RMQC4A1836DGBA, RMQC4A1818DGBA

18-Mbit DDR™ II SRAM
2-word Burst

R10DS0248EJ0100
Rev.1.00
Jan. 13, 2015

Description

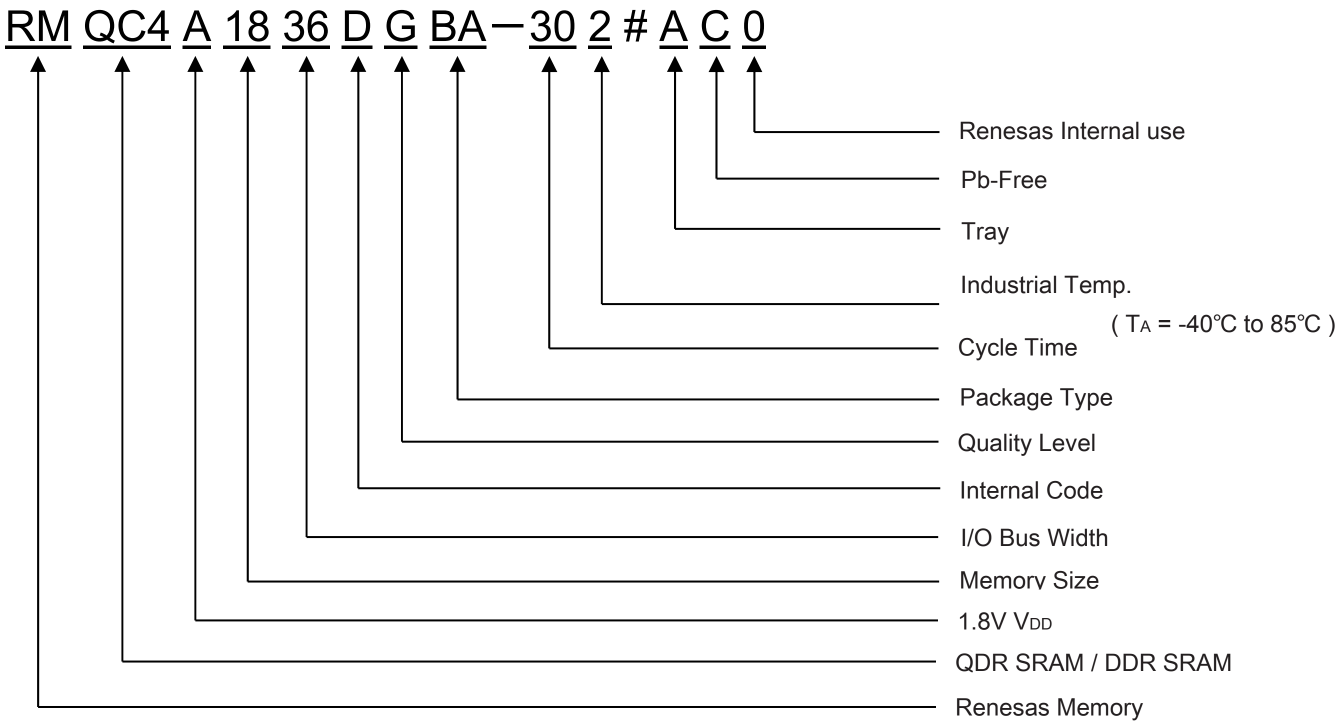
The RMQC4A1836DGBA is a 524,288-word by 36-bit and the RMQC4A1818DGBA is a 1,048,576-word by 18-bit synchronous quad data rate static RAM fabricated with advanced CMOS technology using full CMOS six-transistor memory cell. It integrates unique synchronous peripheral circuitry and a burst counter. All input registers are controlled by an input clock pair (K and /K) and are latched on the positive edge of K and /K. These products are suitable for applications which require synchronous operation, high speed, low voltage, high density and wide bit configuration. These products are packaged in 165-pin plastic FBGA package.

Features

- Power Supply
  - 1.8 V for core (V_{DD}), 1.4 V to V_{DD} for I/O (V_{DDQ})
- Clock
  - Fast clock cycle time for high bandwidth
  - Two input clocks (K and /K) for precise DDR timing at clock rising edges only
  - Two input clocks for output data (C and /C) to minimize clock skew and flight time mismatches
  - Two output echo clocks (CQ and /CQ) simplify data capture in high-speed systems
  - Clock-stop capability with µs restart
- I/O
  - Common data input/output bus
  - Pipelined double data rate operation
  - HSTL I/O
  - User programmable output impedance
  - PLL circuitry for wide output data valid window and future frequency scaling
- Function
  - Two-tick burst for low DDR transaction size
  - Internally self-timed write control
  - Simple control logic for easy depth expansion
  - JTAG 1149.1 compatible test access port
- Package
  - 165 FBGA package (13 x 15 x 1.4 mm)

Orderable Part Name Definition

Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Example	R	M	Q	*X*	*X*	A	*X*	*X*	*X*	*X*	D	G	B	A	-	3	0	2	#	A	C	0



Order Information

Orderable Part Name	**Organization (word x bit)**	**Cycle time**	**Clock frequency**	**Operating Ambient Temperature**	**Core Supply Voltage (V)**	**Package**
RMQC4A1836DGBA-302#AC0	512k x 36	3.00ns	333MHz	T_A = −40 to 85°C	1.8 ± 0.1	165-pin PLASTIC BGA (13 x 15) Pb-free
RMQC4A1836DGBA-332#AC0		3.30ns	300MHz			
RMQC4A1818DGBA-302#AC0	1M x 18	3.00ns	333MHz			
RMQC4A1818DGBA-332#AC0		3.30ns	300MHz			

Pin Arrangement

[RMQC4A1836DGBA]

512k x 36

(Top View)

