Features

- 256K x 18 & 128K x 36 Organizations
- CMOS Technolgy
- Synchronous Pipeline Mode Of Operation with Standard Write
- Single Clock compatible with LVTTL Levels
- +3.3V Power Supply and Ground
- Common I/O & LVTTL I/O Compatible
- Registered Addresses, Write Enables, Synchronous Select and Data Ins
- Registered Outputs
- Asynchronous Output Enable and Power Down Inputs
- Boundary Scan using limited set of JTAG 1149.1 functions
- Byte Write Capability & Global Write Enable
- 7 X 17 Bump Ball Grid Array Package with SRAM JEDEC Standard Pinout and Boundary SCAN Order.

Description

The IBM0418BSRLAA & IBM0436BSRLAA 4Mb SRAM is Synchronous Pipeline Mode, high performance CMOS Static Random Access Memory that is versatile, wide I/O, and achieves 7 ns cycle times. K clock is used to initiate the read/write operation and all internal operations are self-timed. At the rising edge of the K Clock, all Addresses, Write-Enables, Sync Select and Data Ins are registered internally. Data Outs are updated from output registers off the next rising edge of the K Clock. Data-Ins are registered in the same cycle as the writre controls. The chip is operated with a +3.3V power supply and is compatible with LVTTL I/O interfaces.

X36 BGA Bump Layout (Top View)

	1	2	3	4	5	6	7
A	V_{DDQ}	SA5	SA7	NC	SA16	SA14	V_{DDQ}
B	NC	NC	SA8	NC	SA11	NC	NC
C	NC	SA6	SA9	V_{DD}	SA10	SA15	NC
D	DQc18	DQc19	V_{SS}	NC	V_{SS}	DQb10	DQb9
E	DQc20	DQc21	V_{SS}	$\overline{SS}$	V_{SS}	DQb12	DQb11
F	V_{DDQ}	DQc22	V_{SS}	$\overline{G}$	V_{SS}	DQb13	V_{DDQ}
G	DQc23	DQc24	$\overline{SBWc}$	NC	$\overline{SBWb}$	DQb15	DQb14
H	DQc25	DQc26	V_{SS}	NC	V_{SS}	DQb17	DQb16
J	V_{DDQ}	V_{DD}	NC	V_{DD}	NC	V_{DD}	V_{DDQ}
K	DQd34	DQd35	VSS	K	VSS	DQa8	DQa7
L	DQd32	DQd33	$\overline{SBWd}$	NC	$\overline{SBWa}$	DQa6	DQa5
M	V_{DDQ}	DQd31	V_{SS}	$\overline{SW}$	V_{SS}	DQa4	V_{DDQ}
N	DQd29	DQd30	V_{SS}	SA0	V_{SS}	DQa3	DQa2
P	DQd27	DQd28	V_{SS}	SA1	V_{SS}	DQa1	DQa0
R	NC	SA4	M1*	V_{DD}	M2*	SA12	NC
T	NC	NC	SA3	SA2	SA13	NC	ZZ
U	V_{DDQ}	TMS	TDI	TCK	TDO	NC	V_{DDQ}

Note: * M1 and M2 are clock mode pins. For this application, M1 and M2 need to connect to V_{SS} and V_{DD}, respectively.

X18 BGA Bump Layout (Top View)

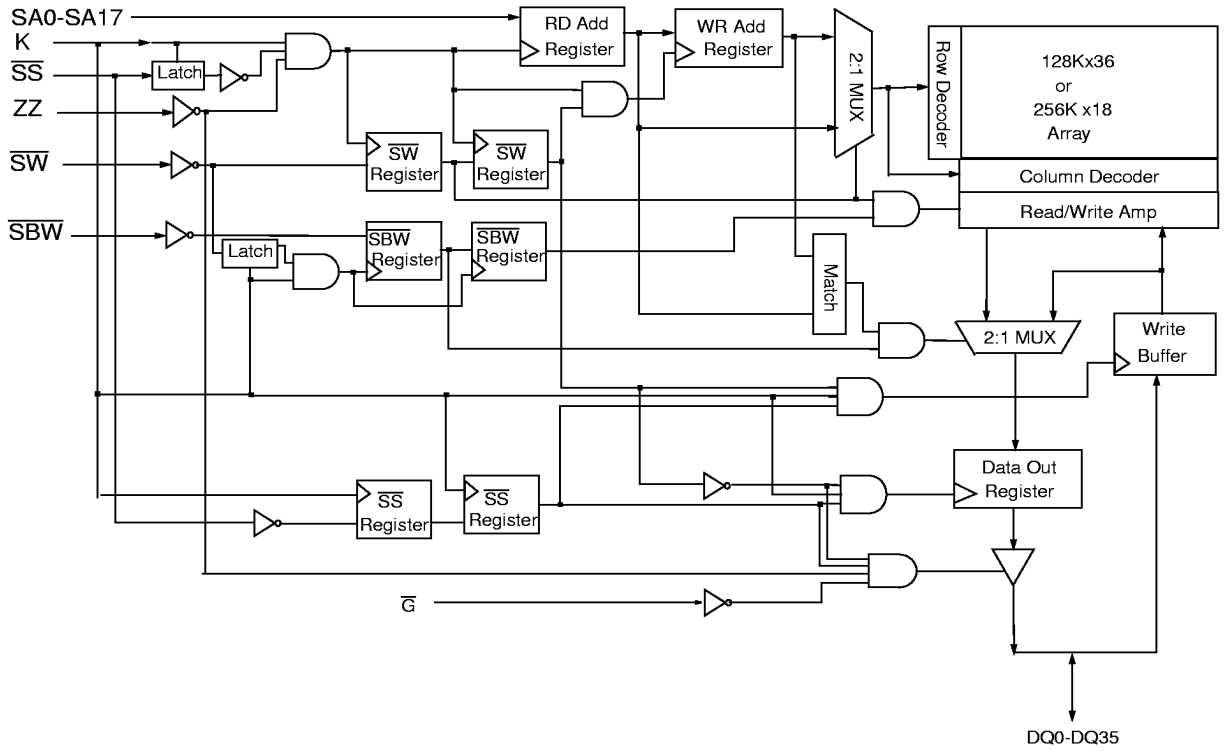
	1	2	3	4	5	6	7
A	V_{DDQ}	SA5	SA7	NC	SA16	SA14	V_{DDQ}
B	NC	NC	SA8	NC	SA11	NC	NC
C	NC	SA6	SA9	V_{DD}	SA10	SA15	NC
D	DQb9	NC	V_{SS}	NC	V_{SS}	DQa1	NC
E	NC	DQb12	V_{SS}	$\overline{SS}$	V_{SS}	NC	DQa2
F	V_{DDQ}	NC	V_{SS}	$\overline{G}$	V_{SS}	DQa4	V_{DDQ}
G	NC	DQb15	$\overline{SBWb}$	NC	V_{SS}	NC	DQa5
H	DQb16	NC	V_{SS}	NC	V_{SS}	DQa8	NC
J	V_{DDQ}	V_{DD}	NC	V_{DD}	NC	VDD	V_{DDQ}
K	NC	DQb17	V_{SS}	K	V_{SS}	NC	DQa7
L	DQb14	NC	V_{SS}	NC	$\overline{SBWa}$	DQa6	NC
M	V_{DDQ}	DQb13	V_{SS}	$\overline{SW}$	V_{SS}	NC	V_{DDQ}
N	DQb11	NC	V_{SS}	SA0	V_{SS}	DQa3	NC
P	NC	DQb10	V_{SS}	SA1	V_{SS}	NC	DQa0
R	NC	SA4	M1	V_{DD}	M2	SA13	NC
T	NC	SA2	SA3	NC	SA17	SA12	ZZ
U	V_{DDQ}	TMS	TDI	TCK	TDO	NC	V_{DDQ}

