8Mb LW LS R-R HSTL High Speed Synchronous SRAMs (256K x 36 or 512K x 18) **Preliminary**

Description

The CXK77Q36B80AGB (organized as 262,144 words by 36 bits) and the CXK77Q18B80AGB (organized as 524,288 words by 18 bits) are high speed CMOS synchronous static RAMs with common I/O pins. These synchronous SRAMs integrate input registers, high speed RAM, output registers, and a one-deep write buffer onto a single monolithic IC. Register - Register (R-R) read operations and Late Write (LW) write operations are supported, providing a high-performance user interface.

Two distinct R-R modes of operation are supported, selectable via the M2 mode pin. When M2 is “high”, these devices function as conventional R-R SRAMs, and pin 4P functions as a conventional SA address input. When M2 is “low”, these devices function as Late Select (LS) R-R SRAMs, and pin 4P functions as a Late Select SAS address input.

When Late Select R-R mode is selected, the SRAM is divided into two banks internally. During write operations, SAS is registered in the same cycle as the other address and control signals, and is used to select to which bank input data is ultimately written (through one stage of write pipelining). During read operations, SAS is registered one full clock cycle after the other address and control signals, and is used to select from which bank output data is read.

All address and control input signals except $\overline{G}$ (Output Enable) and ZZ (Sleep Mode) are registered on the rising edge of K (Input Clock).

During read operations, output data is driven valid from the rising edge of K, one full clock cycle after all address and control input signals (except SAS) are registered.

During write operations, input data is registered on the rising edge of K, one full clock cycle after all address and control input signals (including SAS) are registered.

The output drivers are series terminated, and the output impedance is programmable through an external impedance matching resistor RQ. By connecting RQ between ZQ and V_{SS}, the output impedance of all DQ pins can be precisely controlled.

Sleep (power down) mode control is provided through the asynchronous ZZ input. 350 MHz operation is obtained from a single 2.5V or 3.3V power supply. JTAG boundary scan interface is provided using a subset of IEEE standard 1149.1 protocol.

Features

4 Speed Bins	Cycle Time / Access Time
-28	2.8ns / 1.6ns
-33	3.3ns / 1.6ns
-37 (-37A)	3.7ns / 1.8ns (1.6ns)
-4 (-4A)	4.0ns / 2.0ns (1.8ns)

- Single 2.5V or 3.3V power supply (V_{DD}): 2.5V ± 5% or 3.3V ± 5%
- Dedicated output supply voltage (V_{DDQ}): 1.5V or 1.8V typical
- HSTL-compatible I/O interface with dedicated input reference voltage (V_{REF}):V_{DDQ}/2 typical
- Register - Register (R-R) read operations
- Late Write (LW) write operations
- Conventional or Late Select (LS) mode of operation, selectable via dedicated mode pin (M2)
- Full read/write coherency
- Byte Write capability
- Two cycle deselect
- Differential input clocks (K/$\overline{K}$)
- Asynchronous output enable ($\overline{G}$)
- Programmable impedance output drivers
- Sleep (power down) mode via dedicated mode pin (ZZ)
- JTAG boundary scan (subset of IEEE standard 1149.1)
- 119 pin (7x17), 1.27mm pitch, 14mm x 22mm Ball Grid Array (BGA) package

256K x 36 Pin Assignment (Top View)

	1	2	3	4	5	6	7
A	V_{DDQ}	SA	SA	NC	SA	SA	V_{DDQ}
B	NC	NC (2)	SA	NC	SA	SA	NC
C	NC	SA	SA	V_{DD}	SA	SA	NC
D	DQc	DQc	V_{SS}	ZQ	V_{SS}	DQb	DQb
E	DQc	DQc	V_{SS}	$\overline{SS}$	V_{SS}	DQb	DQb
F	V_{DDQ}	DQc	V_{SS}	$\overline{G}$	V_{SS}	DQb	V_{DDQ}
G	DQc	DQc	$\overline{SBW}$c	NC	$\overline{SBW}$b	DQb	DQb
H	DQc	DQc	V_{SS}	NC	V_{SS}	DQb	DQb
J	V_{DDQ}	V_{DD}	V_{REF}	V_{DD}	V_{REF}	V_{DD}	V_{DDQ}
K	DQd	DQd	V_{SS}	K	V_{SS}	DQa	DQa
L	DQd	DQd	$\overline{SBW}$d	$\overline{K}$	$\overline{SBW}$a	DQa	DQa
M	V_{DDQ}	DQd	V_{SS}	$\overline{SW}$	V_{SS}	DQa	V_{DDQ}
N	DQd	DQd	V_{SS}	SA	V_{SS}	DQa	DQa
P	DQd	DQd	V_{SS}	SA / SAS (6)	V_{SS}	DQa	DQa
R	NC	SA	M1 (4)	V_{DD}	M2 (5)	SA	NC
T	NC	NC (1)	SA	SA	SA	NC (1)	ZZ
U	V_{DDQ}	TMS	TDI	TCK	TDO	RSVD (3)	V_{DDQ}

Notes:

1. Pad Locations 2T and 6T are true no-connects. However, they are defined as SA address inputs in x18 LW SRAMs.
2. Pad Location 2B is a true no-connect. However, it is defined as an SA address input in 16Mb LW SRAMs.
3. Pad Location 6U must be left unconnected. It is used by Sony for internal test purposes.
4. Pad Location 3R is defined as an M1 mode pin in LW SRAMs. However, it must be tied “low” in this device.
5. Pad Location 5R is defined as an M2 mode pin in this device. It must be tied “high” or “low”. When M2 is tied “high”, this device functions as a conventional R-R SRAM. When M2 is tied “low”, this device functions as a Late Select R-R SRAM.
6. Pad Location 4P is defined as an SA address input in LW SRAMs. However, it functions as a conventional SA address input in this device only when M2 is tied “high”. It functions as a Late Select SAS address input in this device when M2 is tied “low”.

512K x 18 Pin Assignment (Top View)

	1	2	3	4	5	6	7
A	V_{DDQ}	SA	SA	NC	SA	SA	V_{DDQ}
B	NC	NC (2)	SA	NC	SA	SA	NC
C	NC	SA	SA	V_{DD}	SA	SA	NC
D	DQb	NC (1b)	V_{SS}	ZQ	V_{SS}	DQa	NC (1b)
E	NC (1b)	DQb	V_{SS}	$\overline{SS}$	V_{SS}	NC (1b)	DQa
F	V_{DDQ}	NC (1b)	V_{SS}	$\overline{G}$	V_{SS}	DQ6a	V_{DDQ}
G	NC (1b)	DQb	$\overline{SBW}$b	NC	V_{SS}	NC (1b)	DQa
H	DQb	NC (1b)	V_{SS}	NC	V_{SS}	DQa	NC (1b)
J	V_{DDQ}	V_{DD}	V_{REF}	V_{DD}	V_{REF}	V_{DD}	V_{DDQ}
K	NC (1b)	DQb	V_{SS}	K	V_{SS}	NC (1b)	DQa
L	DQb	NC (1b)	V_{SS}	$\overline{K}$	$\overline{SBW}$a	DQa	NC (1b)
M	V_{DDQ}	DQb	V_{SS}	$\overline{SW}$	V_{SS}	NC (1b)	V_{DDQ}
N	DQb	NC (1b)	V_{SS}	SA	V_{SS}	DQa	NC (1b)
P	NC (1b)	DQb	V_{SS}	SA / SAS (6)	V_{SS}	NC (1b)	DQa
R	NC	SA	M1 (4)	V_{DD}	M2 (5)	SA	NC
T	NC	SA	SA	NC (1a)	SA	SA	ZZ
U	V_{DDQ}	TMS	TDI	TCK	TDO	RSVD (3)	V_{DDQ}

Notes:

1a. Pad Location 4T is a true no-connect. However, it is defined as an SA address input in x36 LW SRAMs.

1b. Pad Locations 2D, 7D, 1E, 6E, 2F, 1G, 6G, 2H, 7H, 1K, 6K, 2L, 7L, 6M, 2N, 7N, 1P, and 6P are true no-connects. However, they are defined as DQ data inputs / outputs in x36 LW SRAMs.

2. Pad Location 2B is a true no-connect. However, it is defined as an SA address input in 16Mb LW SRAMs.

3. Pad Location 6U must be left unconnected. It is used by Sony for internal test purposes.

4. Pad Location 3R is defined as an M1 mode pin in LW SRAMs. However, it must be tied “low” in this device.

5. Pad Location 5R is defined as an M2 mode pin in this device. It must be tied “high” or “low”. When M2 is tied “high”, this device functions as a conventional R-R SRAM. When M2 is tied “low”, this device functions as a Late Select R-R SRAM.

6. Pad Location 4P is defined as an SA address input in LW SRAMs. However, it functions as a conventional SA address input in this device only when M2 is tied “high”. It functions as a Late Select SAS address input in this device when M2 is tied “low”.

