and read burst stop.
5. In 100MHz and below 100MHz operating conditions, tRDL=1CLK and tDAL=1CLK + 20ns is also supported. SAMSUNG recommends tRDL=2CLK and tDAL=2CLK + tRP.

AC CHARACTERISTICS (AC operating conditions unless otherwise noted)

REFER TO THE INDIVIDUAL COMPONENET, NOT THE WHOLE MODULE.

Parameter		Symbol	7A		Unit	Note
			Min	Max		
CLK cycle time	CAS latency=3	t_{CC}	7.5	1000	ns	1
	CAS latency=2		10			
CLK to valid output delay	CAS latency=3	t_{SAC}		5.4	ns	1,2
	CAS latency=2			6		
Output data hold time	CAS latency=3	t_{OH}	3		ns	2
	CAS latency=2		3			
CLK high pulse width		t_{CH}	2.5		ns	3
CLK low pulse width		t_{CL}	2.5		ns	3
Input setup time		t_{SS}	1.5		ns	3
Input hold time		t_{SH}	0.8		ns	3
CLK to output in Low-Z		t_{SLZ}	1		ns	2
CLK to output in Hi-Z	CAS latency=3	t_{SHZ}		5.4	ns	
	CAS latency=2			6		

Notes : 1. Parameters depend on programmed CAS latency.

2. If clock rising time is longer than 1ns, (tr/2-0.5)ns should be added to the parameter.

3. Assumed input rise and fall time (tr & tf) = 1ns.
   If tr & tf is longer than 1ns, transient time compensation should be considered,
   i.e., [(tr + tf)/2-1]ns should be added to the parameter.

SIMPLIFIED TRUTH TABLE

(V=Valid, X=Don't care, H=Logic high, L=Logic low)

Command			CKEn-1	CKEn	$\overline{CS}$	$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	DQM	$BA_{0,1}$	A_{10}/AP	A_0 ~ A_9, A_{11}, A_{12}	Note
Register	Mode register set		H	X	L	L	L	L	X	OP code			1,2
Refresh	Auto refresh		H	H	L	L	L	H	X	X			3
	Self refresh	Entry		L									3
		Exit	L	H	L	H	H	H	X	X			3
					H	X	X	X					3
Bank active & row addr.			H	X	L	L	H	H	X	V	Row address		
Read & column address	Auto precharge disable		H	X	L	H	L	H	X	V	L	Column address	4
	Auto precharge enable										H		4,5
Write & column address	Auto precharge disable		H	X	L	H	L	L	X	V	L	Column address	4
	Auto precharge enable										H		4,5
Burst stop			H	X	L	H	H	L	X	X			6
Precharge	Bank selection		H	X	L	L	H	L	X	V	L	X	
	All banks									X	H		
Clock suspend or active power down		Entry	H	L	H	X	X	X	X	X			
					L	V	V	V					
		Exit	L	H	X	X	X	X	X				
Precharge power down mode		Entry	H	L	H	X	X	X	X	X			
					L	H	H	H					
		Exit	L	H	H	X	X	X	X				
					L	V	V	V					
DQM			H	X					V	X			7
No operation command			H	X	H	X	X	X	X	X			
					L	H	H	H					

Notes : 1. OP Code : Operand code
A_0 ~ A_{12} & BA_0 ~ BA_1 : Program keys. (@ MRS)

2. MRS can be issued only at all banks precharge state.
A new command can be issued after 2 clock cycles of MRS.

3. Auto refresh functions are as same as CBR refresh of DRAM.
The automatical precharge without row precharge command is meant by "Auto".
Auto/self refresh can be issued only at all banks precharge state.

4. BA_0 ~ BA_1 : Bank select addresses.
If both BA_0 and BA_1 are "Low" at read, write, row active and precharge, bank A is selected.
If BA_0 is "High" and BA_1 is "Low" at read, write, row active and precharge, bank B is selected.
If BA_0 is "Low" and BA_1 is "High" at read, write, row active and precharge, bank C is selected.
If both BA_0 and BA_1 are "High" at read, write, row active and precharge, bank D is selected.
If A_{10}/AP is "High" at row precharge, BA_0 and BA_1 is ignored and all banks are selected.