Note: * M1 and M2 are clock mode pins. For this application, M1 and M2 need to connect to V_{SS} and V_{DD} respectively.

Pin Description

SA0-SA17	Address Input	TDO	IEEE 1149 Test Output
DQa,DQb,DQc,DQd	Data I/O (DQ0-8,DQ9-17,DQ18-26,DQ27-35)	$\overline{SS}$	Synchronous Select
K	Clock (LVTTL Compatible)	M1, M2	Clock Mode Inputs
$\overline{SW}$	Write Enable, global	V_{DD}	Power Supply (+3.3V)
$\overline{SBWa}$	Write Enable, Byte a (DQ0 to DQ8)	V_{SS}	Ground
$\overline{SBWb}$	Write Enable, Byte b (DQ9 to DQ17)	V_{DDQ}	Output Power Supply
$\overline{SBWc}$	Write Enable, Byte c (DQ18 to DQ26)	$\overline{G}$	Asynchronous Output Enable
$\overline{SBWd}$	Write Enable, Byte d (DQ27 to DQ35)	ZZ	Asynchronous Sleep Mode
TMS,TDI,TCK	IEEE 1149 Test Inputs	NC	No Connect

Block Diagram



SRAM FEATURES

Standard Write

In Standard Write function, write data must be registered in the same cycle as addresses and controls.

Mode Control

Mode control pins: M1 and M2 are used to select four different JEDEC standard read protocols. This SRAM only supports the single clock pipeline (M1 = V_{SS}, M2 = V_{DD}) protocol. Mode control inputs must be set with power up and must not change during SRAM operation.

Power Down Mode

Power Down Mode, or “Sleep Mode” is accomplished by switching asynchronous signal ZZ high. When the SRAM is in Sleep Mode, the outputs will go to a High-Z state and the SRAM will draw standby current. SRAM data will be preserved and a recovery time (t_{ZZR}) is required before the SRAM resumes to normal operation.

Ordering Information

Part Number	Organization	Speed	Leads
IBM04184BSLAA-7	256K x 18	3.5ns Access / 7ns Cycle	7 X 17 BGA
IBM04364BSLAA-7	128K x 36	3.5ns Access / 7ns Cycle	7 X 17 BGA

Clock Truth Table

K	ZZ	$\overline{SS}$	$\overline{SW}$	$\overline{SBWa}$	$\overline{SBWb}$	$\overline{SBWc}$	$\overline{SBWd}$	DQ (n)	DQ (n+1)	MODE
L→H	L	L	H	X	X	X	X	X	D_{OUT} 0-35	Read Cycle All Bytes
L→H	L	L	L	L	H	H	H	X	D_{IN} 0-8	Write Cycle 1st Byte
L→H	L	L	L	H	L	H	H	X	D_{IN} 9-17	Write Cycle 2nd Byte
L→H	L	L	L	H	H	L	H	X	D_{IN} 18-26	Write Cycle 3rd Byte
L→H	L	L	L	H	H	H	L	X	D_{IN} 27-35	Write Cycle 4th Byte
L→H	L	L	L	L	L	L	L	X	D_{IN} 0-35	Write Cycle All Bytes
L→H	L	L	L	H	H	H	H	X	High-Z	Abort Write Cycle
L→H	L	H	X	X	X	X	X	X	High-Z	Deselect Cycle
X	H	X	X	X	X	X	X	High-Z	High-Z	Sleep Mode

Output Enable Truth Table

Operation	$\overline{G}$	DQ
Read	L	D_{OUT} 0-35
Read	H	High-Z
Sleep (ZZ=H)	X	High-Z
Write ($\overline{SW}$=L)	X	High-Z
Deselect ($\overline{SS}$=H)	X	High-Z

Absolute Maximum Ratings

Item	Symbol	Rating	Units	Notes
Power Supply Voltage	V_{DD}	-0.5 to 3.9	V	1
Output Power Supply Voltage	V_{DDQ}	-0.5 to 3.9	V	1
Input Voltage	V_{IN}	-0.5 to V_{DD}+0.5	V	1
Output Voltage	V_{OUT}	-0.5 to V_{DD}+0.5	V	1
Operating Temperature	T_J	0 to +110	°C	1
Storage Temperature	T_{STG}	-55 to +125	°C	1
Short Circuit Output Current	I_{OUT}	25	mA	1
Latchup Current	I_{LI}	>200	mA	

1. Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Recommended DC Operating Conditions (T_J=0 to 110°C)

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Voltage	V_{DD}	3.135	3.3	3.47	V	1
OCD Supply Voltage	V_{DDQ}	2.25	2.5	3.47	V	1
Input High Voltage	V_{IH}	2.0	—	V_{DD}+0.3	V	1, 2
Input Low Voltage	V_{IL}	-0.3	—	0.8	V	1, 3
Output Current	I_{OUT}	—	5	8	mA	

1. All voltages referenced to V_{SS}. All V_{DD}, V_{DDQ} and V_{SS} pins must be connected.
2. V_{IH}(Max)DC = V_{DD} + 0.3 V, V_{IH}(Max)AC = V_{DD} + 1.5 V (pulse width ≤ 4.0ns).
3. V_{IL}(Min)DC = - 0.3 V, V_{IL}(Min)AC= -1.5 V (pulse width ≤ 4.0ns).

Capacitance (T_J=0 to +110°C, V_{DD}= 3.3 ± 5% V, f=1MHz)

Parameter	Symbol	Test Condition	Max	Units
Input Capacitance	C_{IN}	V_{IN} = 0V	4	pF
Data I/O Capacitance (DQ0-DQ35)	C_{OUT}	V_{OUT} = 0V	5	pF

DC Electrical Characteristics (T_J= 0 to +110°C, V_{DD}=V_{DDQ}=3.3 ± 5% V)

Parameter	Symbol	Min.	Max.	Units	Notes
Average Power Supply Operating Current - X18 (I_{OUT} = 0, V_{IN} = V_{IH} or V_{IL}, ZZ & $\overline{SS}$ = V_{IL})	I_{DD7}	—	400	mA	1
Average Power Supply Operating Current - X36 (I_{OUT} = 0, V_{IN} = V_{IH} or V_{IL}, ZZ & $\overline{SS}$ = V_{IL})	I_{DD7}	—	450	mA	1
Power Supply Standby Current (ZZ =V_{IH}, All other inputs = V_{IH} or V_{IL}, I_{OUT} = 0)	I_{SBZZ}	—	120	mA	1
Power Supply Standby Current ($\overline{SS}$=V_{IH},ZZ=V_{IL}, All other inputs= V_{IH} or V_{IL}, IOUT=0)	I_{SBSS}		150	mA	1
Input Leakage Current, any input (V_{IN} = V_{SS} or V_{DD})	I_{LI}	—	+1	µA	
Output Leakage Current (V_{OUT} = V_{SS} to 3.0V, DQ in High-Z) (V_{OUT} = 3.0 to V_{DD}, DQ in High-Z)	I_{LO1} I_{LO2}	— -	+2 +100	µA	
Output High "H" Level Voltage (I_{OH}=-8mA @ 2.4V)	V_{OH}	2.4	—	V	
Output Low "L" Level Voltage (I_{OL}=+8mA @ 0.4V)	V_{OL}	—	0.4	V	
Output High "H" Level Voltage (I_{OH}=-8mA @ 2.4V) Vddq = 2.5V	V_{OH}	1.6	—	V	
Output Low "L" Level Voltage (I_{OL}=+8mA @ 0.4V) Vddq = 2.5V	V_{OL}	—	0.4	V	

1. I_{OUT} = Chip Output Current. Idd5 refers to 5ns cycle time and Idd6 refers to 6ns cycle time, etc.

PBGA Thermal Characteristics

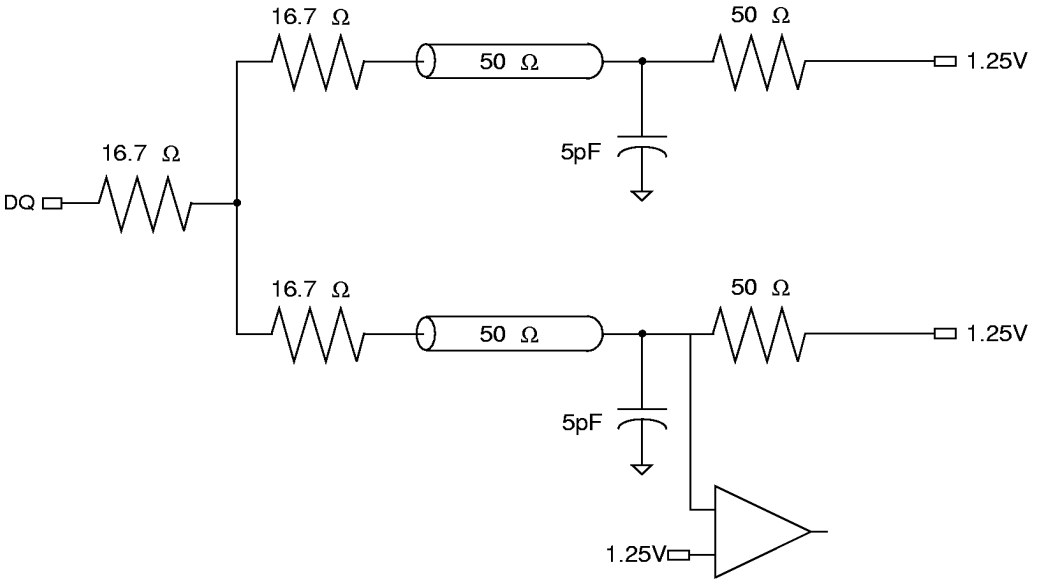
Item	Symbol	Rating	Units
Thermal Resistance Junction to Case	RΘJC	1	°C/W

AC Test Conditions (T_J=0 to +110C, V_{DD}= 3.3 +10/–5% V, V_{DDQ}= 2.5 ± 5% V)

Parameter	Symbol	Conditions	Units	Notes
Input High Level	V_{IH}	2.25	V	
Input Low Level	V_{IL}	0.25	V	
Input Rise Time	T_R	1.0	ns	
Input Fall Time	T_F	1.0	ns	
Clock Input Rise Time	$T_{R\text{-}Clock}$	1.0	ns	
Clock Input Fall Time	$T_{F\text{-}Clock}$	1.0	ns	
Output Load Conditions				1