Pin Description

Symbol	Type	Description
SA	Input	Synchronous Address Inputs - Registered on the rising edge of K.
SAS	Input	Synchronous Late Select Address Input (Late Select R-R Mode Only) - Registered on the rising edge of K. Sampled one cycle after the other address and control inputs during read operations. Sampled in the same cycle as the other address and control inputs during write operations.
DQa, DQb DQc, DQd	I/O	Synchronous Data Inputs / Outputs - Registered on the rising edge of K during write operations. Driven from the rising edge of K during read operations. DQa - indicates Data Byte a DQb - indicates Data Byte b DQc - indicates Data Byte c DQd - indicates Data Byte d
K, $\overline{K}$	Input	Differential Input Clocks
$\overline{SS}$	Input	Synchronous Select Input - Registered on the rising edge of K. $\overline{SS}$ = 0 specifies a write operation when $\overline{SW}$ = 0 specifies a read operation when $\overline{SW}$ = 1 $\overline{SS}$ = 1 specifies a deselect operation
$\overline{SW}$	Input	Synchronous Global Write Enable Input - Registered on the rising edge of K. $\overline{SW}$ = 0 specifies a write operation when $\overline{SS}$ = 0 $\overline{SW}$ = 1 specifies a read operation when $\overline{SS}$ = 0
$\overline{SBW}$a, $\overline{SBW}$b, $\overline{SBW}$c, $\overline{SBW}$d	Input	Synchronous Byte Write Enable Inputs - Registered on the rising edge of K. $\overline{SBW}$a = 0 specifies write Data Byte a when $\overline{SS}$ = 0 and $\overline{SW}$ = 0 $\overline{SBW}$b = 0 specifies write Data Byte b when $\overline{SS}$ = 0 and $\overline{SW}$ = 0 $\overline{SBW}$c = 0 specifies write Data Byte c when $\overline{SS}$ = 0 and $\overline{SW}$ = 0 $\overline{SBW}$d = 0 specifies write Data Byte d when $\overline{SS}$ = 0 and $\overline{SW}$ = 0
$\overline{G}$	Input	Asynchronous Output Enable Input - Deasserted (high) disables the data output drivers.
ZZ	Input	Asynchronous Sleep Mode Input - Asserted (high) forces the SRAM into low-power mode.
M1	Input	Read Operation Protocol Select 1 - This mode pin must be tied “low” at power-up to select Register - Register read operations
M2	Input	Read Operation Protocol Select 2 - This mode pin must be tied “high” or “low” at power-up. M2 = 0 selects Late Select R-R functionality M2 = 1 selects conventional R-R functionality
ZQ	Input	Output Impedance Control Resistor Input - This pin must be connected to V_{SS} through an external resistor RQ to program data output driver impedance. See the Programmable Output Driver Impedance section for further information
V_{DD}		2.5V or 3.3V Core Power Supply - Core supply voltage.
V_{DDQ}		Output Power Supply - Output buffer supply voltage.
V_{REF}		Input Reference Voltage - Input buffer threshold voltage.
V_{SS}		Ground
TCK	Input	JTAG Clock
TMS	Input	JTAG Mode Select - Weakly pulled “high” internally.
TDI	Input	JTAG Data In - Weakly pulled “high” internally.
TDO	Output	JTAG Data Out
RSVD		Reserved - This pin is used for Sony test purposes only. It must be left unconnected.
NC		No Connect - These pins are true no-connects, i.e. there is no internal chip connection to these pins. They can be left unconnected or tied directly to V_{DD}, V_{DDQ}, or V_{SS}.

•Clock Truth Table

K	ZZ	$\overline{SS}$ (t_n)	$\overline{SW}$ (t_n)	$\overline{SBW}$x (t_n)	$\overline{G}$	Operation	DQ (t_n)	DQ (t_{n+1})
X	H	X	X	X	X	Sleep (Power Down) Mode	Hi - Z	Hi - Z
L→H	L	H	X	X	X	Deselect	X	Hi - Z
L→H	L	L	H	X	H	Read	Hi - Z	Hi - Z
L→H	L	L	H	X	L	Read	X	Q(t_n)
L→H	L	L	L	L	X	Write All Bytes	X	D(t_n)
L→H	L	L	L	X	X	Write Bytes With $\overline{SBW}$x = L	X	D(t_n)
L→H	L	L	L	H	X	Abort Write	X	Hi - Z

•Dynamic M2 Mode Pin State Changes

Although M2 is defined as a static input (that is, it must be tied “high” or “low” at power-up), in some instance (such as during device testing) it may be desirable to change its state dynamically (that is, without first powering off the SRAM) while preserving the contents of the memory array. If so, the following criteria must be met:

1. At least two (2) consecutive deselect operations must be initiated prior to changing the state of M2, to ensure that the most recent read or write operation completes successfully.
2. At least thirty-two (32) consecutive deselect operations must be initiated after changing the state of M2 before any read or write operations can be initiated, to allow the SRAM sufficient time to recognize the change in state.

•Sleep (Power Down) Mode

Sleep (power down) mode is provided through the asynchronous input signal ZZ. When ZZ is asserted (high), the output drivers will go to a Hi-Z state, and the SRAM will begin to draw standby current. Contents of the memory array will be preserved. An enable time (t_{ZZE}) must be met before the SRAM is guaranteed to be in sleep mode, and a recovery time (t_{ZZR}) must be met before the SRAM can resume normal operation.

•Programmable Output Driver Impedance

These devices have programmable impedance output drivers. The output impedance is controlled by an external resistor, RQ, connected between the SRAM’s ZQ pin and V_{SS}, and is equal to one-fifth the value of this resistor, nominally. See the DC Electrical Characteristics section for further information.

The output impedance is updated whenever the output drivers are in a Hi-Z state. Consequently, impedance updates will occur during write and deselect operations, and when $\overline{G}$ is deasserted (high) (see **Note 1** below). At power up, 8192 clock cycles followed by an impedance update via one of the three methods described above are required to ensure that the output impedance has reached the desired value. After power up, periodic impedance updates via one of the three methods described above are also required to ensure that the output impedance remains within specified tolerances.

Note 1: In order to allow the SRAM sufficient time to update the output impedance when $\overline{G}$ is deasserted (high), $\overline{G}$ must meet setup and hold times with respect to K clock. See the AC Electrical Characteristics sections for further information.

•Power-Up Sequence

For reliability purposes, Sony recommends that power supplies power up in the following sequence: V_{SS}, V_{DD}, V_{DDQ}, V_{REF}, and Inputs. V_{DDQ} should never exceed V_{DD}. If this power supply sequence cannot be met, a large bypass diode may be required between V_{DD} and V_{DDQ}. Please contact Sony Memory Application Department for further information.

•Absolute Maximum Ratings(1)

Parameter	Symbol	Rating	Units
Supply Voltage	V_{DD}	-0.5 to +3.8	V
Output Supply Voltage	V_{DDQ}	-0.5 to +2.3	V
Input Voltage (Address, Control, Data, Clock)	V_{IN}	-0.5 to V_{DDQ} + 0.5 (2.3V max)	V
Input Voltage (M1, M2)	V_{MIN}	-0.5 to V_{DD} + 0.5 (3.8V max)	V
Input Voltage (TCK, TMS, TDI))	V_{TIN}	-0.5 to +3.8	V
Operating Temperature	T_A	0 to 85	°C
Junction Temperature	T_J	0 to 110	°C
Storage Temperature	T_{STG}	-55 to 150	°C

(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 other than those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

•BGA Package Thermal Characteristics

Parameter	Symbol	Rating	Units
Junction to Case Temperature	Θ_{JC}	3.6	°C/W

•I/O Capacitance

(T_A = 25°C, f = 1 MHz)

Parameter		Symbol	Test Conditions	Min	Max	Units
Input Capacitance	Address	C_{IN}	V_{IN} = 0V	---	3.5	pF
	Control	C_{IN}	V_{IN} = 0V	---	3.5	pF
	Clock	C_{KIN}	V_{IN} = 0V	---	3.5	pF
Output Capacitance	Data	C_{OUT}	V_{OUT} = 0V	---	4.5	pF

Note: These parameters are sampled and are not 100% tested.

•DC Recommended Operating Conditions

(V_{SS} = 0V, T_A = 0 to 85°C)

Parameter	Symbol	Min	Typ	Max	Units	Notes
Supply Voltage	V_{DD}	2.37	2.5 or 3.3	3.47	V	
Output Supply Voltage	V_{DDQ}	1.4	---	1.9	V	
Input Reference Voltage	V_{REF}	0.6	---	1.0	V	1
Input High Voltage (Address, Control, Data)	V_{IH}	V_{REF} + 0.1	---	V_{DDQ} + 0.3	V	2
Input Low Voltage (Address, Control, Data)	V_{IL}	-0.3	---	V_{REF} - 0.1	V	3
Input High Voltage (M1, M2)	V_{MIH}	1.2	---	V_{DD} + 0.3	V	
Input Low Voltage (M1, M2)	V_{MIL}	-0.3	---	0.4	V	
Clock Input Signal Voltage	V_{KIN}	-0.3	---	V_{DDQ} + 0.3	V	
Clock Input Differential Voltage	V_{DIF}	0.2	---	V_{DDQ} + 0.6	V	
Clock Input Common Mode Voltage	V_{CM}	0.6	---	1.0	V	

1. The peak-to-peak AC component superimposed on V_{REF} may not exceed 5% of the DC component.
2. V_{IH} (max) AC = V_{DDQ} + 0.75V for pulse widths less than one-quarter of the cycle time (t_{CYC}/4).
3. V_{IL} (min) AC = -0.75V for pulse widths less than one-quarter of the cycle time (t_{CYC}/4).

•DC Electrical Characteristics

(V_{DD} = 2.5V ± 5% or 3.3V ± 5%, V_{SS} = 0V, T_A = 0 to 85°C)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units	Notes
Input Leakage Current (Address, Control, Clock)	I_{LI}	V_{IN} = V_{SS} to V_{DDQ}	-5	---	5	uA	
Input Leakage Current (M1, M2)	I_{MLI}	V_{MIN} = V_{SS} to V_{DD}	-5	---	5	uA	
Output Leakage Current	I_{LO}	V_{OUT} = V_{SS} to V_{DDQ} $\overline{G}$ = V_{IH}	-5	---	5	uA	
Average Power Supply Operating Current	I_{DD-28} I_{DD-33} I_{DD-37} I_{DD-4}	I_{OUT} = 0 mA $\overline{SS}$ = V_{IL}, ZZ = V_{IL}	--- --- --- ---	--- --- --- ---	750 700 680 600	mA	4
Average Power Supply Operating Current (3 MHz Operation)	I_{DD3}	I_{OUT} = 0 mA $\overline{SS}$ = V_{IL}, ZZ = V_{IL} t_{CYC} = 3 MHz	---	---	200	mA	
Power Supply Standby Current	I_{SB}	I_{OUT} = 0 mA ZZ = V_{IH}	---	---	100	mA	
Output High Voltage	V_{OH}	I_{OH} = -6.0 mA RQ = 250Ω	V_{DDQ} - 0.4	---	---	V	
Output Low Voltage	V_{OL}	I_{OL} = 6.0 mA RQ = 250Ω	---	---	0.4	V	
Output Driver Impedance	R_{OUT}	V_{OH}, V_{OL} = V_{DDQ}/2 RQ < 150Ω	---	---	33 (30*1.1)	Ω	1,3
		V_{OH}, V_{OL} = V_{DDQ}/2 150Ω ≤ RQ ≤ 300Ω	(RQ/5)* 0.9	RQ/5	(RQ/5)* 1.1	Ω	3
		V_{OH}, V_{OL} = V_{DDQ}/2 RQ > 300Ω	54 (60*0.9)	---	---	Ω	2,3

1. For maximum output drive (i.e. minimum impedance), the ZQ pin can be tied directly to V_{SS}.
2. For minimum output drive (i.e. minimum impedance), the ZQ pin can be left unconnected or tied to V_{DDQ}.
3. This parameter is guaranteed by design through extensive corner lot characterization.
4. Average Power Supply Operating Current in devices marked as "-33" is guaranteed (by test) to meet both the I_{DD-33} specification at 300 MHz operation and the I_{DD-4} specification at 250 MHz operation.