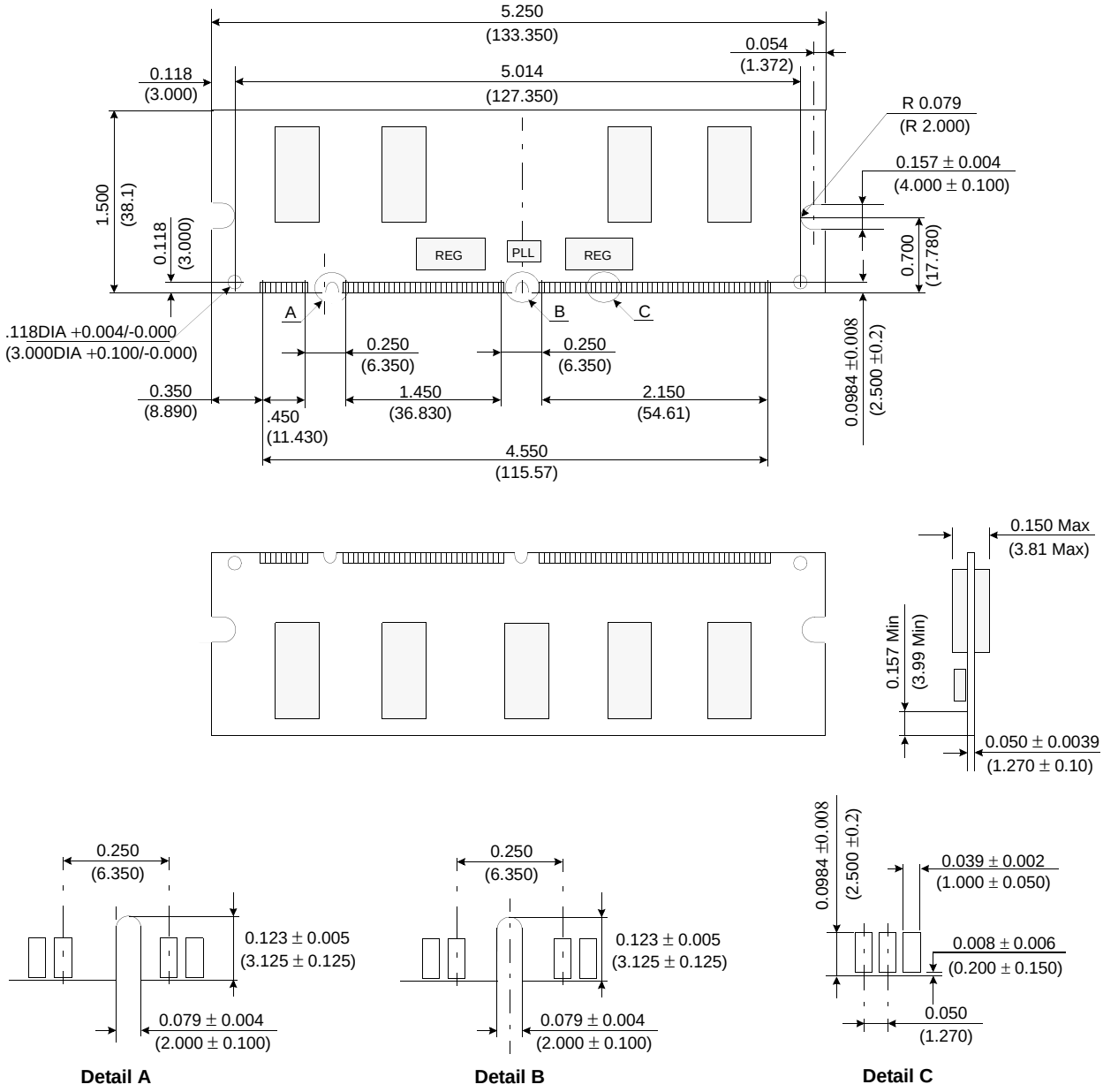
5. During burst read or write with auto precharge, new read/write command can not be issued.
Another bank read/write command can be issued after the end of burst.
New row active of the associated bank can be issued at t_{RP} after the end of burst.