1. See AC Test Loading on page 7.

AC Test Loading

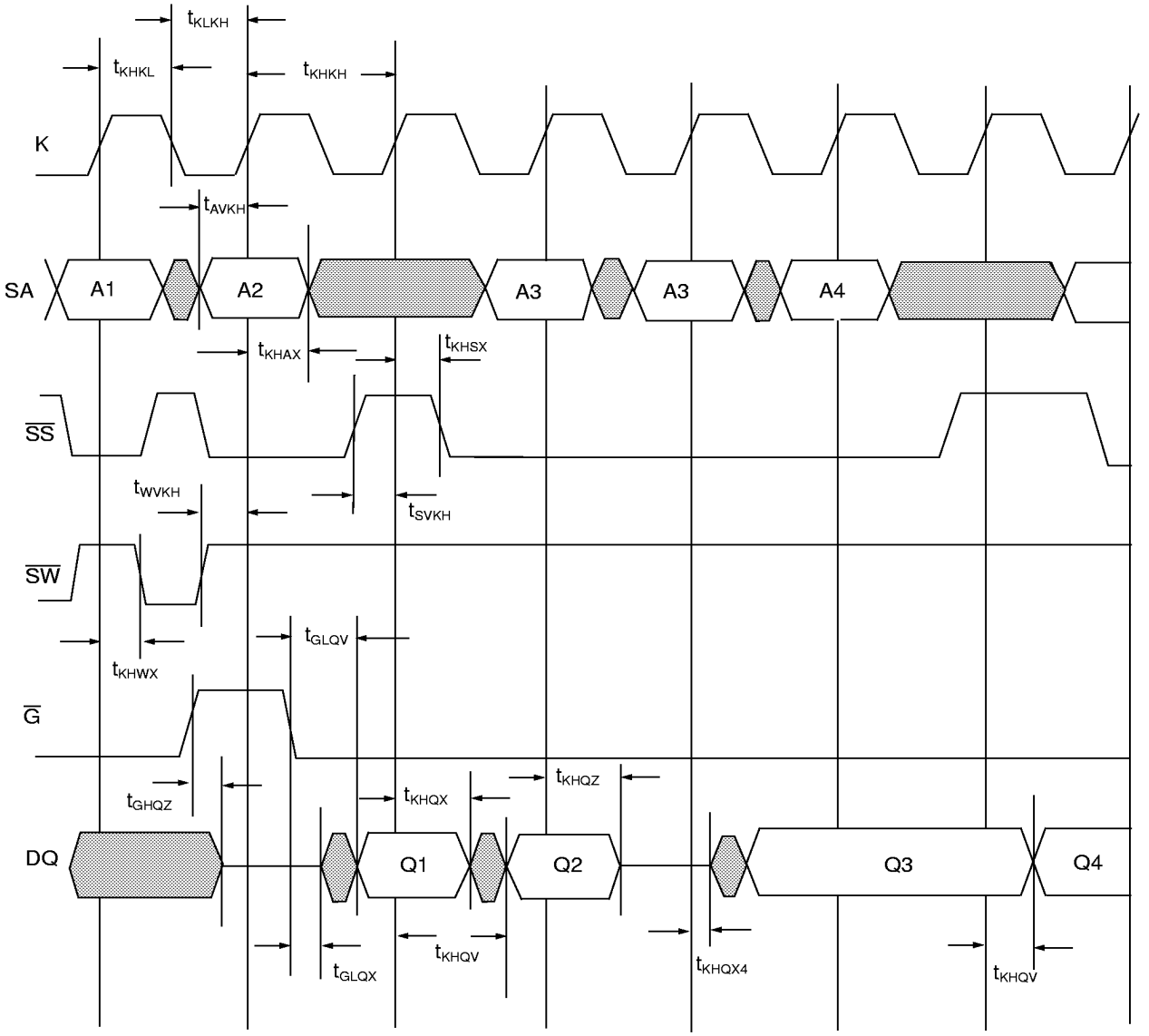


AC Characteristics (T_J=0 to +110°C, V_{DD}= 3.3 +10/–5% V, V_{DDQ}= 2.5 ± 5% V)