•AC Electrical Characteristics

Parameter	Symbol	-28		-33		-37		-4		Units	Notes
		Min	Max	Min	Max	Min	Max	Min	Max		
K Cycle Time	t_{KHKH}	2.8	---	3.3	---	3.7	---	4.0	---	ns	
K Clock High Pulse Width	t_{KHKL}	1.1	---	1.3	---	1.4	---	1.5	---	ns	
K Clock Low Pulse Width	t_{KLKH}	1.1	---	1.3	---	1.4	---	1.5	---	ns	
Address / Late Select Setup Time	t_{AVKH}	0.3	---	0.3	---	0.3	---	0.3	---	ns	1
Address / Late Select Hold Time	t_{KHAX}	0.5	---	0.6	---	0.7	---	0.7	---	ns	
Write Enables Setup Time	t_{WVKH}	0.3	---	0.3	---	0.3	---	0.3	---	ns	1
Write Enables Hold Time	t_{KHWX}	0.5	---	0.6	---	0.7	---	0.7	---	ns	
Synchronous Select Setup Time	t_{SVKH}	0.3	---	0.3	---	0.3	---	0.3	---	ns	1
Synchronous Select Hold Time	t_{KHSX}	0.5	---	0.6	---	0.7	---	0.7	---	ns	
Data Input Setup Time	t_{DVKH}	0.3	---	0.3	---	0.3	---	0.3	---	ns	1
Data Input Hold Time	t_{KHDX}	0.5	---	0.6	---	0.7	---	0.7	---	ns	
K Clock High to Output Valid ("A" Sub-Bin)	t_{KHQV}	---	1.6	---	1.6	---	1.8 1.6	---	2.0 1.8	ns	
K Clock High to Output Hold	t_{KHQX}	0.7	---	0.7	---	0.7	---	0.7	---	ns	2
K Clock High to Output Low-Z	t_{KHQX1}	0.7	---	0.7	---	0.7	---	0.7	---	ns	2,3
K Clock High to Output High-Z	t_{KHQZ}	0.7	1.7	0.7	1.8	0.7	1.9	0.7	2.0	ns	2,3
Output Enable Setup Time	t_{GVKH}	0.5	---	0.5	---	0.5	---	0.5	---	ns	2,4
Output Enable Hold Time	t_{KHGX}	1.0	---	1.0	---	1.0	---	1.0	---	ns	2,4
Output Enable Low to Output Valid	t_{GLQV}	---	1.7	---	1.8	---	1.9	---	2.0	ns	
Output Enable Low to Output Low-Z	t_{GLQX}	0.3	---	0.3	---	0.3	---	0.3	---	ns	2,3
Output Enable High to Output High-Z	t_{GHQZ}	---	1.7	---	1.8	---	1.9	---	2.0	ns	2,3
Sleep Mode Enable Time	t_{ZZE}	---	15	---	15	---	15	---	15	ns	2
Sleep Mode Recovery Time	t_{ZZR}	20	---	20	---	20	---	20	---	ns	2

All parameters are specified over the range T_A = 0 to 85°C.

All parameters are measured from the mid-point of the object signal to the mid-point of the reference signal, unless otherwise noted.

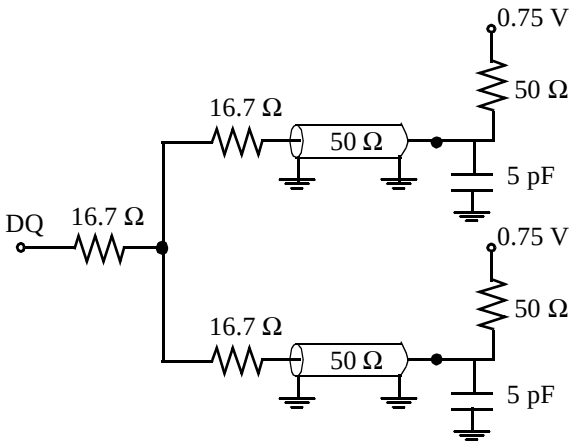
1. These parameters are measured from V_{REF} ± 200mV to the clock mid-point.
2. These parameters are sampled and are not 100% tested.
3. These parameters are measured at ± 50mV from steady state voltage.
4. These parameters apply only when deasserting $\overline{G}$ (high) in order to induce output impedance updates.

•AC Test Conditions (V_{DDQ} = 1.5V)

(V_{DD} = 2.5V ± 5% or 3.3V ± 5%, V_{DDQ} = 1.5V ± 0.1V, T_A = 0 to 85°C)

Parameter	Symbol	Conditions	Units	Notes
Input Reference Voltage	V_{REF}	0.75	V	
Input High Level	V_{IH}	1.25	V	
Input Low Level	V_{IL}	0.25	V	
Input Rise & Fall Time		2.0	V/ns	
Input Reference Level		0.75	V	
Clock Input High Voltage	V_{KIH}	1.25	V	V_{DIF} = 1.0V
Clock Input Low Voltage	V_{KIL}	0.25	V	V_{DIF} = 1.0V
Clock Input Common Mode Voltage	V_{CM}	0.75	V	
Clock Input Rise & Fall Time		2.0	V/ns	
Clock Input Reference Level		$K/\overline{K}$ cross	V	
Output Reference Level		0.75	V	
Output Load Conditions		RQ = 250Ω		See Figure 1 below

Figure 1: AC Test Output Load (V_{DDQ} = 1.5V)

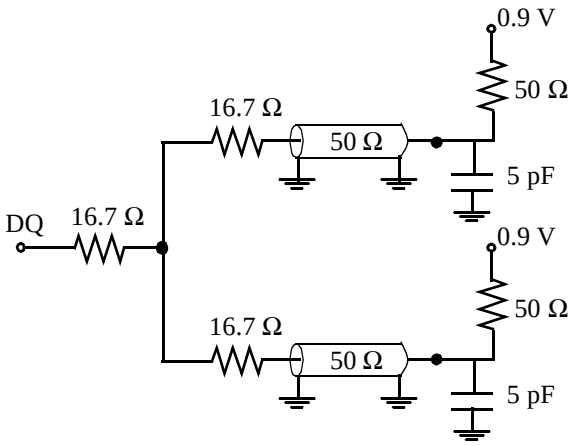


•AC Test Conditions (V_{DDQ} = 1.8V)

(V_{DD} = 2.5V ± 5% or 3.3V ± 5%, V_{DDQ} = 1.8V ± 0.1V, T_A = 0 to 85°C)

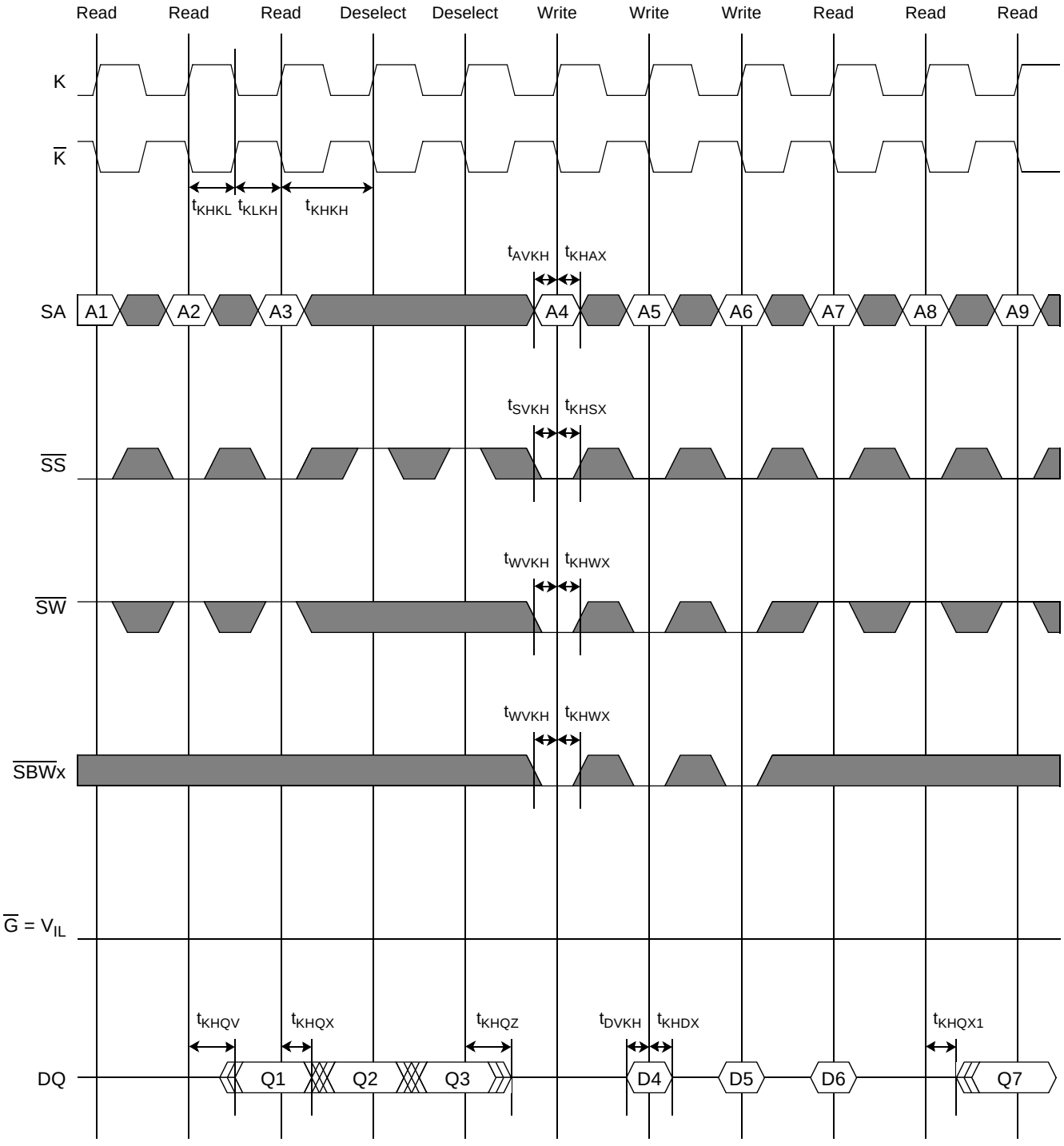
Parameter	Symbol	Conditions	Units	Notes
Input Reference Voltage	V_{REF}	0.9	V	
Input High Level	V_{IH}	1.4	V	
Input Low Level	V_{IL}	0.4	V	
Input Rise & Fall Time		2.0	V/ns	
Input Reference Level		0.9	V	
Clock Input High Voltage	V_{KIH}	1.4	V	V_{DIF} = 1.0V
Clock Input Low Voltage	V_{KIL}	0.4	V	V_{DIF} = 1.0V
Clock Input Common Mode Voltage	V_{CM}	0.9	V	
Clock Input Rise & Fall Time		2.0	V/ns	
Clock Input Reference Level		K/$\overline{K}$ cross	V	
Output Reference Level		0.9	V	
Output Load Conditions		RQ = 250Ω		See Figure 2 below