6. Burst stop command is valid at every burst length.

7. DQM sampled at positive going edge of a CLK and masks the data-in at the very CLK (Write DQM latency is 0), but makes Hi-Z state the data-out of 2 CLK cycles after. (Read DQM latency is 2)

PACKAGE DIMENSIONS : 32Mx72 (M390S3253ET1)

Units : Inches (Millimeters)



Detail A **Detail B** **Detail C**

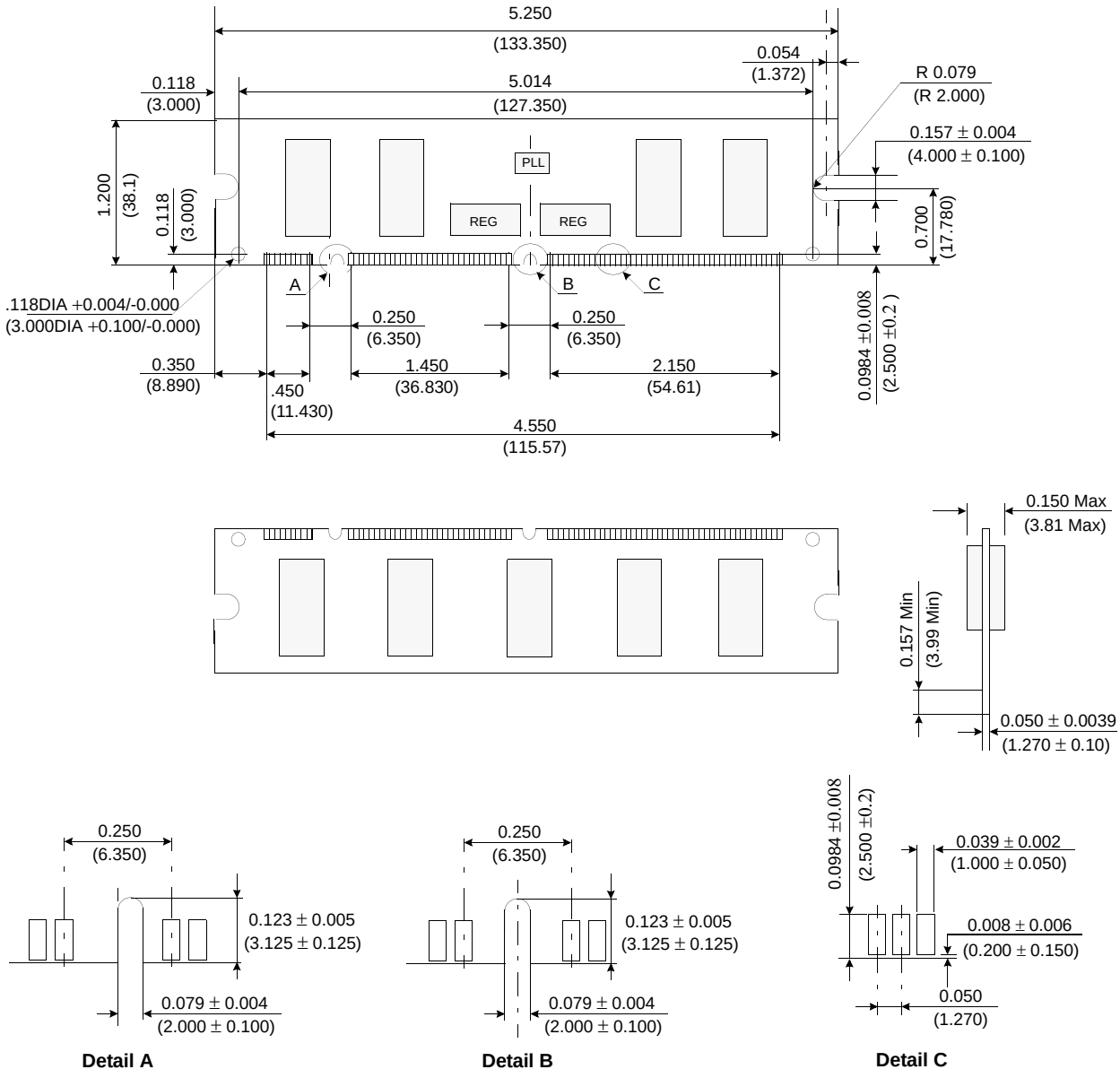
Tolerances : ± 0.005(.13) unless otherwise specified

The used device is 32Mx8 SDRAM, TSOPII
SDRAM Part No. : K4S560832E

This module is based on JEDEC PC133 Specification

PACKAGE DIMENSIONS : 32Mx72 (M390S3253ETU)

Units : Inches (Millimeters)