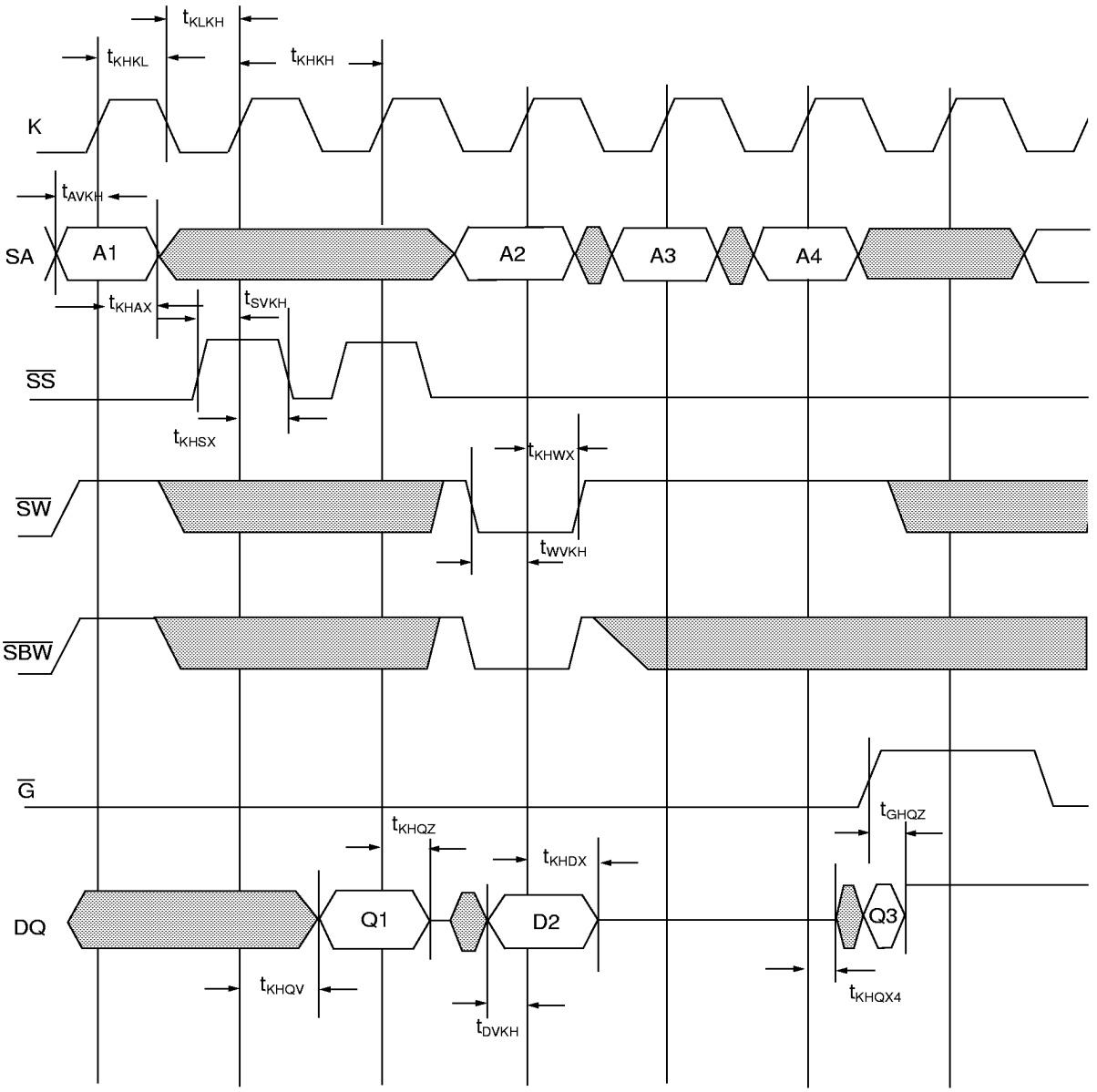
Parameter	Symbol					-7		Units	Notes
						Min.	Max.		
Cycle Time	t_{KHKH}					7.0	—	ns	
Clock High Pulse Width	t_{KHKL}					1.5	—	ns	
Clock Low Pulse Width	t_{KLKH}					1.5	—	ns	
Clock to Output Valid	t_{KHQV}					—	3.5	ns	1
Address Setup Time	t_{AVKH}					0.5	—	ns	
Address Hold Time	t_{KHAX}					1.0	—	ns	
Sync Select Setup Time	t_{SVKH}					0.5	—	ns	
Sync Select Hold Time	t_{KHSX}					1.0	—	ns	
Write Enables Setup Time	t_{WVKH}					0.5	—	ns	
Write Enables Hold Time	t_{KHWX}					1.0	—	ns	
Data In Setup Time	t_{DVKH}					0.5	—	ns	
Data In Hold Time	t_{KHDX}					1.0	—	ns	
Data Out Hold Time	t_{KHQX}					1.0	—	ns	1
Clock High to Output High-Z	t_{KHQZ}					—	3.5	ns	1, 2
Clock High to Output Active	t_{KHQX4}					0.5	—	ns	1, 2
Output Enable to High-Z	t_{GHQZ}					—	3.5	ns	1, 2
Output Enable to Low-Z	t_{GLQX}					0.5	—	ns	1, 2
Output Enable to Output Valid	t_{GLQV}					—	3.5	ns	1
Sleep Mode Recovery TIme	t_{ZZR}					7	—	ns	3
Sleep Mode Enable TIme	t_{ZZE}					—	7	ns	3

1. See AC Test Loading on page 7.
2. Transitions are measured ± 200 mV from steady state voltage.
3. This specification is for No Data Retention. For data integrity at least 200ns of Recovery Time is recommended coupled with a 0.5ns Set-up time around K clock.

Timing Diagram (Read and Deselect Cycles)



Timing Diagram (Read Write Cycles)



NOTES:

1. D2 is the input data written in memory location A2.

IEEE 1149.1 TAP AND BOUNDARY SCAN

The SRAM provides a limited set of JTAG functions intended to test the interconnection between SRAM I/Os and printed circuit board traces or other components. There is no multiplexer in the path from I/O pins to the RAM core.

In conformance with IEEE std. 1149.1, the SRAM contains a TAP controller, Instruction register, Boundary Scan register, Bypass register and ID register.

The TAP controller has a standard 16-state machine that resets internally upon power-up, therefore, TRST signal is not required.

Signal List

- TCK: Test Clock
- TMS: Test Mode Select
- TDI: Test Data In
- TDO: Test Data Out

Caution: TCK,TMS,TDI must be tied down, even when JTAG is not used.

JTAG Recommended DC Operating Conditions (T_J=0 to 110°C)

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
JTAG Input High Voltage	V_{IH1}	2.2	—	V_{DD}+0.3	V	1
JTAG Input Low Voltage	V_{IL1}	-0.3	—	0.8	V	1
JTAG Output High Level	V_{OH1}	2.4	—	—	V	1, 2
JTAG Output Low Level	V_{OL1}	—	—	0.4	V	1, 3