Figure 2: AC Test Output Load (V_{DDQ} = 1.8V)



Conventional R-R Mode: Timing Diagram of Read-Write-Read Operations Synchronously Controlled via $\overline{SS}$ and Deselect Operations ($\overline{G}$ = Low)

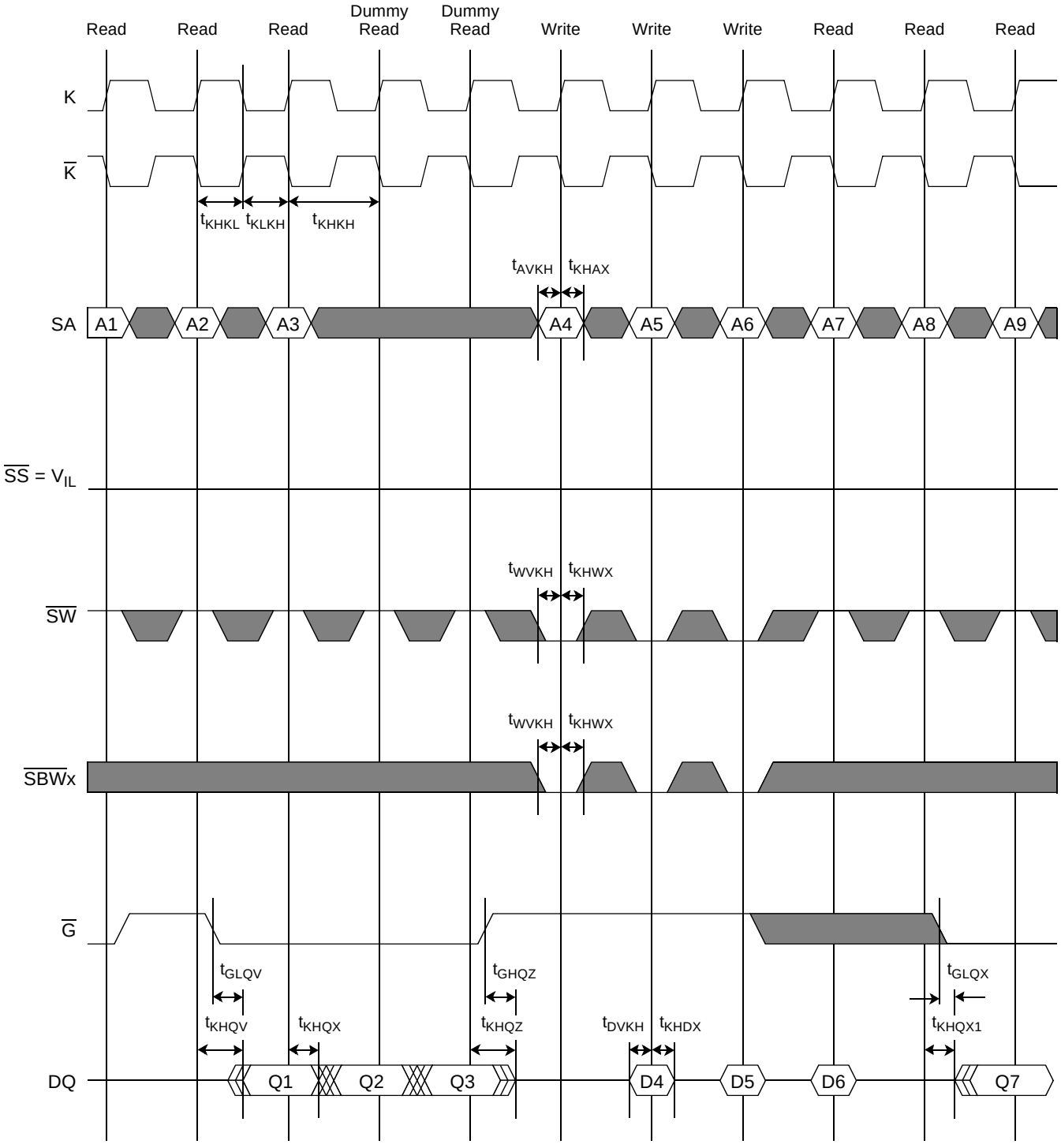
Figure 3



Note: In the diagram above, two Deselect operations are inserted between Read and Write operations to control the data bus transition from output to input. This depiction is for clarity purposes only. It is NOT a requirement. Depending on the application, one Deselect operation may be sufficient.

Conventional R-R Mode: Timing Diagram of Read-Write-Read Operations Asynchronously Controlled via $\overline{G}$ and Dummy Read Operations ($\overline{SS}$ = Low)

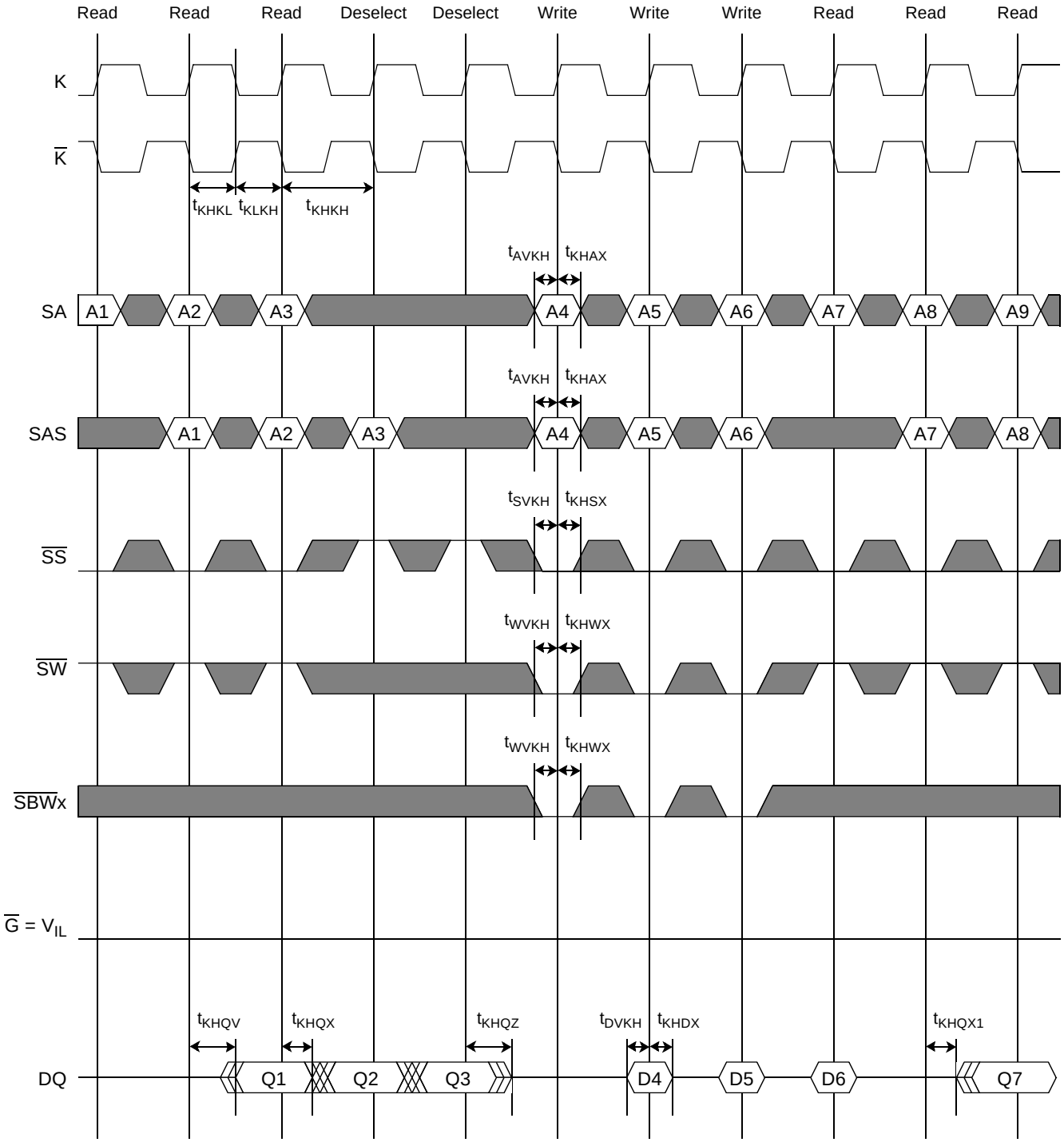
Figure 4



Note: In the diagram above, two Dummy Read operations are inserted between Read and Write operations to control the data bus transition from output to input. This depiction is for clarity purposes only. It is NOT a requirement. Depending on the application, one Dummy Read operation may be sufficient.