Detail A **Detail B** **Detail C**

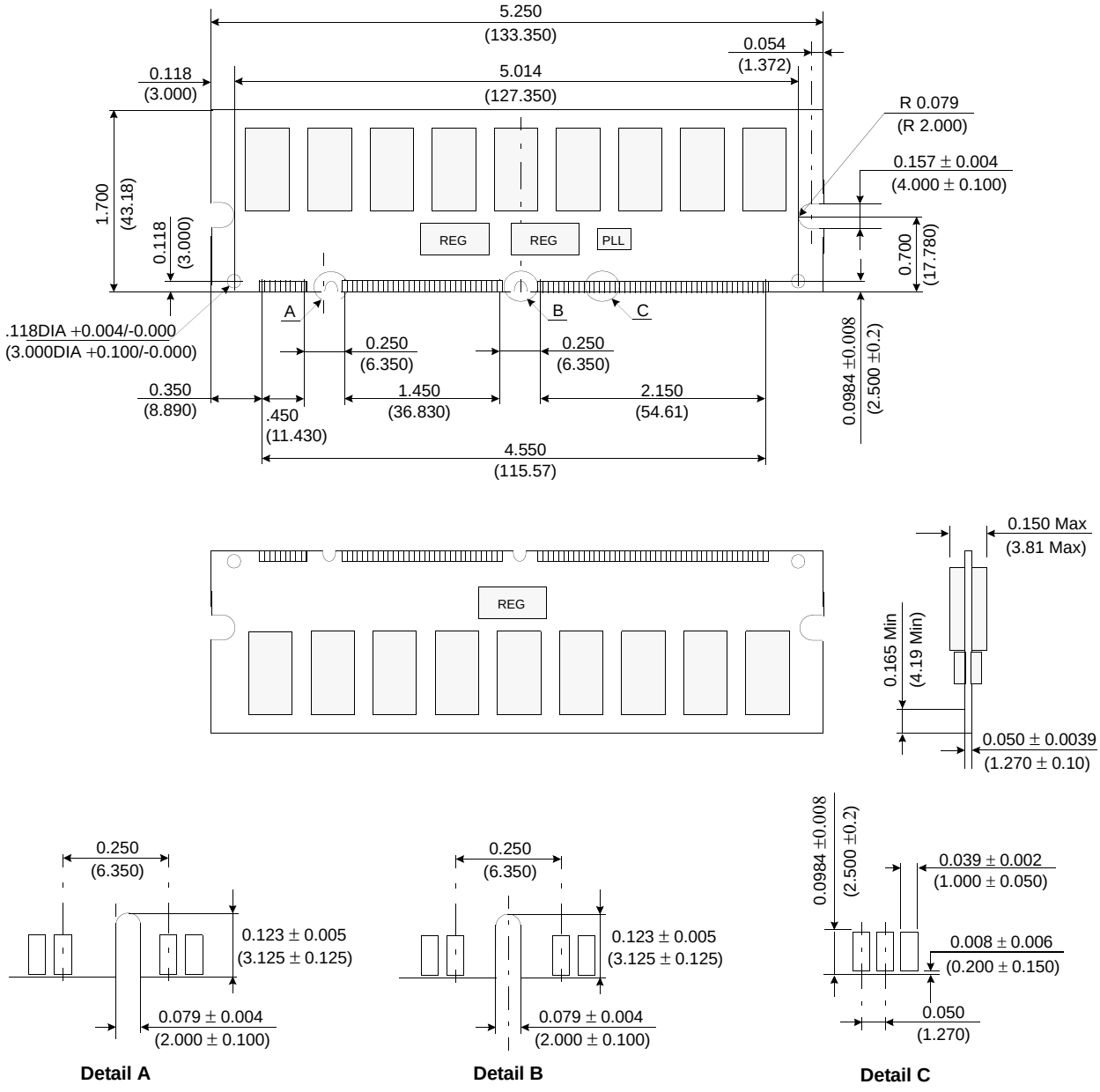
Tolerances : ± 0.005(.13) unless otherwise specified

The used device is 32Mx8 SDRAM, TSOPII
SDRAM Part No. : K4S560832E

This module is based on JEDEC PC133 Specification

PACKAGE DIMENSIONS : 64Mx72 (M390S6450ET1)

Units : Inches (Millimeters)