	1	2	3	4	5	6	7	8	9	10	11
A	/CQ	NC	NC	R-/W	/BW2	/K	/BW1	/LD	SA	NC	CQ
B	NC	DQ27	DQ18	SA	/BW3	K	/BW0	SA	NC	NC	DQ8
C	NC	NC	DQ28	V_{SS}	SA	SA0	SA	V_{SS}	NC	DQ17	DQ7
D	NC	DQ29	DQ19	V_{SS}	V_{SS}	V_{SS}	V_{SS}	V_{SS}	NC	NC	DQ16
E	NC	NC	DQ20	V_{DDQ}	V_{SS}	V_{SS}	V_{SS}	V_{DDQ}	NC	DQ15	DQ6
F	NC	DQ30	DQ21	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	NC	DQ5
G	NC	DQ31	DQ22	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	NC	DQ14
H	/DOFF	V_{REF}	V_{DDQ}	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	V_{DDQ}	V_{REF}	ZQ
J	NC	NC	DQ32	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	DQ13	DQ4
K	NC	NC	DQ23	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	DQ12	DQ3
L	NC	DQ33	DQ24	V_{DDQ}	V_{SS}	V_{SS}	V_{SS}	V_{DDQ}	NC	NC	DQ2
M	NC	NC	DQ34	V_{SS}	V_{SS}	V_{SS}	V_{SS}	V_{SS}	NC	DQ11	DQ1
N	NC	DQ35	DQ25	V_{SS}	SA	SA	SA	V_{SS}	NC	NC	DQ10
P	NC	NC	DQ26	SA	SA	C	SA	SA	NC	DQ9	DQ0
R	TDO	TCK	SA	SA	SA	/C	SA	SA	SA	TMS	TDI

Notes: 1. Address expansion order for future higher density SRAMs: 9A → 3A → 10A → 2A → 7A → 5B.

2. NC pins can be left floating or connected to 0V to V_{DDQ}

[RMQC4A1818DGBA]

1M x 18

(Top View)

	1	2	3	4	5	6	7	8	9	10	11
A	/CQ	NC	SA	R-/W	/BW1	/K	NC	/LD	SA	NC	CQ
B	NC	DQ9	NC	SA	NC	K	/BW0	SA	NC	NC	DQ8
C	NC	NC	NC	V_{SS}	SA	SA0	SA	V_{SS}	NC	DQ7	NC
D	NC	NC	DQ10	V_{SS}	V_{SS}	V_{SS}	V_{SS}	V_{SS}	NC	NC	NC
E	NC	NC	DQ11	V_{DDQ}	V_{SS}	V_{SS}	V_{SS}	V_{DDQ}	NC	NC	DQ6
F	NC	DQ12	NC	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	NC	DQ5
G	NC	NC	DQ13	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	NC	NC
H	/DOFF	V_{REF}	V_{DDQ}	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	V_{DDQ}	V_{REF}	ZQ
J	NC	NC	NC	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	DQ4	NC
K	NC	NC	DQ14	V_{DDQ}	V_{DD}	V_{SS}	V_{DD}	V_{DDQ}	NC	NC	DQ3
L	NC	DQ15	NC	V_{DDQ}	V_{SS}	V_{SS}	V_{SS}	V_{DDQ}	NC	NC	DQ2
M	NC	NC	NC	V_{SS}	V_{SS}	V_{SS}	V_{SS}	V_{SS}	NC	DQ1	NC
N	NC	NC	DQ16	V_{SS}	SA	SA	SA	V_{SS}	NC	NC	NC
P	NC	NC	DQ17	SA	SA	C	SA	SA	NC	NC	DQ0
R	TDO	TCK	SA	SA	SA	/C	SA	SA	SA	TMS	TDI

Notes:
1. Address expansion order for future higher density SRAMs: 9A → 3A → 10A → 2A → 7A → 5B.
2. NC pins can be left floating or connected to 0V to V_{DDQ}

Pin Descriptions

Name	I/O type	Descriptions	Note
SA	Input	Synchronous address inputs: These inputs are registered and must meet the setup and hold times around the rising edge of K. SA0 is used as the lowest address bit for burst READ and burst WRITE operations permitting a random burst start address on ×18 and ×36 of DDR II devices. This input is ignored when device is deselected or once burst operation is in progress.	
/LD	Input	Synchronous load: This input is brought low when a bus cycle sequence is to be defined. This definition includes address and READ/WRITE direction. All transactions operate on a burst of two data.	
R-/W	Input	Synchronous read / write Input: When /LD is low, this input designates the access type (READ when R-/W is high, WRITE when R-/W is low) for the loaded address. R-/W must meet the setup and hold times around the rising edge of K.	
/BW$_x$	Input	Synchronous byte writes: When low, these inputs cause their respective byte to be registered and written during WRITE cycles. These signals are sampled on the same edge as the corresponding data and must meet setup and hold times around the rising edges of K and /K for each of the rising edges comprising the WRITE cycle. See Byte Write Truth Table for signal to data relationship.	
K, /K	Input	Input clock: This input clock pair registers address and control inputs on the rising edge of K, and registers data on the rising edge of K and the rising edge of /K. /K is ideally 180 degrees out of phase with K. All synchronous inputs must meet setup and hold times around the clock rising edges. These balls cannot remain V_{REF} level.	
C, /C	Input	Output clock: This clock pair provides a user-controlled means of tuning device output data. Ideally, /C is 180 degrees out of phase with C. If C and /C are tied high, K and /K are used as the output reference clocks instead of C and /C clocks. If tied high, C and /C must remain high and not to be toggled during device operation. These balls cannot remain VREF level.	
/DOFF	Input	PLL disable: When low, this input causes the PLL to be bypassed for stable, low frequency operation.	
TMS TDI	Input	IEEE1149.1 test inputs: 1.8 V I/O levels. These balls may be left unconnected if the JTAG function is not used in the circuit.	
TCK	Input	IEEE1149.1 clock input: 1.8 V I/O levels. This ball must be tied to V_{SS} if the JTAG function is not used in the circuit.	
ZQ	Input	Output impedance matching input: This input is used to tune the device outputs to the system data bus impedance. Q and CQ output impedance are set to 0.2 × RQ, where RQ is a resistor from this ball to ground. This ball can be connected directly to V_{DDQ}, which enables the minimum impedance mode. This ball cannot be connected directly to V_{SS} or left unconnected.	