Late Select R-R Mode: Timing Diagram of Read-Write-Read Operations Synchronously Controlled via $\overline{SS}$ and Deselect Operations ($\overline{G}$ = Low)

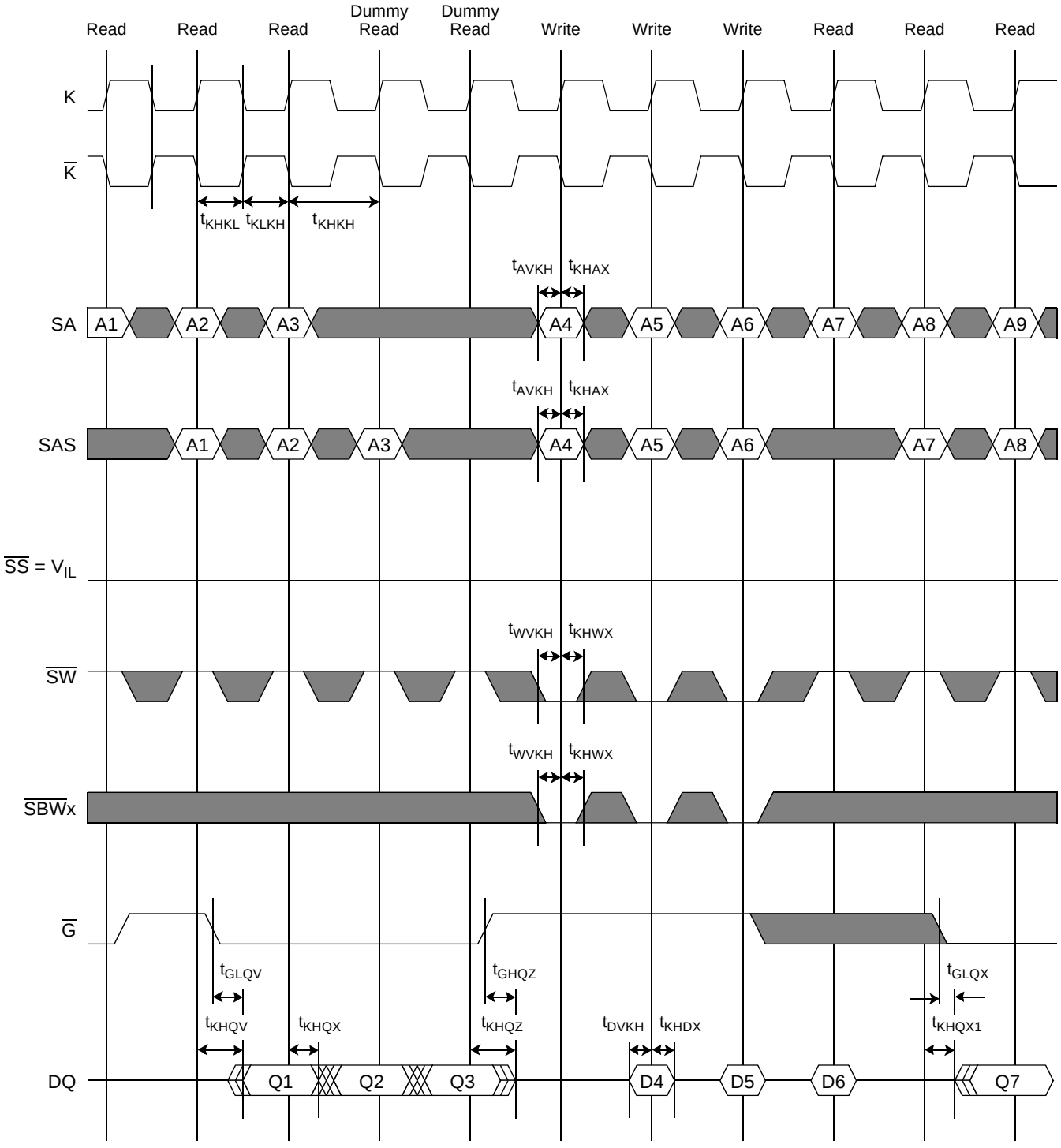
Figure 5



Note: In the diagram above, two Deselect operations are inserted between Read and Write operations to control the data bus transition from output to input. This depiction is for clarity purposes only. It is NOT a requirement. Depending on the application, one Deselect operation may be sufficient.

Late Select R-R Mode: Timing Diagram of Read-Write-Read Operations Asynchronously Controlled via $\overline{G}$ and Dummy Read Operations ($\overline{SS}$ = Low)

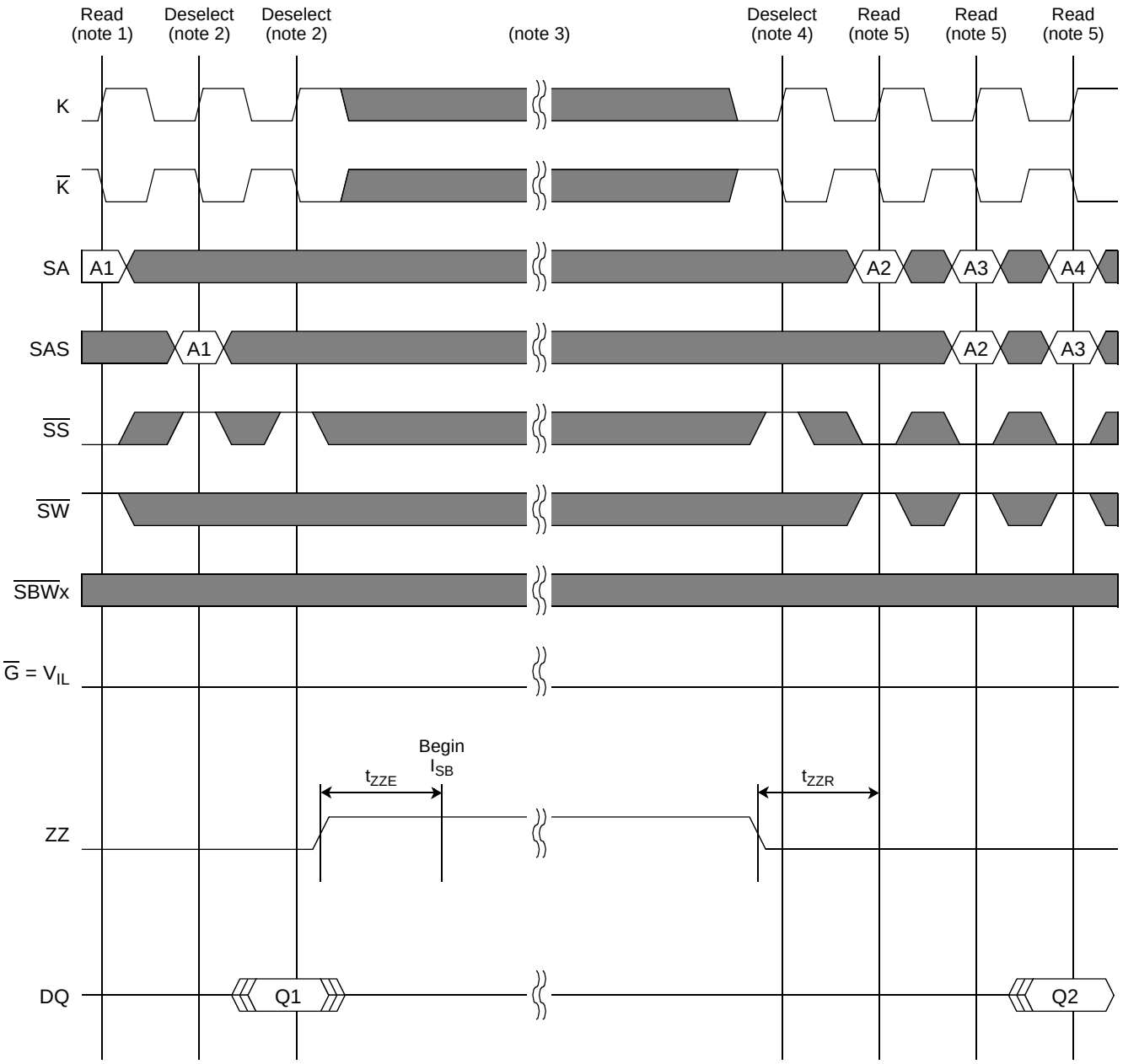
Figure 6



Note: In the diagram above, two Dummy Read operations are inserted between Read and Write operations to control the data bus transition from output to input. This depiction is for clarity purposes only. It is NOT a requirement. Depending on the application, one Dummy Read operation may be sufficient.

Timing Diagram of Sleep (Power-Down) Mode Operation Asynchronously Controlled via ZZ

Figure 7



Note 1: This can be ANY valid operation. The depiction of a Read operation here is provided only as an example.

Note 2: Before ZZ is asserted, at least two (2) Deselect operations must be initiated after the last Read or Write operation is initiated, in order to ensure the successful completion of the last Read or Write operation.

Note 3: While ZZ is asserted, all of the SRAM's address, control, data, and clock inputs are ignored.

Note 4: After ZZ is deasserted, Deselect operations must be initiated until the specified recovery time (t_{ZZR}) has been met. Read and Write operations may NOT be initiated during this time.

Note 5: This can be ANY valid operation. The depiction of a Read operation here is provided only as an example.

•Test Mode Description

These devices provide a JTAG Test Access Port (TAP) and Boundary Scan interface using a limited set of IEEE std. 1149.1 functions. This test mode is intended to provide a mechanism for testing the interconnect between master (processor, controller, etc.), SRAMs, other components, and the printed circuit board.

In conformance with a subset of IEEE std. 1149.1, these devices contain a TAP Controller and four TAP Registers. The TAP Registers consist of one Instruction Register and three Data Registers (ID, Bypass, and Boundary Scan Registers).

The TAP consists of the following four signals:

TCK:	Test Clock	Induces (clocks) TAP Controller state transitions.
TMS:	Test Mode Select	Inputs commands to the TAP Controller. Sampled on the rising edge of TCK.
TDI:	Test Data In	Inputs data serially to the TAP Registers. Sampled on the rising edge of TCK.
TDO:	Test Data Out	Outputs data serially from the TAP Registers. Driven from the falling edge of TCK.

Disabling the TAP

When JTAG is not used, TCK should be tied “low” to prevent clocking the SRAM. TMS and TDI should either be tied “high” through a pull-up resistor or left unconnected. TDO should be left unconnected.

Note: Operation of the TAP does not interfere with normal SRAM operation except when the SAMPLE-Z instruction is selected. Consequently, TCK, TMS, and TDI can be controlled any number of ways without adversely affecting the functionality of the device.