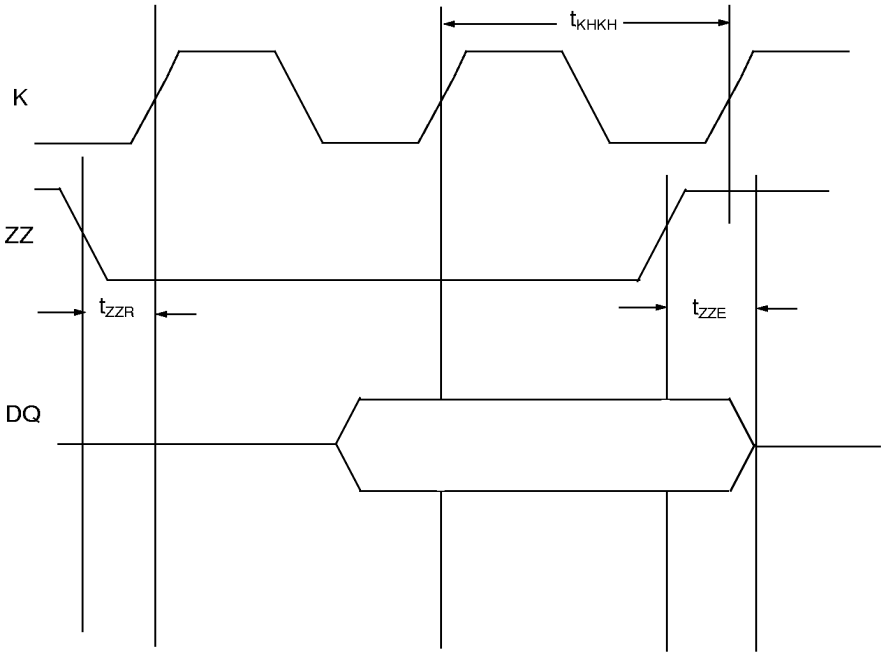
1. All JTAG Inputs/Outputs are LVTTL Compatible only.
2. I_{OH1} = -8mA at 2.4V.
3. IOL1 = +8mA at 0.4V.

JTAG AC Test Conditions (T_J=0 to +110°C, V_{DD}= 3.3 ± 5% V)

Parameter	Symbol	Conditions	Units	Notes
Input Pulse High Level	V_{IH1}	3.0	V	
Input Pulse Low Level	V_{IL1}	0.0	V	
Input Rise Time	T_{R1}	2.0	ns	
Input Fall Time	T_{F1}	2.0	ns	
Input and Output Timing Reference Level		1.5	V	1

1. See AC Test Loading on page 7.

Timing Diagram (Sleep Mode)

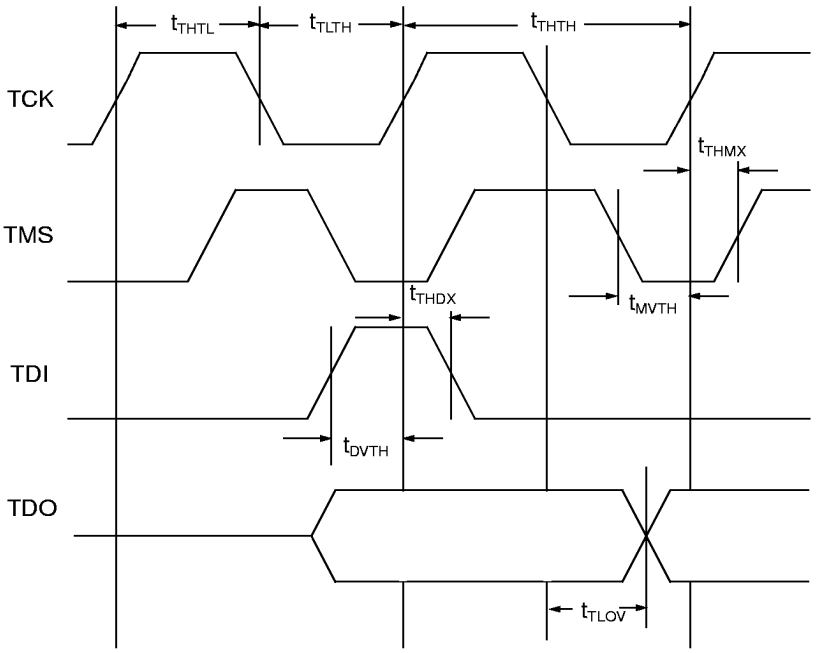


JTAG AC Characteristics (T_J=0 to +110C, V_{DD}= 3.3 ± 5% V)

Parameter	Symbol	Min.	Max.	Units	Notes
TCK Cycle Time	t_{THTH}	20	—	ns	
TCK High Pulse Width	t_{THTL}	7	—	ns	
TCK Low Pulse Width	t_{TLTH}	7	—	ns	
TMS Setup	t_{MVTH}	4	—	ns	
TMS Hold	t_{THMX}	4	—	ns	
TDI Setup	t_{DVTH}	4	—	ns	
TDI Hold	t_{THDX}	4	—	ns	
TCK Low to Valid Data	t_{TLOV}	—	7	ns	1

1. See AC Test Loading on page 7.

JTAG Timing Diagram



Scan Register Definition

Register Name	Bit Size X18	Bit Size X36
Instruction	3	3
Bypass	1	1
ID	32	32
Boundary Scan *	51	70

* The Boundary Scan chain consists of the following bits:
- 36 or 18 bits for Data Inputs Depending on X18 or X36 Configuration
- 15 bits for SA0 - SA14 for X36, 16 bits for SA0 - SA15 for X18
- 4 bits for $\overline{SBWa}$ - $\overline{SBWd}$ in X36, 2 bits for $\overline{SBWa}$ and $\overline{SBWb}$ in X18
- 8 bits for K, $\overline{K}$, $\overline{SS}$, $\overline{G}$, $\overline{SW}$, ZZ, M1 and M2
- 7 bits for Place Holders

* K and $\overline{K}$ clocks connect to a differential receiver that generates a single-ended clock signal. This signal and its inverted value are used for Boundary Scan sampling.

ID Register Definition

Part	Field Bit Number and Description				
	Revision Number (31:28)	Device Density and Configuration (27:18)	Vendor Definition (17:12)	Manufacture JEDEC Code (11:1)	Start Bit(0)
256K X18	0001	011 100 1011	001110	000 101 001 00	1
128K X 36	0001	011 010 1100	001111	000 101 001 00	1

Instruction Set

Code	Instruction	Notes
000	SAMPLE-Z	1
001	IDCODE	2
010	SAMPLE-Z	1
011	PRIVATE	3
100	SAMPLE	4
101	PRIVATE	3
110	PRIVATE	3
111	BYPASS	3

1. Places DQs in High-Z in order to sample all input data regardless of other SRAM inputs.
2. TDI is sampled as an input to the first ID register to allow for the serial shift of the external TDI data.
3. BYPASS register is initiated to V_{SS} when BYPASS instruction is invoked. The BYPASS register also holds the last serially loaded TDI when exiting the Shift DR state.
4. SAMPLE instruction does not place DQs in High-Z.