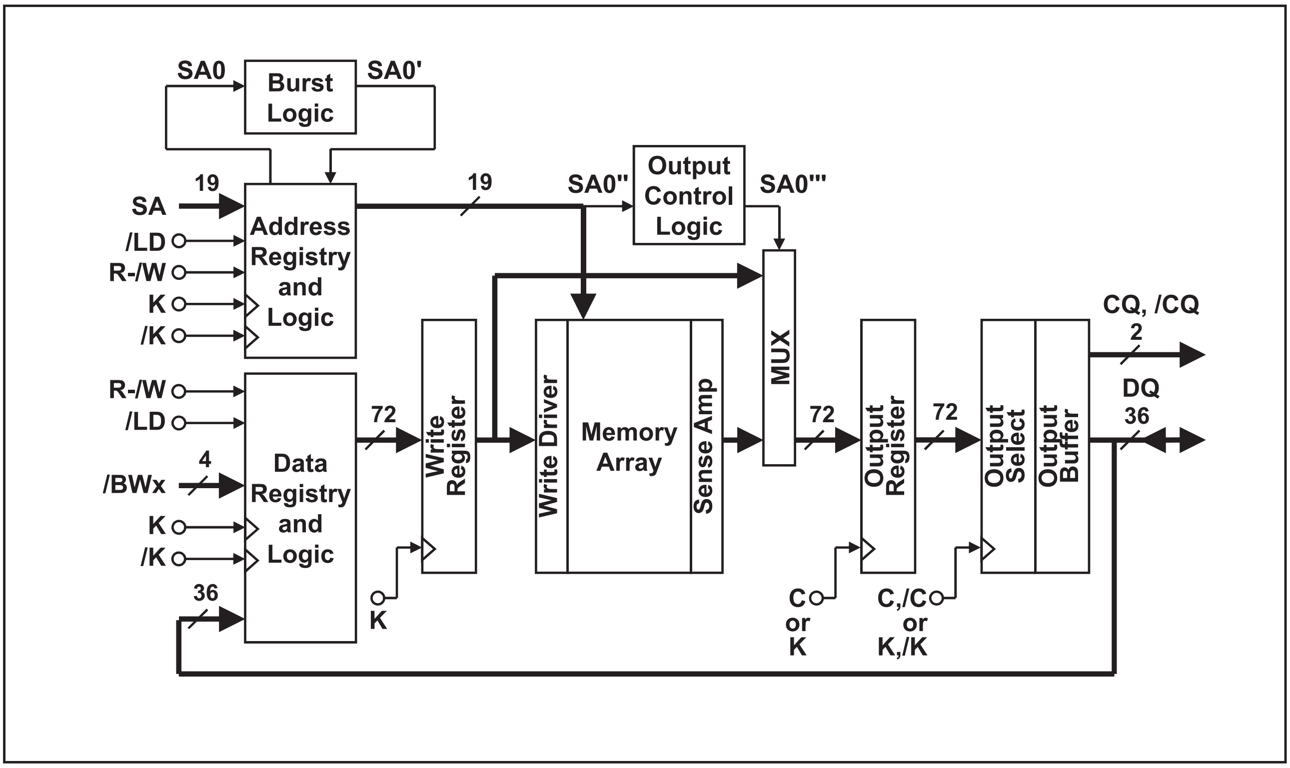
Name	I/O type	Descriptions	Note
DQ_0 to DQ_n	Input	Synchronous data I/Os: Input data must meet setup and hold times around the rising edges of K and /K. Output data is synchronized to the respective C clock, or to the K clock if C and /C are tied high. The x18 device uses DQ0~DQ17. DQ18~DQ35 should be treated as NC pin. The x36 device uses DQ0 to DQ35.	
CQ, /CQ	Output	Synchronous echo clock outputs: The edges of these outputs are tightly matched to the synchronous data outputs and can be used as a data valid indication. These signals run freely and do not stop when Q tri-states.	
TDO	Output	IEEE 1149.1 test output: 1.8 V I/O level.	
V_{DD}	Supply	Power supply: 1.8 V nominal. See DC Characteristics and Operating Conditions for range.	1
V_{DDQ}	Supply	Power supply: Isolated output buffer supply. Nominally 1.5 V. See DC Characteristics and Operating Conditions for range.	1
V_{SS}	Supply	Power supply: Ground.	1
V_{REF}	-	HSTL input reference voltage: Nominally $V_{DDQ}/2$, but may be adjusted to improve system noise margin. Provides a reference voltage for the HSTL input buffers.	
NC	-	No connect: These pins can be left floating or connected to 0V to V_{DDQ}.	

Notes:

1. All power supply and ground balls must be connected for proper operation of the device.

Block Diagram

[RMQC4A1836DGBA]