JTAG DC Recommended Operating Conditions (V_{DD} = 2.5V ± 5% or 3.3V ± 5%, T_A = 0 to 85°C)

Parameter	Symbol	Test Conditions	Min	Max	Units
JTAG Input High Voltage	V_{TIH}	---	1.4	3.6	V
JTAG Input Low Voltage	V_{TIL}	---	-0.3	0.8	V
JTAG Output High Voltage (CMOS)	$V_{TOH-3.3}$	V_{DD} = 3.3V I_{TOH} = -100uA	2.6	---	V
JTAG Output High Voltage (CMOS)	$V_{TOH-2.5}$	V_{DD} = 2.5V I_{TOH} = -100uA	V_{DD} - 0.1	---	V
JTAG Output Low Voltage (CMOS)	V_{TOL}	I_{TOL} = 100uA	---	0.1	V
JTAG Output High Voltage (TTL)	$V_{TOH-3.3}$	V_{DD} = 3.3V I_{TOH} = -8.0mA	2.3	---	V
JTAG Output High Voltage (TTL)	$V_{TOH-2.5}$	V_{DD} = 2.5V I_{TOH} = -6.5mA	V_{DD} - 0.4	---	V
JTAG Output Low Voltage (TTL)	V_{TOL}	I_{TOL} = 8.0mA	---	0.4	V
JTAG Input Leakage Current	I_{TLI}	V_{TIN} = 0V to 3.6V	-10	10	uA

JTAG AC Test Conditions

(V_{DD} = 2.5V ± 5%, T_A = 0 to 85°C)

Parameter	Symbol	Conditions	Units	Notes
JTAG Input High Level	V_{TIH}	2.5	V	
JTAG Input Low Level	V_{TIL}	0.0	V	
JTAG Input Rise & Fall Time		1.0	V/ns	
JTAG Input Reference Level		1.25	V	
JTAG Output Reference Level		1.25	V	
JTAG Output Load Condition				See Fig.1 (page 10)

JTAG AC Test Conditions

(V_{DD} = 3.3V ± 5%, T_A = 0 to 85°C)

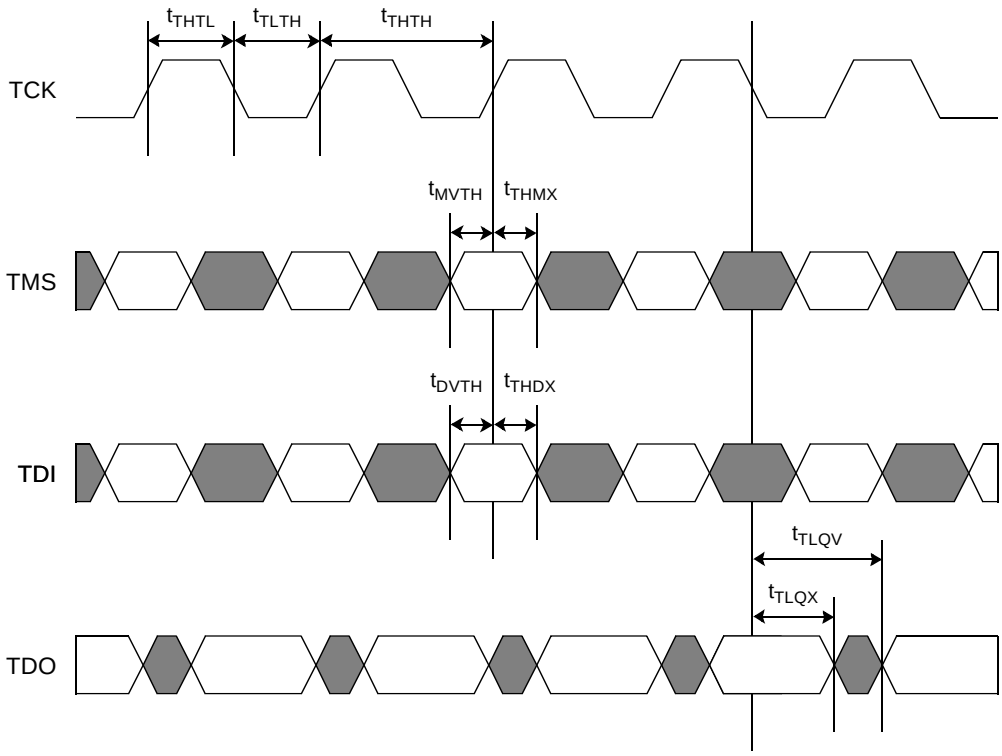
Parameter	Symbol	Conditions	Units	Notes
JTAG Input High Level	V_{TIH}	3.0	V	
JTAG Input Low Level	V_{TIL}	0.0	V	
JTAG Input Rise & Fall Time		1.0	V/ns	
JTAG Input Reference Level		1.5	V	
JTAG Output Reference Level		1.5	V	
JTAG Output Load Condition				See Fig.1 (page 10)

JTAG AC Electrical Characteristics

Parameter	Symbol	Min	Max	Unit
TCK Cycle Time	t_{THTH}	100		ns
TCK High Pulse Width	t_{THTL}	40		ns
TCK Low Pulse Width	t_{TLTH}	40		ns
TMS Setup Time	t_{MVTH}	10		ns
TMS Hold TIme	t_{THMX}	10		ns
TDI Setup Time	t_{DVTH}	10		ns
TDI Hold TIme	t_{THDX}	10		ns
TCK Low to TDO Valid	t_{TLQV}		20	ns
TCK Low to TDO Hold	t_{TLQX}	0		ns

JTAG Timing Diagram

Figure 8



TAP Registers

TAP Registers are serial shift registers that capture serial input data (from TDI) on the rising edge of TCK, and drive serial output data (to TDO) on the subsequent falling edge of TCK. They are divided into two groups: “Instruction Registers”, of which there is one- the Instruction Register, and “Data Registers”, of which there are three - the ID Register, the Bypass Register, and the Boundary Scan Register. Individual TAP registers are “selected” (inserted between TDI and TDO) when the appropriate sequence of commands is given to the TAP Controller.

Instruction Register (3 bits)

The Instruction Register stores the instructions that are executed by the TAP Controller when the TAP Controller is in the “Run-Test / Idle” state, or in any of the various “Data Register” states. It is loaded with the IDCODE instruction at power-up, or when the TAP Controller is in the “Test-Logic Reset” state or the “Capture-IR” state. It is inserted between TDI and TDO when the TAP Controller is in the “Shift-IR” state, at which time it can be loaded with a new instruction. However, newly loaded instructions are not executed by the TAP Controller until the TAP Controller has reached the “Update-IR” state.

The Instruction Register is 3 bits wide, and is encoded as follows:

Code (2:0)	Instruction	Description
000	BYPASS	Inserts the Bypass Register between TDI and TDO.
001	IDCODE	Inserts the ID Register between TDI and TDO.
010	SAMPLE-Z	Captures the SRAM’s I/O ring contents in the Boundary Scan Register. Inserts the Boundary Scan Register between TDI and TDO. Disables the SRAM’s data output drivers.
011	BYPASS	Inserts the Bypass Register between TDI and TDO.
100	SAMPLE	Captures the SRAM’s I/O ring contents in the Boundary Scan Register. Inserts the Boundary Scan Register between TDI and TDO.
101	PRIVATE	Do not use. Reserved for manufacturer use only.
110	BYPASS	Inserts the Bypass Register between TDI and TDO.
111	BYPASS	Inserts the Bypass Register between TDI and TDO.

Bit 0 is the LSB of the Instruction Register, and Bit 2 is the MSB. When the Instruction Register is selected, TDI serially shifts data into the MSB, and the LSB serially shifts data out through TDO.

ID Register (32 bits)

The ID Register is loaded with a predetermined device- and manufacturer-specific identification code when the IDCODE instruction has been loaded into the Instruction Register and the TAP Controller is in the “Capture-DR” state. It is inserted between TDI and TDO when the IDCODE instruction has been loaded into the Instruction Register and the TAP Controller is in the “Shift-DR” state.

The ID Register is 32 bits wide, and is encoded as follows:

Device	Revision Number (31:28)	Part Number (27:12)	Sony ID (11:1)	Start Bit (0)
256K x 36	xxxx	0000 0000 0100 1110	0000 1110 001	1
512K x 18	xxxx	0000 0000 0100 1001	0000 1110 001	1

Bit 0 is the LSB of the ID Register, and Bit 31 is the MSB. When the ID Register is selected, TDI serially shifts data into the MSB, and the LSB serially shifts data out through TDO.

Bypass Register (1 bit)

The Bypass Register is one bit wide, and provides the minimum length serial path between TDI and TDO. It is loaded with a logic "0" when the BYPASS instruction has been loaded in the Instruction Register and the TAP Controller is in the "Capture-DR" state. It is inserted between TDI and TDO when the BYPASS instruction has been loaded into the Instruction Register and the TAP Controller is in the "Shift-DR" state.

Boundary Scan Register (70 bits for x36, 51 bits for x18)

The Boundary Scan Register is equal in length to the number of active signal connections to the SRAM (excluding the TAP pins) plus a number of place holder locations reserved for density and/or functional upgrades. The Boundary Scan Register is loaded with the contents of the SRAM's I/O ring when the SAMPLE or SAMPLE-Z instruction has been loaded into the Instruction Register and the TAP Controller is in the "Capture-DR" state. It is inserted between TDI and TDO when the SAMPLE or SAMPLE-Z instruction has been loaded into the Instruction Register and the TAP Controller is in the "Shift-DR" state.

The Boundary Scan Register contains the following bits:

256K x 36		512K x 18	
DQ	36	DQ	18
SA	18	SA	19
K, $\overline{K}$	2	K, $\overline{K}$	2
$\overline{SS}$, $\overline{SW}$, $\overline{SBW}$x	6	$\overline{SS}$, $\overline{SW}$, $\overline{SBW}$x	4
$\overline{G}$, ZZ	2	$\overline{G}$, ZZ	2
M1, M2	2	M1, M2	2
ZQ	1	ZQ	1
Place Holder	3	Place Holder	3

For deterministic results, all signals composing the SRAM's I/O ring must meet setup and hold times with respect to TCK (same as TDI and TMS) when sampled.

K/$\overline{K}$ are connected to a differential input receiver that generates a single-ended input clock signal to the device. Therefore, in order to capture specific values for these signals in the Boundary Scan Register, these signals must be at opposite logic levels when sampled.

Place Holders are required for some NC pins to allow for future density and/or functional upgrades. They are connected to V_{SS} internally, regardless of pin connection externally.