List of IEEE 1149.1 standard violations:

- 7.2.1.b, e
- 7.7.1.a-f
- 10.1.1.b, e
- 10.7.1.a-d
- 6.1.1.d

Boundary Scan Order (X36) (PH - Place Holder)

Exit Order	Signal	Bump #	Exit Order	Signal	Bump #	Exit Order	Signal	Bump #
1	M2	5R	**25**	DQ13	6F	**49**	DQ26	2H
2	SA1	4P	**26**	DQ11	7E	**50**	DQ25	1H
3	SA2	4T	**27**	DQ12	6E	**51**	$\overline{SBWc}$	3G
4	SA12	6R	**28**	DQ9	7D	**52**	ZQ	4D
5	SA13	5T	**29**	DQ10	6D	**53**	$\overline{SS}$	4E
6	ZZ	7T	**30**	SA14	6A	**54**	$\overline{C}$	4G
7	DQ1	6P	**31**	SA15	6C	**55**	C	4H
8	DQ0	7P	**32**	SA10	5C	**56**	$\overline{SW}$	4M
9	DQ3	6N	**33**	SA16	5A	**57**	$\overline{SBWd}$	3L
10	DQ2	7N	**34**	PH*	6B	**58**	DQ34	1K
11	DQ4	6M	**35**	SA11	5B	**59**	DQ35	2K
12	DQ6	6L	**36**	SA8	3B	**60**	DQ32	1L
13	DQ5	7L	**37**	PH*	2B	**61**	DQ33	2L
14	DQ8	6K	**38**	SA7	3A	**62**	DQ31	2M
15	DQ7	7K	**39**	SA9	3C	**63**	DQ29	1N
16	$\overline{SBWa}$	5L	**40**	SA6	2C	**64**	DQ30	2N
17	$\overline{K}$	4L	**41**	SA5	2A	**65**	DQ27	1P
18	K	4K	**42**	DQ19	2D	**66**	DQ28	2P
19	$\overline{G}$	4F	**43**	DQ18	1D	**67**	SA3	3T
20	$\overline{SBWb}$	5G	**44**	DQ21	2E	**68**	SA4	2R
21	DQ16	7H	**45**	DQ20	1E	**69**	SA0	4N
22	DQ17	6H	**46**	DQ22	2F	**70**	M1	3R
23	DQ14	7G	**47**	DQ24	2G			
24	DQ15	6G	**48**	DQ23	1G			

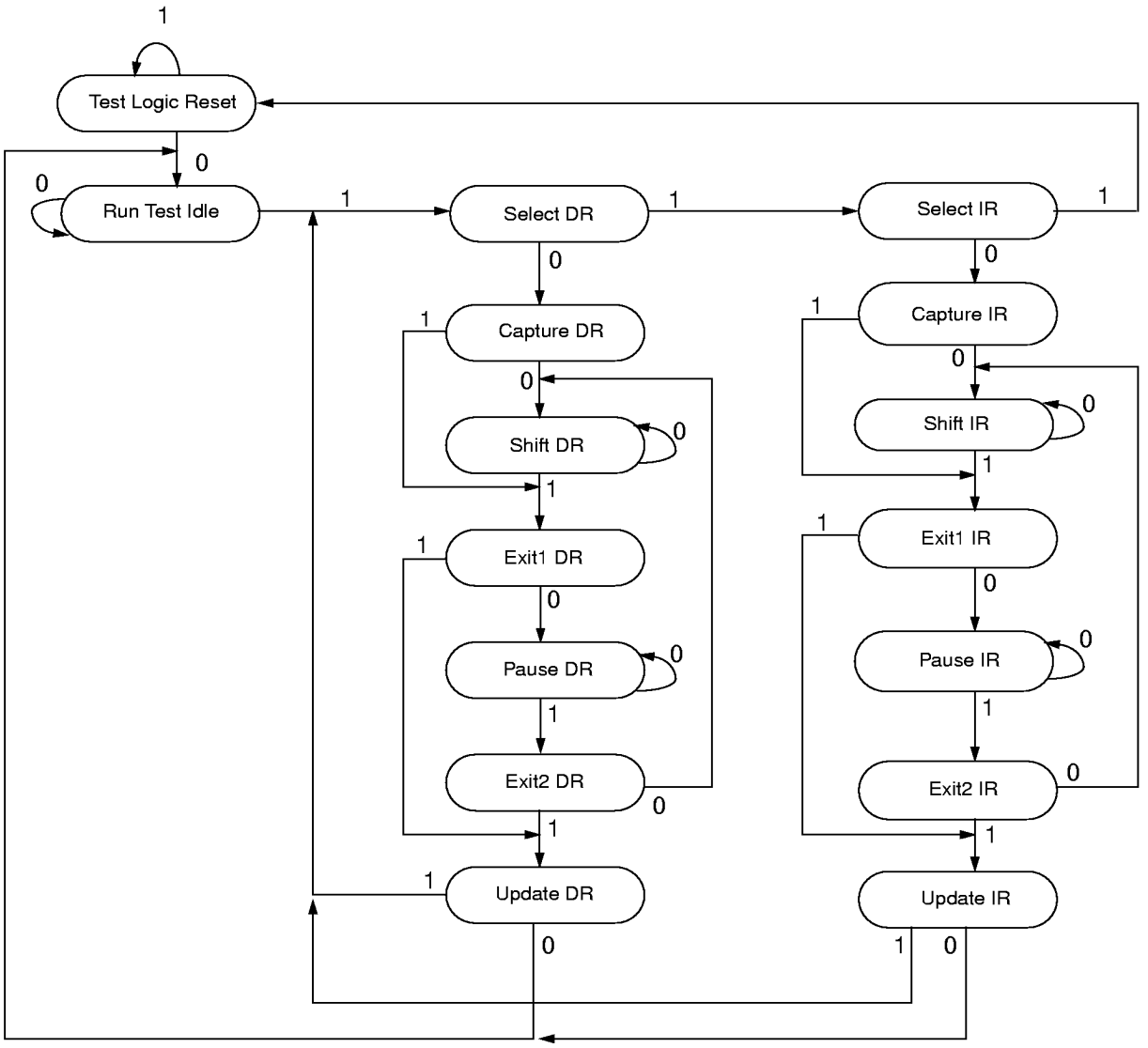
1. * Input of PH register connected to V_{SS}