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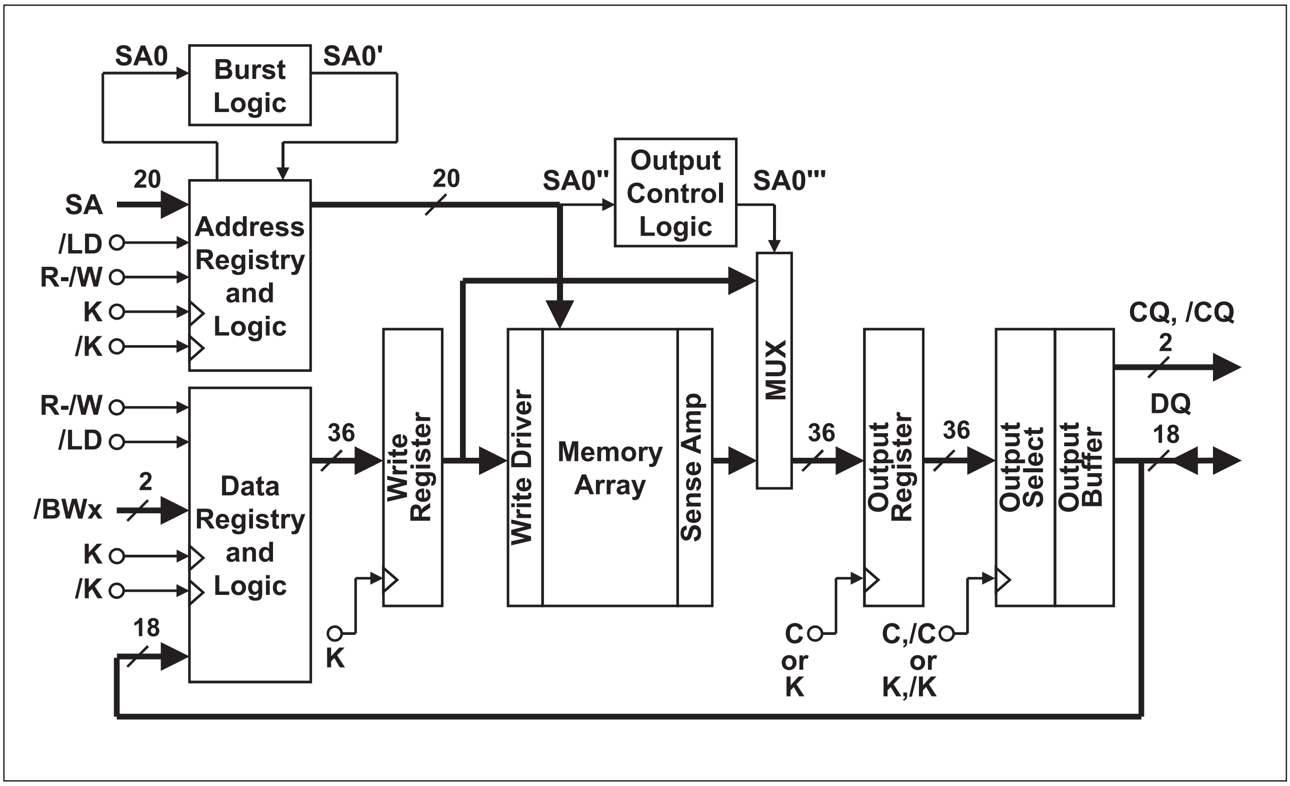
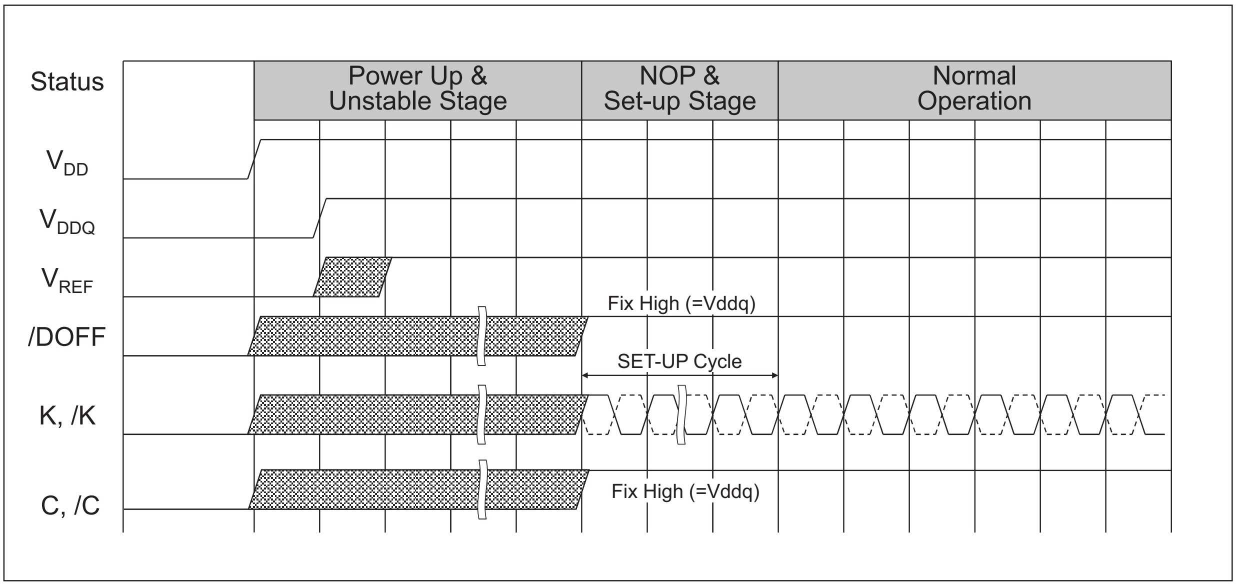


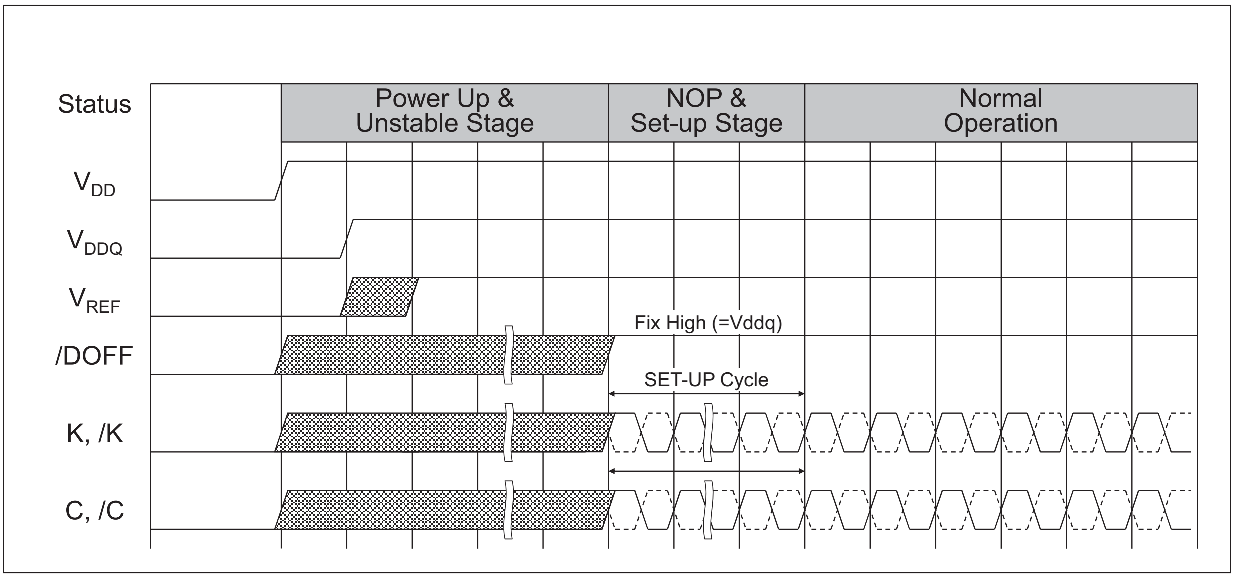
Power-up and Initialization Sequence

- V_{DD} must be stable before K, /K clocks are applied.
- Recommended voltage application sequence : $V_{SS} \rightarrow V_{DD} \rightarrow V_{DDQ}$ & $V_{REF} \rightarrow V_{IN}$. (0 V to V_{DD}, V_{DDQ} < 200 ms)
- Apply V_{REF} after V_{DDQ} or at the same time as V_{DDQ}.
- Then execute either one of the following three sequences.