The Boundary Scan Register Bit Order Assignment tables that follow depict the order in which the bits from the table above are arranged in the Boundary Scan Register. In each notation, Bit 1 is the LSB of the register. When the Boundary Scan Register is selected, TDI serially shifts data into the MSB, and the LSB serially shifts data out through TDO.

Boundary Scan Register Bit Order Assignment
(By Exit Sequence)

256K x 36					
Bit	Signal	Pad	Bit	Signal	Pad
1	M2	5R	36	SA	3B
2	SA / SAS	4P	37	NC (1)	2B
3	SA	4T	38	SA	3A
4	SA	6R	39	SA	3C
5	SA	5T	40	SA	2C
6	ZZ	7T	41	SA	2A
7	DQa	6P	42	DQc	2D
8	DQa	7P	43	DQc	1D
9	DQa	6N	44	DQc	2E
10	DQa	7N	45	DQc	1E
11	DQa	6M	46	DQc	2F
12	DQa	6L	47	DQc	2G
13	DQa	7L	48	DQc	1G
14	DQa	6K	49	DQc	2H
15	DQa	7K	50	DQc	1H
16	$\overline{SBW}$a	5L	51	$\overline{SBW}$c	3G
17	$\overline{K}$	4L	52	ZQ	4D
18	K	4K	53	$\overline{SS}$	4E
19	$\overline{G}$	4F	54	NC (1)	4G
20	$\overline{SBW}$b	5G	55	NC (1)	4H
21	DQb	7H	56	$\overline{SW}$	4M
22	DQb	6H	57	$\overline{SBW}$d	3L
22	DQb	7G	58	DQd	1K
24	DQb	6G	59	DQd	2K
25	DQb	6F	60	DQd	1L
26	DQb	7E	61	DQd	2L
27	DQb	6E	62	DQd	2M
28	DQb	7D	63	DQd	1N
29	DQb	6D	64	DQd	2N
30	SA	6A	65	DQd	1P
31	SA	6C	66	DQd	2P
32	SA	5C	67	SA	3T
33	SA	5A	68	SA	2R
34	SA	6B	69	SA	4N
35	SA	5B	70	M1	3R

512K x 18					
Bit	Signal	Pad	Bit	Signal	Pad
1	M2	5R	36	$\overline{SBW}$b	3G
2	SA	6T	37	ZQ	4D
3	SA / SAS	4P	38	$\overline{SS}$	4E
4	SA	6R	39	NC (1)	4G
5	SA	5T	40	NC (1)	4H
6	ZZ	7T	41	$\overline{SW}$	4M
7	DQa	7P	42	DQb	2K
8	DQa	6N	43	DQb	1L
9	DQa	6L	44	DQb	2M
10	DQa	7K	45	DQb	1N
11	$\overline{SBW}$a	5L	46	DQb	2P
12	$\overline{K}$	4L	47	SA	3T
13	K	4K	48	SA	2R
14	$\overline{G}$	4F	49	SA	4N
15	DQa	6H	50	SA	2T
16	DQa	7G	51	M1	3R
17	DQa	6F			
18	DQa	7E			
19	DQa	6D			
20	SA	6A			
21	SA	6C			
22	SA	5C			
22	SA	5A			
24	SA	6B			
25	SA	5B			
26	SA	3B			
27	NC (1)	2B			
28	SA	3A			
29	SA	3C			
30	SA	2C			
31	SA	2A			
32	DQb	1D			
33	DQb	2E			
34	DQb	2G			
35	DQb	1H			

Note 1: NC pins at pad locations 2B, 4G, and 4H are connected to V_{SS} internally, regardless of pin connection externally.

TAP Instructions

IDCODE

IDCODE is the default instruction loaded into the Instruction Register at power-up, and when the TAP Controller is in the "Test-Logic Reset" state.

When the IDCODE instruction is selected, a predetermined device- and manufacturer-specific identification code is loaded into the ID Register when the TAP Controller is in the "Capture-DR" state, and the ID Register is inserted between TDI and TDO when the TAP Controller is in the "Shift-DR" state.

Normal SRAM operation is not disrupted when the IDCODE instruction is selected.

BYPASS

When the BYPASS instruction is selected, a logic "0" is loaded into the Bypass Register when the TAP Controller is in the "Capture-DR" state, and the Bypass Register is inserted between TDI and TDO when the TAP Controller is in the "Shift-DR" state.

Normal SRAM operation is not disrupted when the BYPASS instruction is selected.

SAMPLE

When the SAMPLE instruction is selected, the individual logic states of all signals composing the SRAM's I/O ring (see the Boundary Scan Register description for the complete list of signals) are loaded into the Boundary Scan Register when the TAP Controller is in the "Capture-DR" state, and the Boundary Scan Register is inserted between TDI and TDO when the TAP Controller is in the "Shift-DR" state.

Normal SRAM operation is not disrupted when the SAMPLE instruction is selected.

SAMPLE-Z

When the SAMPLE-Z instruction is selected, the individual logic states of all signals composing the SRAM's I/O ring (see the Boundary Scan Register description for the complete list of signals) are loaded into the Boundary Scan Register when the TAP Controller is in the "Capture-DR" state, and the Boundary Scan Register is inserted between TDI and TDO when the TAP Controller is in the "Shift-DR" state.

Additionally, when the SAMPLE-Z instruction is selected, the SRAM's data output drivers are disabled.

Consequently, normal SRAM operation is disrupted when the SAMPLE-Z instruction is selected. Read operations initiated while the SAMPLE-Z instruction is selected will fail.

TAP Controller

The TAP Controller is a 16-state state machine that controls access to the various TAP Registers and executes the operations associated with each TAP Instruction. State transitions are controlled by TMS and occur on the rising edge of TCK.

The TAP Controller enters the “Test-Logic Reset” state in one of two ways:

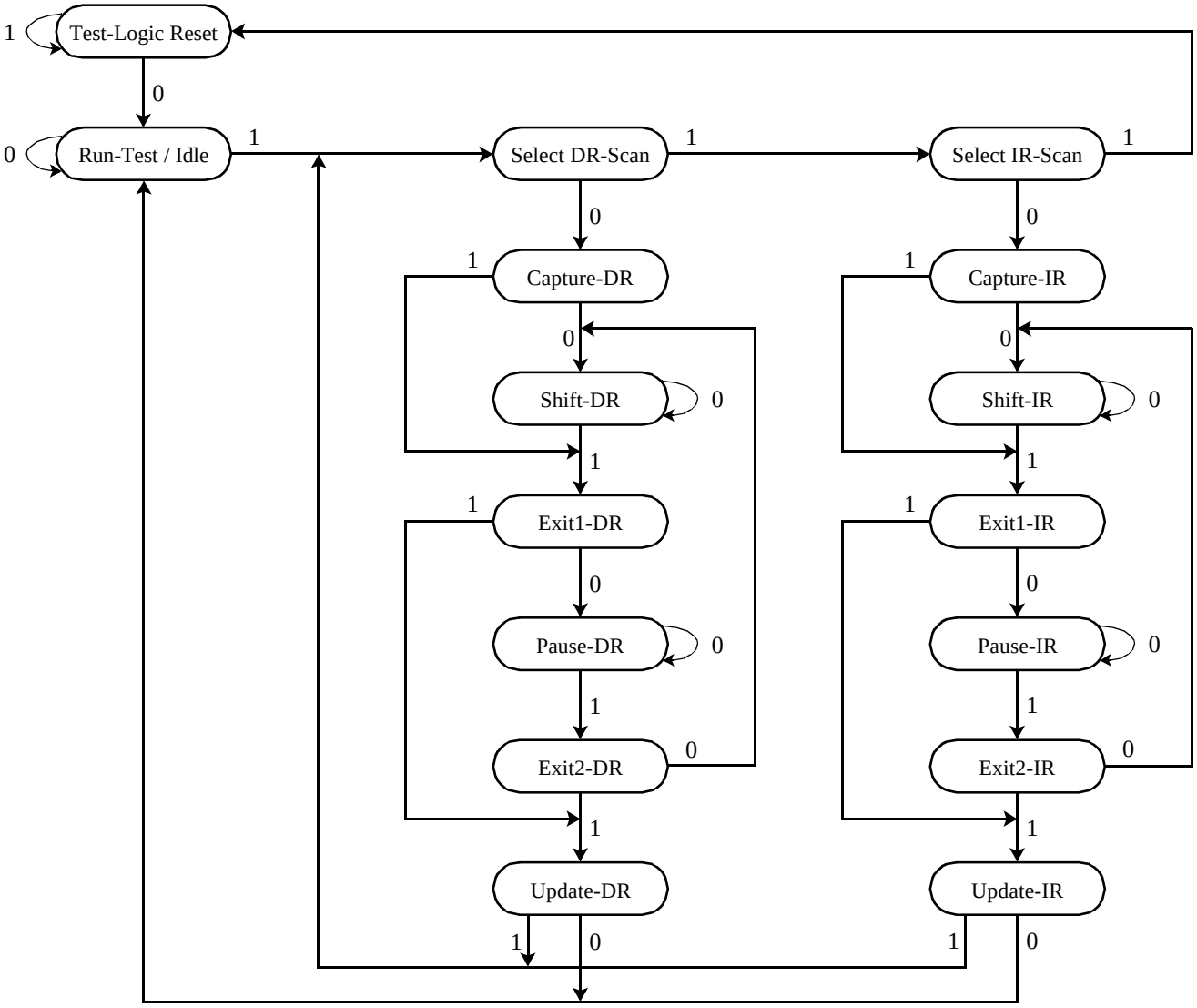
1. At power up.
2. When a logic “1” is applied to TMS for at least 5 consecutive rising edges of TCK.

The TDI input receiver is sampled only when the TAP Controller is in either the “Shift-IR” state or the “Shift-DR” state.

The TDO output driver is active only when the TAP Controller is in either the “Shift-IR” state or the “Shift-DR” state.