Boundary Scan Order (X18) (PH =Place Holder)

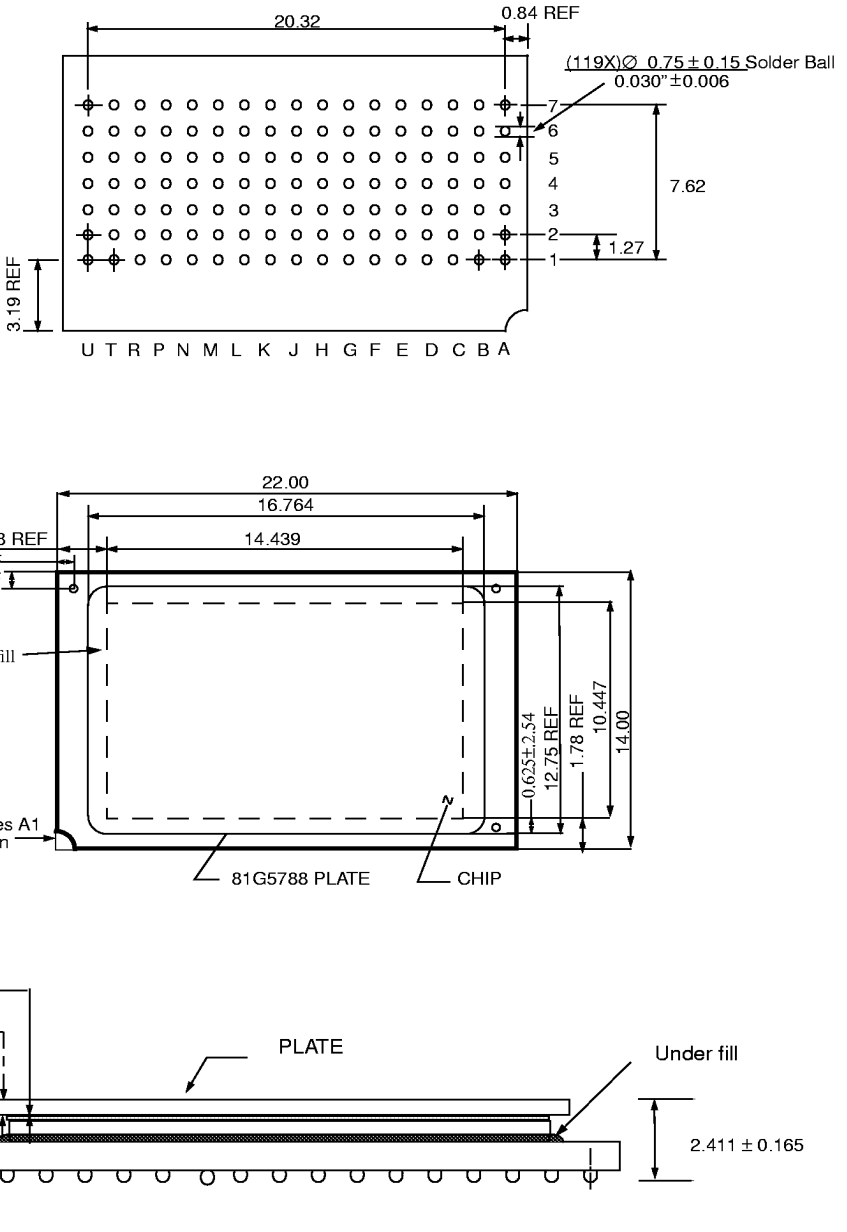
Exit Order	Signal	Bump #	Exit Order	Signal	Bump #
1	M2	5R	**27**	PH*	2B
2	SA12	6T	**28**	SA7	3A
3	SA1	4P	**29**	SA9	3C
4	SA13	6R	**30**	SA6	2C
5	SA17	5T	**31**	SA5	2A
6	ZZ	7T	**32**	DQ9	1D
7	DQ0	7P	**33**	DQ12	2E
8	DQ3	6N	**34**	DQ15	2G
9	DQ6	6L	**35**	DQ16	1H
10	DQ7	7K	**36**	$\overline{\text{SBWb}}$	3G
11	$\overline{\text{SBWa}}$	5L	**37**	ZQ	4D
12	$\overline{\text{K}}$	4L	**38**	$\overline{\text{SS}}$	4E
13	K	4K	**39**	$\overline{\text{C}}$	4G
14	$\overline{\text{G}}$	4F	**40**	C	4H
15	DQ8	6H	**41**	$\overline{\text{SW}}$	4M
16	DQ5	7G	**42**	DQ17	2K
17	DQ4	6F	**43**	DQ14	1L
18	DQ2	7E	**44**	DQ13	2M
19	DQ1	6D	**45**	DQ11	1N
20	SA14	6A	**46**	DQ10	2P
21	SA15	6C	**47**	SA3	3T
22	SA10	5C	**48**	SA4	2R
23	SA16	5A	**49**	SA0	4N
24	PH*	6B	**50**	SA2	2T
25	SA11	5B	**51**	M1	3R
26	SA8	3B			

1. * Input of PH register connected to V_{SS}.

TAP Controller State Machine



7 x 17 BGA Dimensions



Note: All dimensions in Millimeters

Revision Log

Rev	Contents of Modification
5/30/96	Initial Release.
7/96	Added Thermal resistance, update currents.
11/24/96	Clean up
1/97	Updated package drawing.
3/97	Corrected part number from IBM04184BSRLAA to IBM0418BSLAA. Added note to Sleep Mode. Update AC Characteristics. Added x36 parametrics and part number(s).
3/21/97	Updated AC test conditions and levels for meausurements on high and low levels. Changed Termination voltage for AC test.