1. Single Clock Mode
   - Drive /DOFF high (/DOFF can be tied high from the start).
   - Then provide stable clocks (K, /K) for at least 20 us.



2. Double Clock Mode (C and /C control outputs)
   - Drive /DOFF high (/DOFF can be tied high from the start)
   - Then provide stable clocks (K, /K , C, /C) for at least 20 us.



3. PLL Off Mode (/DOFF tied low)
   - In the "NOP and setup stage", provide stable clocks (K, /K) for at least 20 us.

PLL Constraints

1. These chips use the PLL. The clock input should have low phase jitter which is specified as tKC var.
2. The lower end of the frequency at which the PLL can operate is 120 MHz.

   (Please refer to AC Characteristics table for detail.)
3. When the operating frequency is changed or /DOFF level is changed, setup cycles are required again.

Programmable Output Impedance

1. Output buffer impedance can be programmed by terminating the ZQ ball to VSS through a precision resistor (RQ). The value of RQ is five times the output impedance desired. The allowable range of RQ to guarantee impedance matching with a tolerance of 15% is between 175 Ω and 350 Ω. The total external capacitance of ZQ ball must be less than 7.5 pF.

K Truth Table

Operation	K	/LD	R-/W	DQ		
Write Cycle: Load address, input write data on two consecutive K and /K rising edges	↑	L	L	Data in		
				Input data	D(A+0)	D(A+1)
				Input clock	K(t+1)↑	/K(t+1)↑
Read Cycle: Load address, output read data on two consecutive C and /C rising edges	↑	L	H	Data out		
				Output data	Q(A+0)	Q(A+1)
				Input clock	/C(t+1)↑	C(t+2)↑
NOP (No operation)	↑	H	x	High-Z		
Standby (Clock stopped)	Stopped	x	x	Previous state		

Notes:

1. H: high level, L: low level, ×: don’t care, ↑: rising edge.
2. Data inputs are registered at K and /K rising edges. Data outputs are delivered at C clock edges, except if C and /C are high, then data outputs are delivered at K clock edges.
3. /R and /W must meet setup/hold times around the rising edges (low to high) of K and are registered at the rising edge of K.
4. This device contains circuitry that will ensure the outputs will be in high-Z during power-up.
5. Refer to state diagram and timing diagrams for clarification.
6. When clocks are stopped, the following cases are recommended; the case of K = low, /K = high, C = low and /C = high, or the case of K = high, /K = low, C = high and /C = low. This condition is not essential, but permits most rapid restart by overcoming transmission line charging symmetrically.
7. A+0 refers to the address input during a WRITE or READ cycle. A+1 refers to the next internal burst address in accordance with the linear burst sequence.

Linear Burst Sequence Table

	SA0	SA0	Notes
External address	0	1	
1st internal burst address	1	0	

Byte Write Truth Table (x 36)

Operation	K	/K	/BW0	/BW1	/BW2	/BW3
Write D0 to D35	↑	-	L	L	L	L
	-	↑	L	L	L	L
Write D0 to D8	↑	-	L	H	H	H
	-	↑	L	H	H	H
Write D9 to D17	↑	-	H	L	H	H
	-	↑	H	L	H	H
Write D18 to D26	↑	-	H	H	L	H
	-	↑	H	H	L	H
Write D27 to D35	↑	-	H	H	H	L
	-	↑	H	H	H	L
Write nothing	↑	-	H	H	H	H
	-	↑	H	H	H	H

Notes:

1. H: high level, L: low level, ↑: rising edge.
2. Assumes a WRITE cycle was initiated. /BWx can be altered for any portion of the BURST WRITE operation provided that the setup and hold requirements are satisfied.

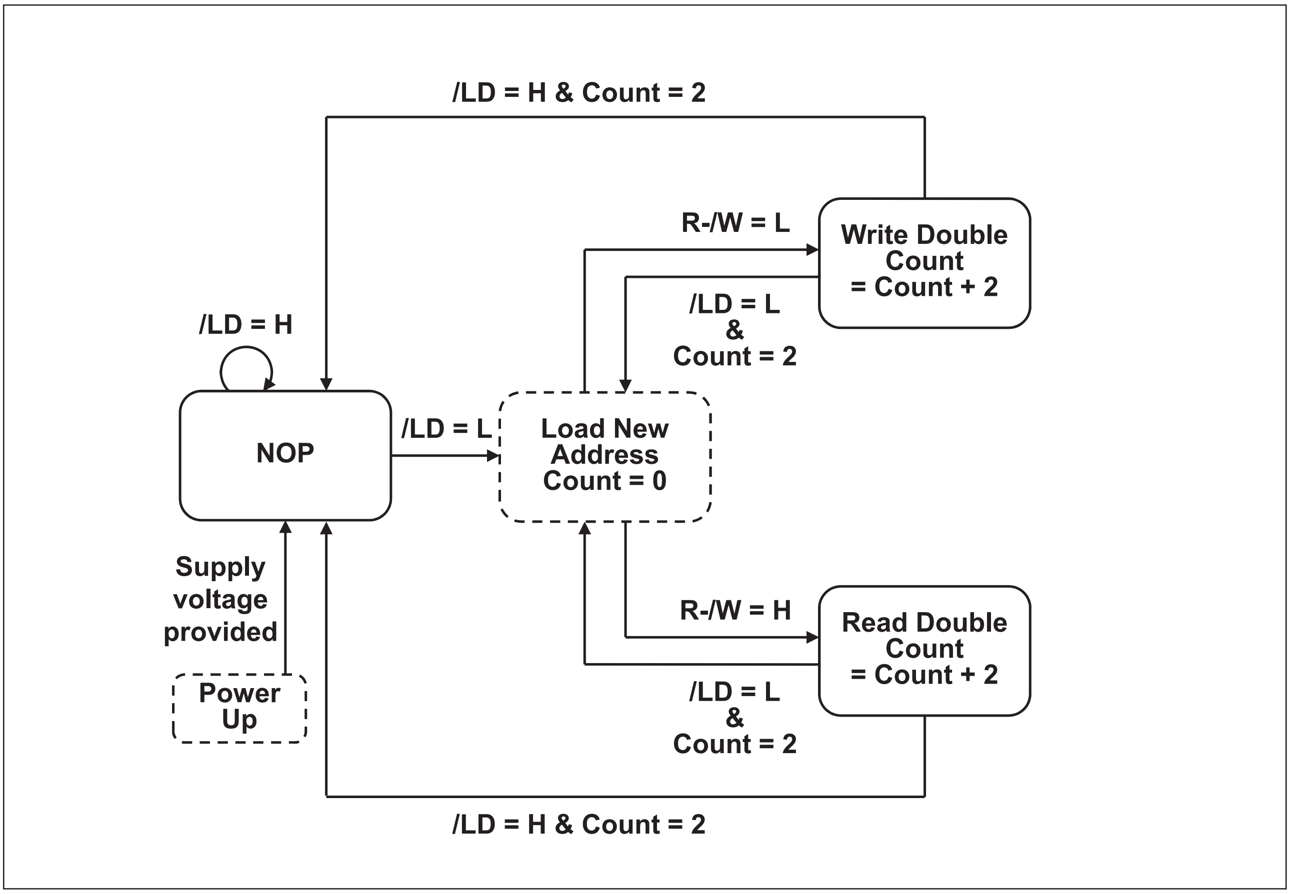
Byte Write Truth Table (x 18)