Detail A **Detail B** **Detail C**

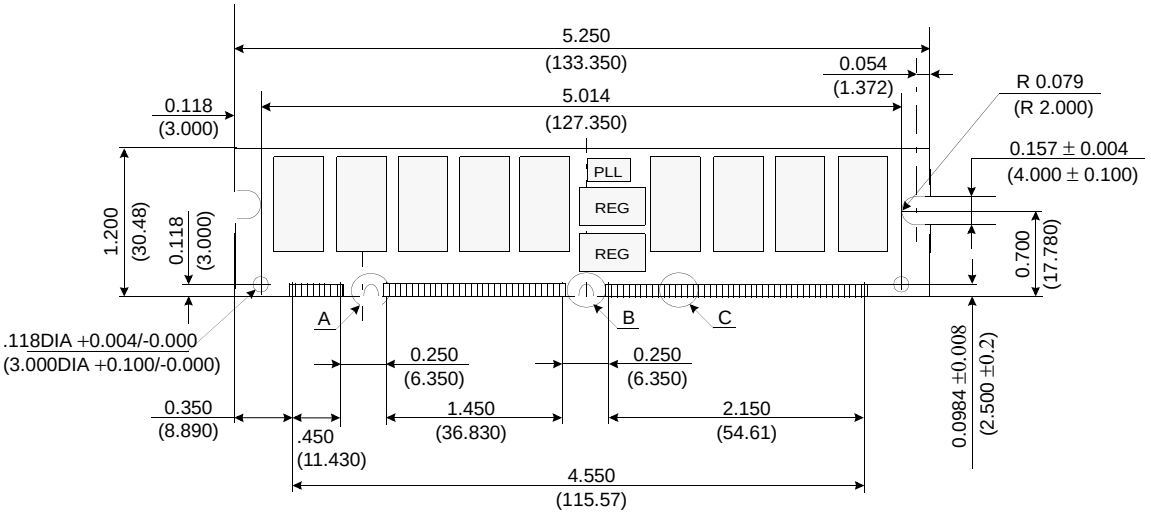
Tolerances : ± 0.005(.13) unless otherwise specified

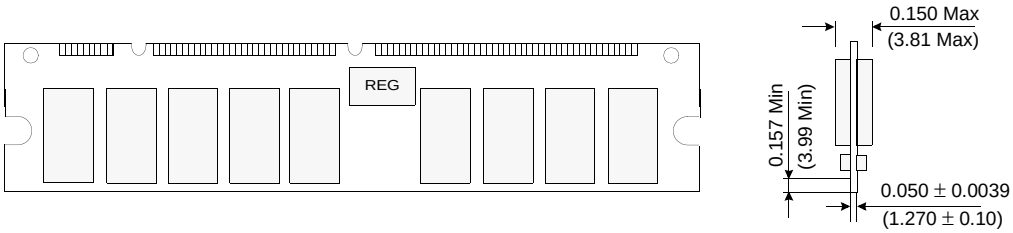
The used device is 64Mx4 SDRAM, TSOPII
SDRAM Part No. : K4S560432E

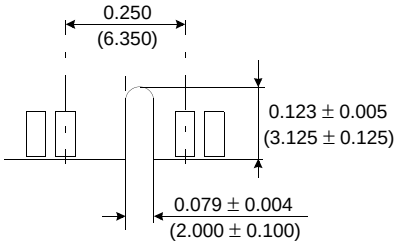
This module is based on JEDEC PC133 Specification

PACKAGE DIMENSIONS : 64Mx72 (M390S6450ETU)

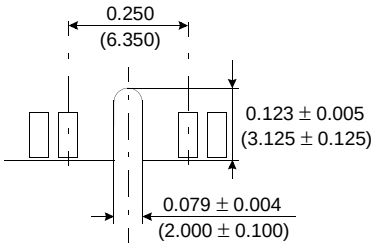
Units : Inches (Millimeters)