TAP Controller State Diagram

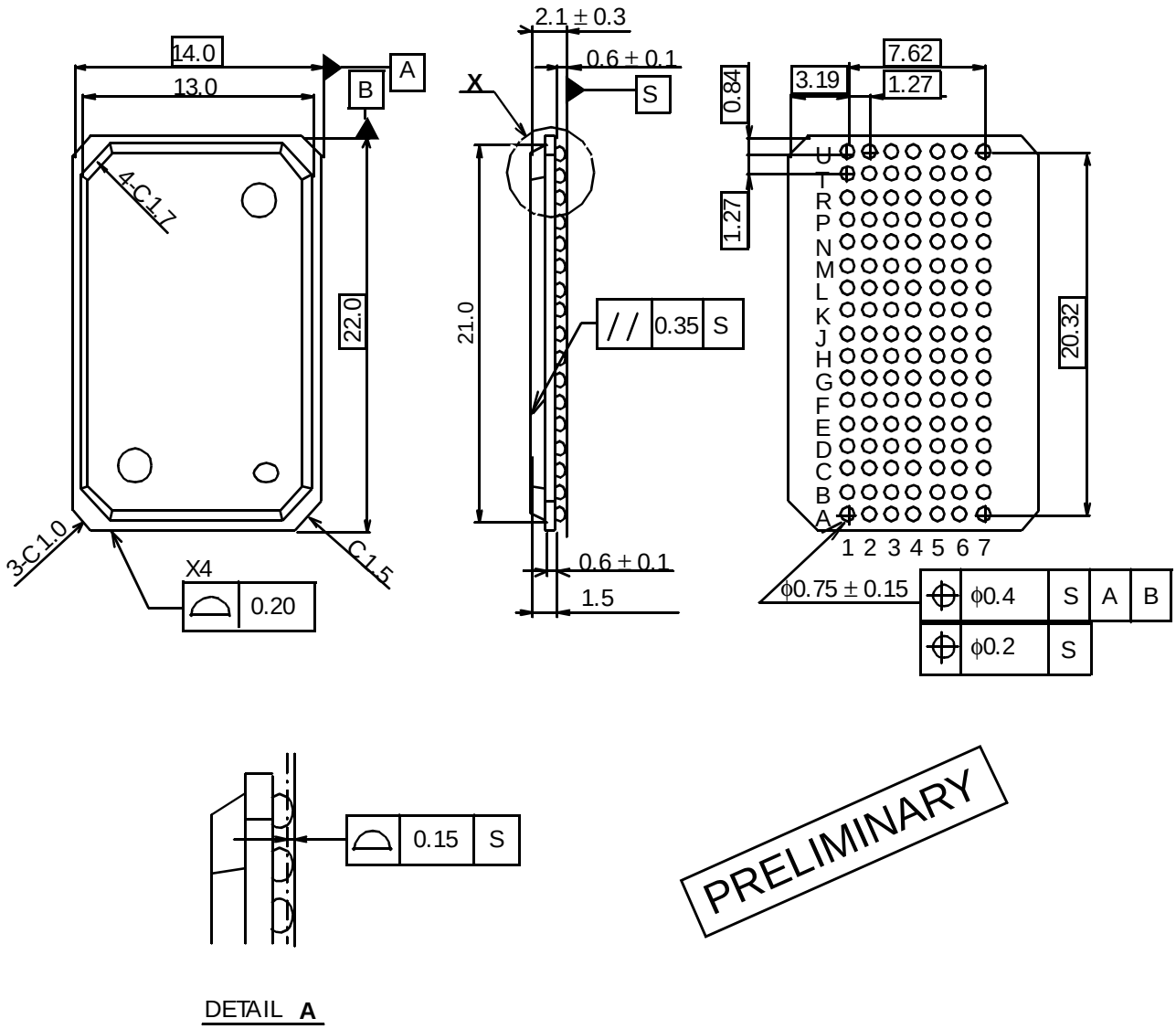
Figure 9



•Ordering Information

Part Number	V_{DD}	I/O Type	Size	Speed (Cycle Time / Access Time)
CXK77Q36B80AGB-28	2.5V or 3.3V	HSTL	256K x 36	2.8ns / 1.6ns
CXK77Q36B80AGB-33	2.5V or 3.3V	HSTL	256K x 36	3.3ns / 1.6ns
CXK77Q36B80AGB-37 CXK77Q36B80AGB-37A	2.5V or 3.3V	HSTL	256K x 36	3.7ns / 1.8ns 3.7ns / 1.6ns
CXK77Q36B80AGB-4 CXK77Q36B80AGB-4A	2.5V or 3.3V	HSTL	256K x 36	4.0ns / 2.0ns 4.0ns / 1.8ns
CXK77Q18B80AGB-28	2.5V or 3.3V	HSTL	512K x 18	2.8ns / 1.6ns
CXK77Q18B80AGB-33	2.5V or 3.3V	HSTL	512K x 18	3.3ns / 1.6ns
CXK77Q18B80AGB-37 CXK77Q18B80AGB-37A	2.5V or 3.3V	HSTL	512K x 18	3.7ns / 1.8ns 3.7ns / 1.6ns
CXK77Q18B80AGB-4 CXK77Q18B80AGB-4A	2.5V or 3.3V	HSTL	512K x 18	4.0ns / 2.0ns 4.0ns / 1.8ns

(7x17) 119 Pin BGA Package Dimensions

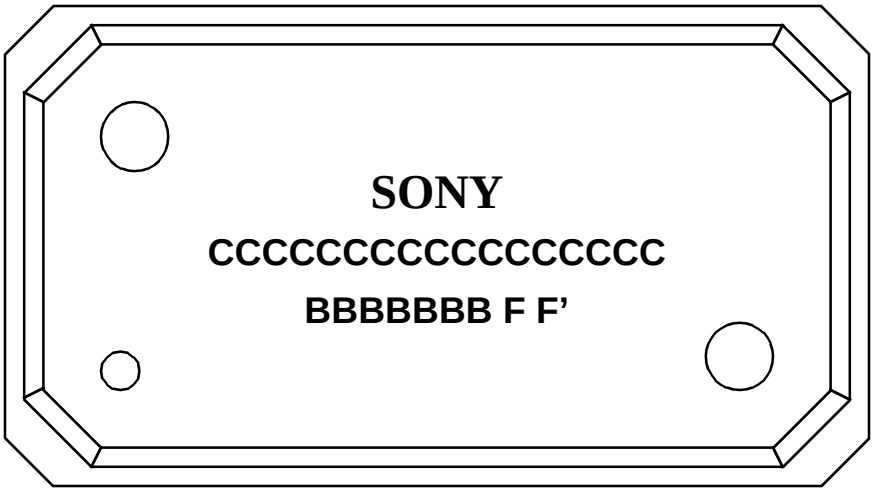


PACKAGE STRUCTURE

PACKAGE MATERIAL	EPOXY RESIN
BORAD TREATMENT	COPPER-CLAD LAMINATE
LEAD MATERIAL	SOLDER
PACKAGE MASS	1.1g

SONY CODE	BGA-119P-021
EIAJ CODE	BGA119-P-1422
JEDEC CODE	————

(7x17) 119 Pin BGA Package Marking



Description

1) C Field: Part Number Code (up to 17 characters).
2) B Field: Lot Code (up to 7 characters).
3) F Field: Wafer Fab Plant Code (1 character).
   e.g. F = "W" indicates Wafertech Fab.
   e.g. F = "" (blank) indicates TSMC Fab (no character is used for TSMC).
4) F' Field: Revised Control Code (1 character).

Example 1: Wafertech Fab

Example 2: TSMC Fab

•Revision History

Rev. #	Rev. Date	Description of Modification
rev 0.0	07/18/00	Initial Version
rev 1.0	11/03/00	1. Modified DC Recommended Operating Conditions (p. 7). V_{MIH} (min) V_{REF} + 0.3V to 1.2V V_{MIL} (max) V_{REF} - 0.3V to 0.4V 2. Modified DC Electrical Characteristics (p. 8). I_{DD-33} (max) 700mA to 740mA I_{DD-37} (max) 640mA to 680mA I_{DD-4} (max) 590mA to 640mA 3. Modified 2.5V V_{DD} AC Test Conditions (p. 10). Removed note stating that both Conventional R-R and Late Select R-R Modes are tested at 2.5V V_{DD}. This is the default case - no note is needed. 4. Modified 3.3V V_{DD} AC Test Conditions (p. 11). Removed note stating that only Conventional R-R Mode is tested at 3.3V V_{DD}. Both modes are tested at 3.3V V_{DD} as well as 2.5V V_{DD}. 5. Modified JTAG DC Recommended Operating Conditions (p. 17). $V_{TOH-3.3}$ (min) at I_{TOH} = -100uA 2.7V to 2.6V $V_{TOH-3.3}$ (min) at I_{TOH} = -8mA 2.4V to 2.3V 6. Added BGA Package Marking (p. 27)
rev 1.1	02/21/01	1. Modified DC Recommended Operating Conditions (p. 7). V_{DDQ} (max) 1.6V to 1.9V V_{REF}, V_{CM} (max) 0.9V to 1.0V 2. Modified AC Electrical Characteristics (p. 9). -37 t_{KHQV} 1.7ns to 1.8ns 3. Combined 1.5V V_{DDQ} AC Test Conditions for V_{DD} = 2.5V and 3.3V (p.10). 4. Added 1.8V V_{DDQ} AC Test Conditions for V_{DD} = 2.5V and 3.3V (p.11). 5. Modified JTAG DC Recommended Operating Conditions (p. 17). I_{TOH} Test Condition for $V_{TOH-2.5}$ (min) = V_{DD} - 0.4V -8.0mA to -6.5mA
rev 1.2	04/18/01	1. Modified DC Electrical Characteristics (p. 8). I_{DD-4} (max) 640mA to 600mA Added note 1 stating that Average Power Supply Operating Current at 250 MHz operation (I_{DD-4}) is tested with no tester guardband.
rev 1.3	08/13/01	1. Modified DC Electrical Characteristics (p. 8). Removed note 1 stating that Average Power Supply Operating Current at 250 MHz operation (I_{DD-4}) is tested with no tester guardband. 2. Modified AC Electrical Characteristics (p. 9). -28 t_{KHQV} 1.5ns to 1.6ns
rev 1.4	09/21/01	1. Modified DC Electrical Characteristics (p. 8). I_{DD-28} (max) 830mA to 750mA I_{DD-33} (max) 740mA to 700mA
rev 1.5	10/02/01	1. Modified DC Electrical Characteristics (p. 8). Added note 4 stating that Average Power Supply Operating Current in devices marked as "-33" is guaranteed (by test) to meet both the I_{DD-33} specification at 300 MHz operation and the I_{DD-4} specification at 250 MHz operation.
rev 1.6	10/18/01	1. Modified DC Electrical Characteristics (p. 8). I_{MLI} (min/max) ±10uA to ±5uA I_{LO} (min/max) ±10uA to ±5uA