Operation	K	/K	/BW0	/BW1
Write D0 to D17	↑	-	L	L
	-	↑	L	L
Write D0 to D8	↑	-	L	H
	-	↑	L	H
Write D9 to D17	↑	-	H	L
	-	↑	H	L
Write nothing	↑	-	H	H
	-	↑	H	H

Notes:

1. H: high level, L: low level, ↑: rising edge.
2. Assumes a WRITE cycle was initiated. /BWx can be altered for any portion of the BURST WRITE operation provided that the setup and hold requirements are satisfied.

Bus Cycle State Diagram



Notes:

1. SA0 is internally advanced in accordance with the burst order table. Bus cycle is terminated at the end of this sequence (burst count = 2).
2. State machine control timing sequence is controlled by K.

Electrical Characteristics

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit	Notes
Input voltage on any ball	V_{IN}	–0.5 to V_{DD} + 0.5 (2.5 V max.)	V	1,4
Input/output voltage	$V_{I/O}$	–0.5 to V_{DDQ} + 0.5 (2.5 V max.)	V	1,4
Core supply voltage	V_{DD}	–0.5 to 2.5	V	1,4
Output supply voltage	V_{DDQ}	–0.5 to V_{DD}	V	1,4
Junction temperature	Tj	+125 (max)	°C	5
Storage temperature	T_{STG}	–55 to +125	°C	

Notes:

1. All voltage is referenced to V_{SS}.
2. Permanent device damage may occur if Absolute Maximum Ratings are exceeded. Functional operation should be restricted the Operation Conditions. Exposure to higher than recommended voltages for extended periods of time could affect device reliability.
3. These CMOS memory circuits have been designed to meet the DC and AC specifications shown in the tables after thermal equilibrium has been established.
4. The following supply voltage application sequence is recommended: V_{SS}, V_{DD}, V_{DDQ}, V_{REF} then V_{IN}. Remember, according to the Absolute Maximum Ratings table, V_{DDQ} is not to exceed 2.5 V, whatever the instantaneous value of V_{DDQ}.
5. Some method of cooling or airflow should be considered in the system.

Recommended DC Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Power supply voltage -- core	V_{DD}	1.7	1.8	1.9	V	1
Power supply voltage -- I/O	V_{DDQ}	1.4	1.5	V_{DD}	V	1,2
Input reference voltage -- I/O	V_{REF}	0.68	0.75	0.95	V	3
Input high voltage	$V_{IH\ (DC)}$	V_{REF} + 0.1	-	V_{DDQ} + 0.3	V	1,4,5
Input low voltage	$V_{IL\ (DC)}$	-0.3	-	V_{REF} - 0.1	V	1,4,5

Notes:

1. At power-up, V_{DD} and V_{DDQ} are assumed to be a linear ramp from 0V to V_{DD}(min.) or V_{DDQ}(min.) within 200ms. During this time, $V_{DDQ} < V_{DD}$ and $V_{IH} < V_{DDQ}$. During normal operation, V_{DDQ} must not exceed V_{DD}.
2. Please pay attention to Tj not to exceed the temperature shown in the absolute maximum ratings table due to current from V_{DDQ}.
3. Peak to peak AC component superimposed on V_{REF} may not exceed 5% of V_{REF}.
4. These are DC test criteria. The AC V_{IH} / V_{IL} levels are defined separately to measure timing parameters.
5. Overshoot: $V_{IH\ (AC)} \le V_{DDQ} + 0.5$ V for $t \le t_{KHKH}/2$

   Undershoot: $V_{IL\ (AC)} \ge -0.5$ V for $t \le t_{KHKH}/2$

   During normal operation, $V_{IH(DC)}$ must not exceed V_{DDQ} and $V_{IL(DC)}$ must not be lower than V_{SS}.

DC Characteristics

(T_A = -40 to +85°C, V_{DD} = 1.8V ± 0.1V, V_{DDQ} = 1.5V, V_{REF} = 0.75V)

Parameter	Symbol	Test condition	MIN.	MAX.			Unit	Notes
				333 MHz	300 MHz	250MHz		
Operating Supply Current (Write / Read)	**I_{DD}**	(x36)		510	480	430	mA	1,2,3
		(x18)		440	420	380		
Standby Supply Current (NOP)	**I_{SB1}**	(x36)		380	370	340	mA	2,4,5
		(x18)		360	350	320		
Input leakage current	**I_{LI}**		-2	2			µA	9
Output leakage current	**I_{LO}**		-5	5			µA	10
Output high voltage	**V_{OH} (Low)**	$\lvert I_{OH}\rvert \leq 0.1$ mA	$V_{DDQ} - 0.2$	V_{DDQ}			V	8
	V_{OH}	Note 6	$V_{DDQ}/2 - 0.12$	$V_{DDQ}/2 + 0.12$			V	8
Output low voltage	**V_{OL} (Low)**	$I_{OL} \leq 0.1$ mA	V_{SS}	0.2			V	8
	V_{OL}	Note 7	$V_{DDQ}/2 - 0.12$	$V_{DDQ}/2 + 0.12$			V	8

Notes:

1. All inputs (except ZQ, V_{REF}) are held at either V_{IH} or V_{IL}.
2. I_{OUT} = 0 mA. V_{DD} = V_{DD} max, t_{KHKH} = t_{KHKH} min.
3. Operating supply currents (I_{DD}) are measured at 100% bus utilization. I_{DD} of DDR family is current of device with 100% write cycle (if I_{DD}(Write) > I_{DD}(Read)) or 100% read cycle (if I_{DD}(Write) < I_{DD}(Read)).
4. All address / data inputs are static at either $V_{IN} > V_{IH}$ or $V_{IN} < V_{IL}$.
5. Reference value. (Condition = NOP currents are valid when entering NOP after all pending READ and WRITE cycles are completed.)
6. Outputs are impedance-controlled. $|I_{OH}| = (V_{DDQ}/2)/(RQ/5)$ for values of 175 Ω ≤ RQ ≤ 350 Ω.
7. Outputs are impedance-controlled. $I_{OL} = (V_{DDQ}/2)/(RQ/5)$ for values of 175 Ω ≤ RQ ≤ 350 Ω.
8. AC load current is higher than the shown DC values. AC I/O curves are available upon request.
9. $0 \leq V_{IN} \leq V_{DDQ}$ for all input balls (except V_{REF}, ZQ, TCK, TMS, TDI ball).
10. $0 \leq V_{OUT} \leq V_{DDQ}$ (except TDO ball), output disabled.

Thermal Resistance

Parameter	Symbol	Airflow	Typ	Unit	Test condition	Notes
Junction to Ambient	θ_{JA}	1 m/s	13	°C/W	EIA/JEDEC JESD51	1
Junction to Case	θ_{JC}	-	6.3			

Notes:

1. These parameters are calculated under the condition. These are reference values.
2. $Tj = Ta + \theta_{JA} \times Pd$
   $Tj = Tc + \theta_{JC} \times Pd$
   where
   Tj : junction temperature when the device has achieved a steady-state after application of Pd (°C)
   Ta :ambient temperature (°C)
   Tc :temperature of external surface of the package or case (°C)
   θ_{JA} :thermal resistance from junction-to-ambient (°C/W)
   θ_{JC} :thermal resistance from junction-to-case (package) (°C/W)
   Pd :power dissipation that produced change in junction temperature (W) (cf.JESD51-2A)

Capacitance

($T_A = +25°C$, Frequency = 1.0MHz, $V_{DD} = 1.8V$, $V_{DDQ} = 1.5V$)

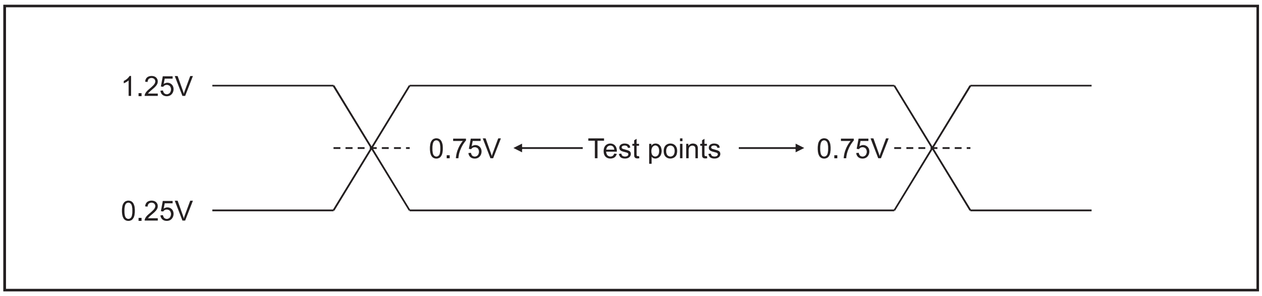
Parameter	Symbol	Min	Typ	Max	Unit	Test condition	Note
Input capacitance (SA, /R, /W, /BW)	C_{IN}	-	4	5	pF	$V_{IN} = 0$ V	1,2
Clock input capacitance (K, /K, C, /C)	C_{CLK}	-	4	5	pF	$V_{CLK} = 0$ V	1,2
Output capacitance (DQ, CQ, /CQ)	$C_{I/O}$	-	5	6	pF	$V_{I/O} = 0$ V	1,2

Notes:

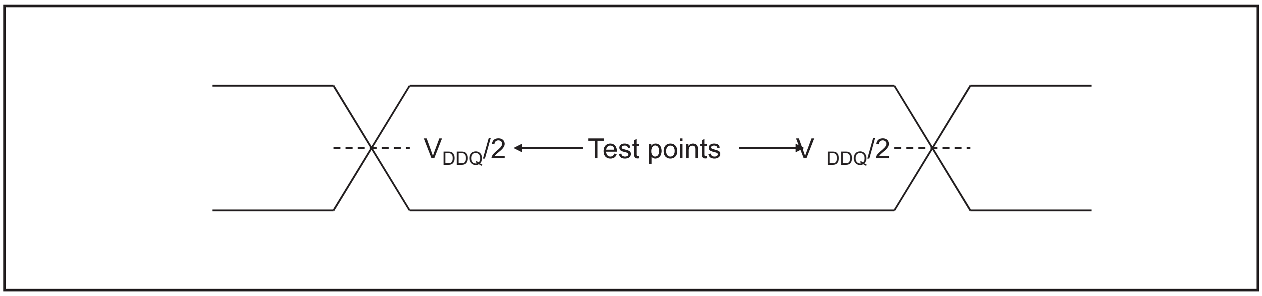
1. These parameters are sampled and not 100% tested.
2. Except JTAG (TCK, TMS, TDI, TDO) pins.