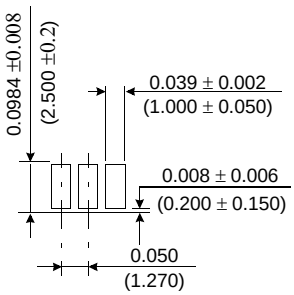




Detail A



Detail B



Detail C

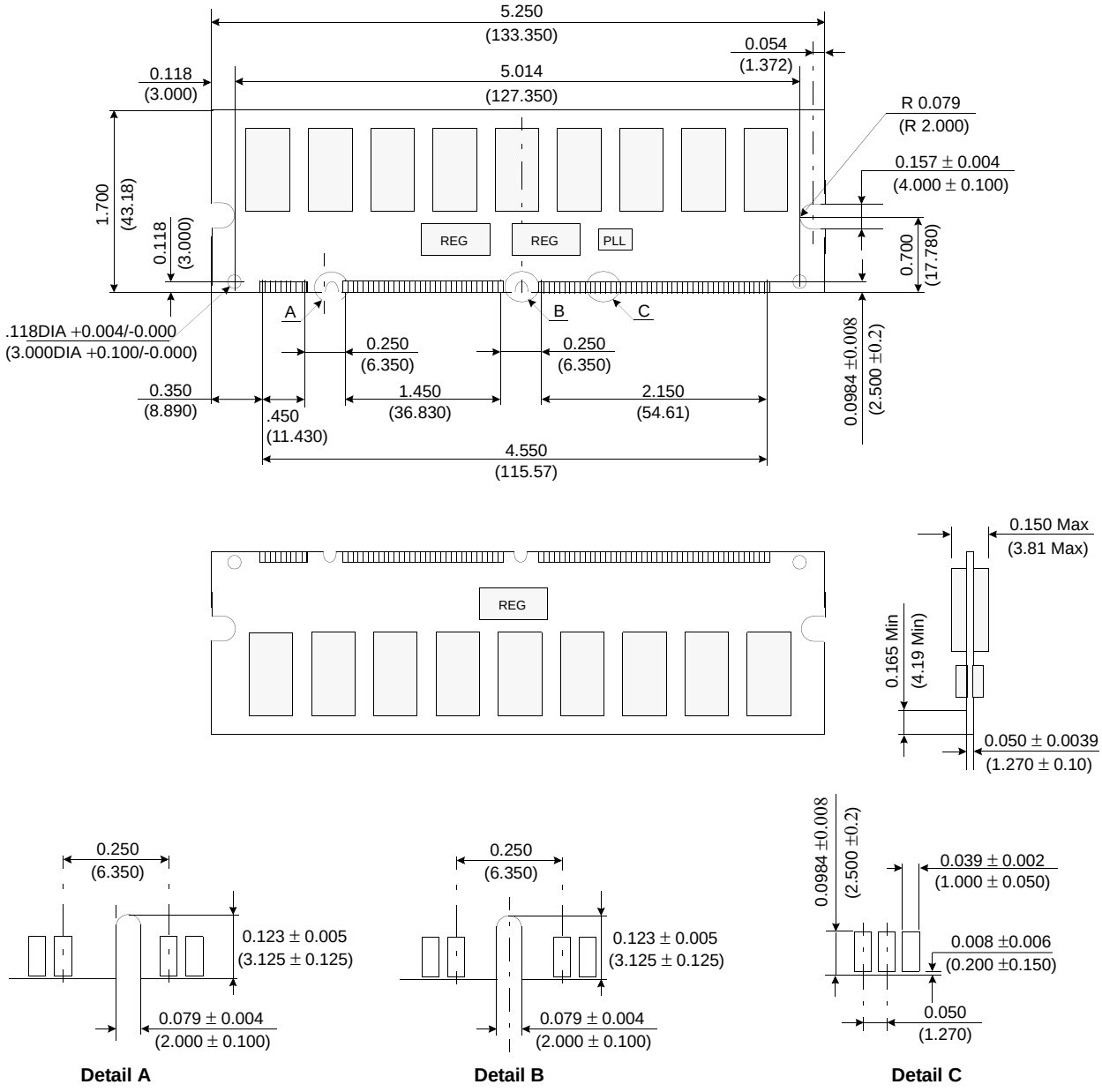
Tolerances : ± 0.005(.13) unless otherwise specified

The used device is 64Mx4 SDRAM, TSOPII
SDRAM Part No. : K4S560432E

This module is based on JEDEC PC133 Specification

PACKAGE DIMENSIONS : 64Mx72 (M390S6453ET1)

Units : Inches (Millimeters)



Detail A **Detail B** **Detail C**

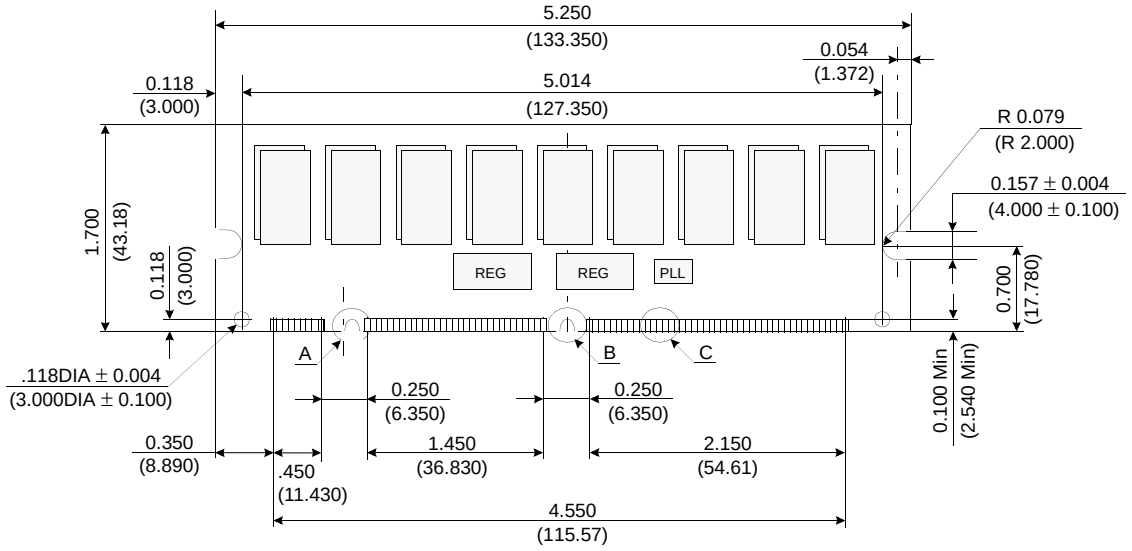
Tolerances :± 0.005(.13) unless otherwise specified

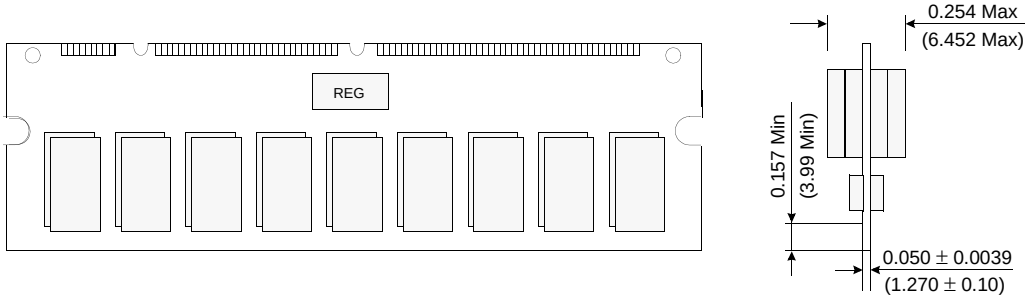
The used device is 32Mx8 SDRAM, TSOPII
SDRAM Part No. : K4S560832E

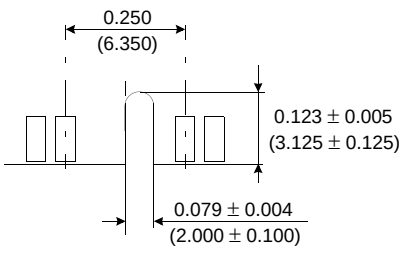
This module is based on JEDEC PC133 Specification

PACKAGE DIMENSIONS : 128Mx72 (M390S2858ET1)

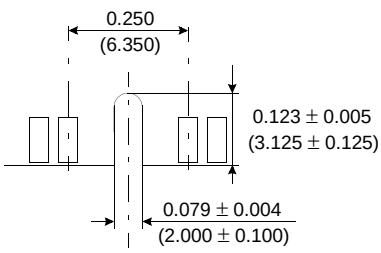
Units : Inches (Millimeters)



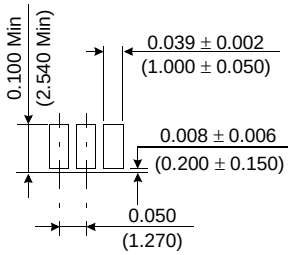




Detail A



Detail B



Detail C

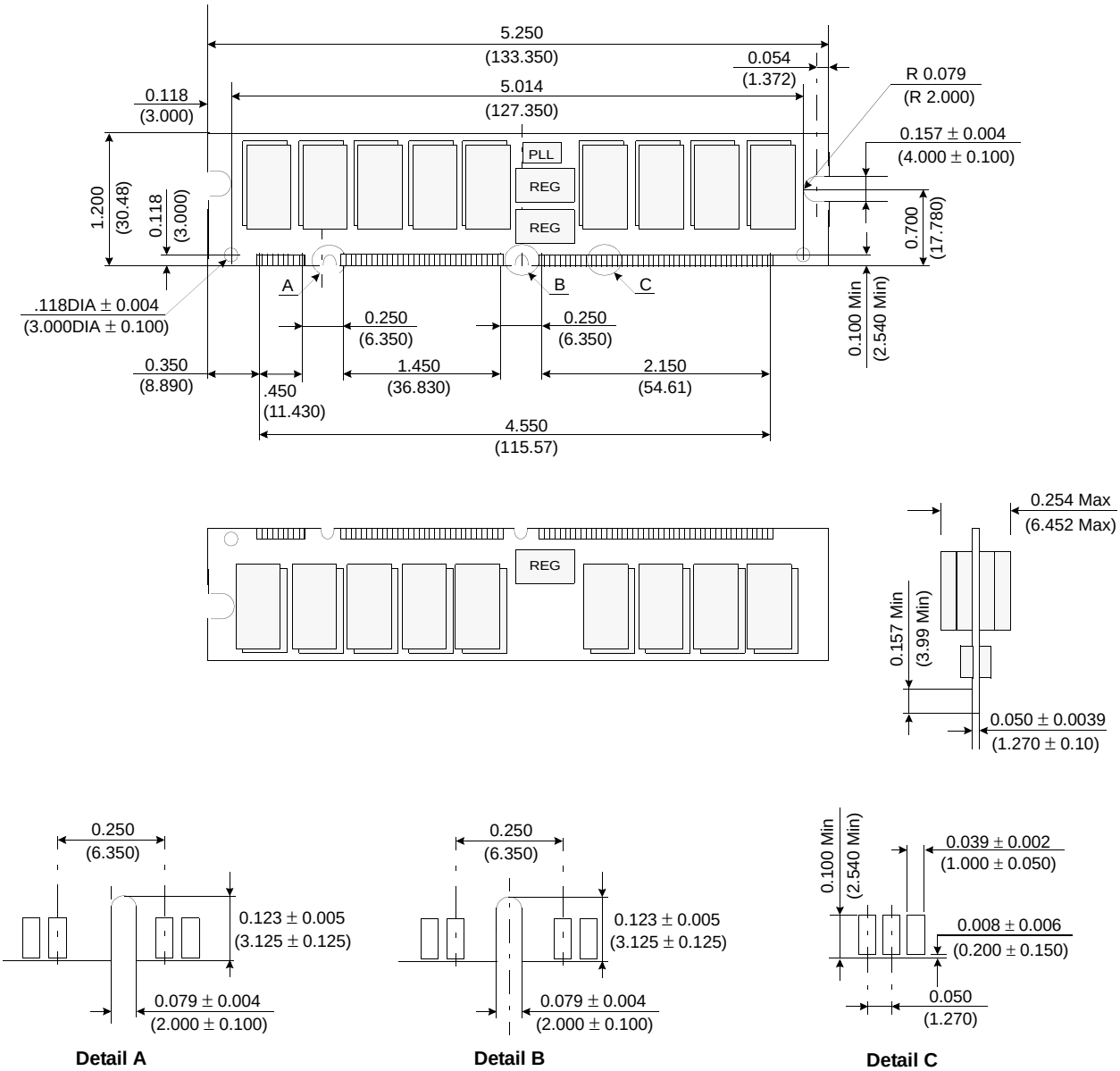
Tolerances : ± 0.005(.13) unless otherwise specified

SDRAM Part No. : K4S510632E
- The used device is stacked 128Mx4 SDRAM, TSOPII
- Staktek's stacking technology is Samsung's stacking technology of choice

This module is based on JEDEC PC133 Specification

PACKAGE DIMENSIONS : 128Mx72 (M390S2858ETU)

Units : Inches (Millimeters)



Detail A **Detail B** **Detail C**

Tolerances : ± 0.005(.13) unless otherwise specified

SDRAM Part No. : K4S510632E
- The used device is stacked 128Mx4 SDRAM, TSOPII
- Staktek's stacking technology is Samsung's stacking technology of choice

This module is based on JEDEC PC133 Specification