AC Test Conditions

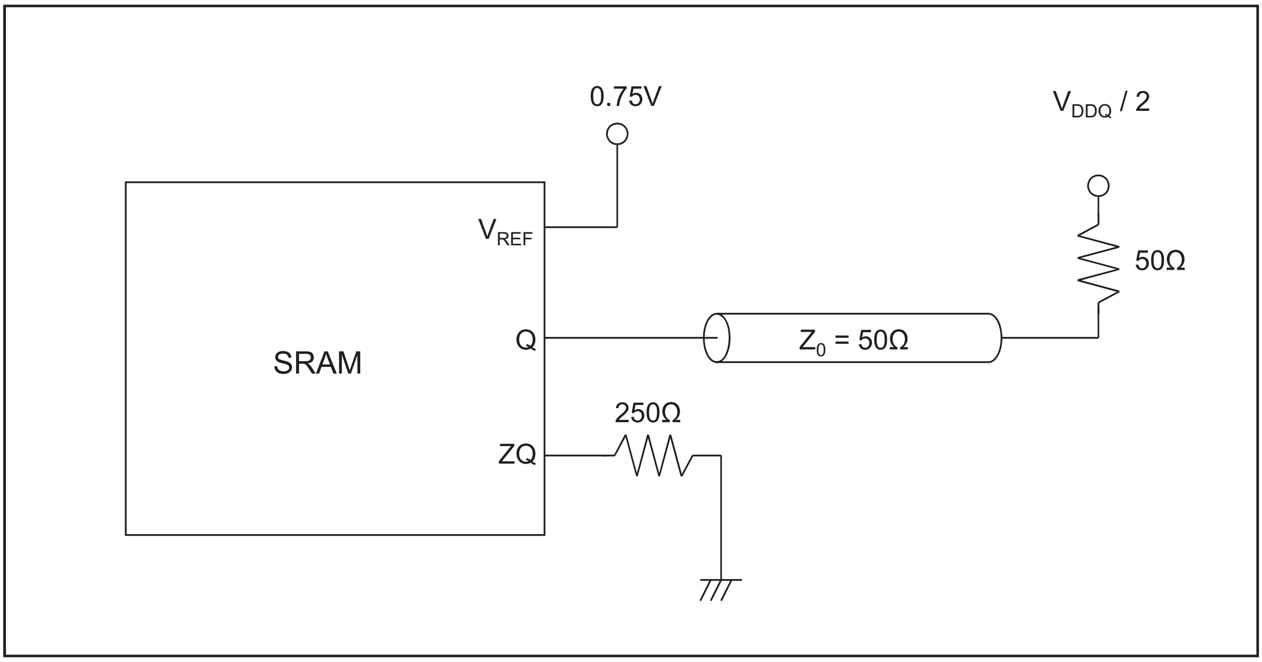
Input waveform (Rise/fall time ≤ 0.3 ns)



Output waveform



Output load conditions



AC Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Input high voltage	$V_{IH\ (AC)}$	V_{REF} + 0.2	-	-	V	1,2,3,4
Input low voltage	$V_{IL\ (AC)}$	-	-	V_{REF} – 0.2	V	1,2,3,4

Notes:

1. All voltages referenced to V_{SS} (GND). During normal operation, V_{DDQ} must not exceed V_{DD}.
2. These conditions are for AC functions only, not for AC parameter test.
3. Overshoot: $V_{IH\ (AC)} \le V_{DDQ} + 0.5$ V for $t \le t_{KHKH}/2$
   Undershoot: $V_{IL\ (AC)} \ge -0.5$ V for $t \le t_{KHKH}/2$
   Control input signals may not have pulse widths less than t_{KHKL} (min) or operate at cycle rates less than t_{KHKH} (min).
4. To maintain a valid level, the transitioning edge of the input must:
   a. Sustain a constant slew rate from the current AC level through the target AC level, $V_{IL\ (AC)}$ or $V_{IH\ (AC)}$.
   b. Reach at least the target AC level.
   c. After the AC target level is reached, continue to maintain at least the target DC level, $V_{IL\ (DC)}$ or $V_{IH\ (DC)}$.

AC Characteristics

(T_A = -40 to +85°C, V_{DD} = 1.8V ± 0.1V, V_{DDQ} = 1.5V, V_{REF} = 0.75V)

Parameter	**Symbol**	333MHz		300MHz		250MHz		Unit	Notes
		Min	Max	Min	Max	Min	Max		
Clock									
Average clock cycle time (K, /K, C, /C)	t_{KHKH}	3.0	8.4	3.3	8.4	4.0	8.4	ns	
Clock high time (K, /K, C, /C)	t_{KHKL}	1.20	-	1.32	-	1.60	-	ns	
Clock low time (K, /K, C, /C)	t_{KLKH}	1.20	-	1.32	-	1.60	-	ns	
Clock to /clock (K to /K, C to /C)	$t_{KH/KH}$	1.35	-	1.49	-	1.80	-	ns	
/Clock to clock (/K to K, C to /C)	$t_{/KHKH}$	1.35	-	1.49	-	1.80	-	ns	
Clock to data clock (K to C, /K, /C)	t_{KHCH}	0	1.30	0	1.45	0	1.80	ns	
PLL Timing									
Clock phase jitter (K, /K, C, /C)	t_{KC} var	-	0.20	-	0.20	-	0.20	ns	3
Lock time (K,C)	t_{KC} lock	20	-	20	-	20	-	us	2
K static to PLL reset	t_{KC} reset	30	-	30	-	30	-	ns	5
Output Times									
C, /C high to output valid	t_{CHQV}	-	0.45	-	0.45	-	0.45	ns	
C, /C high to output hold	t_{CHQX}	-0.45	-	-0.45	-	-0.45	-	ns	
C, /C high to echo clock valid	t_{CHCQV}	-	0.45	-	0.45	-	0.45	ns	
C, /C high to echo clock hold	t_{CHCQX}	-0.45	-	-0.45	-	-0.45	-	ns	
CQ, /CQ high to output valid	t_{CQHQV}	-	0.25	-	0.27	-	0.30	ns	5
CQ, /CQ high to output hold	t_{CQHQX}	-0.25		-0.27	-	-0.30	-	ns	5
Clock to /Clock (CQ to /CQ)	$t_{CQH/CQH}$	1.25	-	1.40	-	1.75	-	ns	5
/Clock to Clock (/CQ to CQ)	$t_{/CQHCQH}$	1.25	-	1.40	-	1.75	-	ns	5
C, /C high to output high-Z	t_{CHQZ}	-	0.45	-	0.45	-	0.45	ns	4
C, /C high to output low-Z	t_{CHQX1}	-0.45	-	-0.45	-	-0.45	-	ns	4
Setup Times									
Address valid to K rising edge	t_{AVKH}	0.40	-	0.40	-	0.50	-	ns	1
Control inputs valid to K rising edge	t_{IVKH}	0.40	-	0.40	-	0.50	-	ns	1
Data-in valid to K, /K rising edge	t_{DVKH}	0.30	-	0.30	-	0.35	-	ns	1
Hold Times									
K rising edge to address hold	t_{KHAX}	0.40	-	0.40	-	0.50	-	ns	1
K rising edge to control inputs hold	t_{KHIX}	0.40	-	0.40	-	0.50	-	ns	1
K, /K rising edge to data-in hold	t_{KHDX}	0.30	-	0.30	-	0.35	-	ns	1

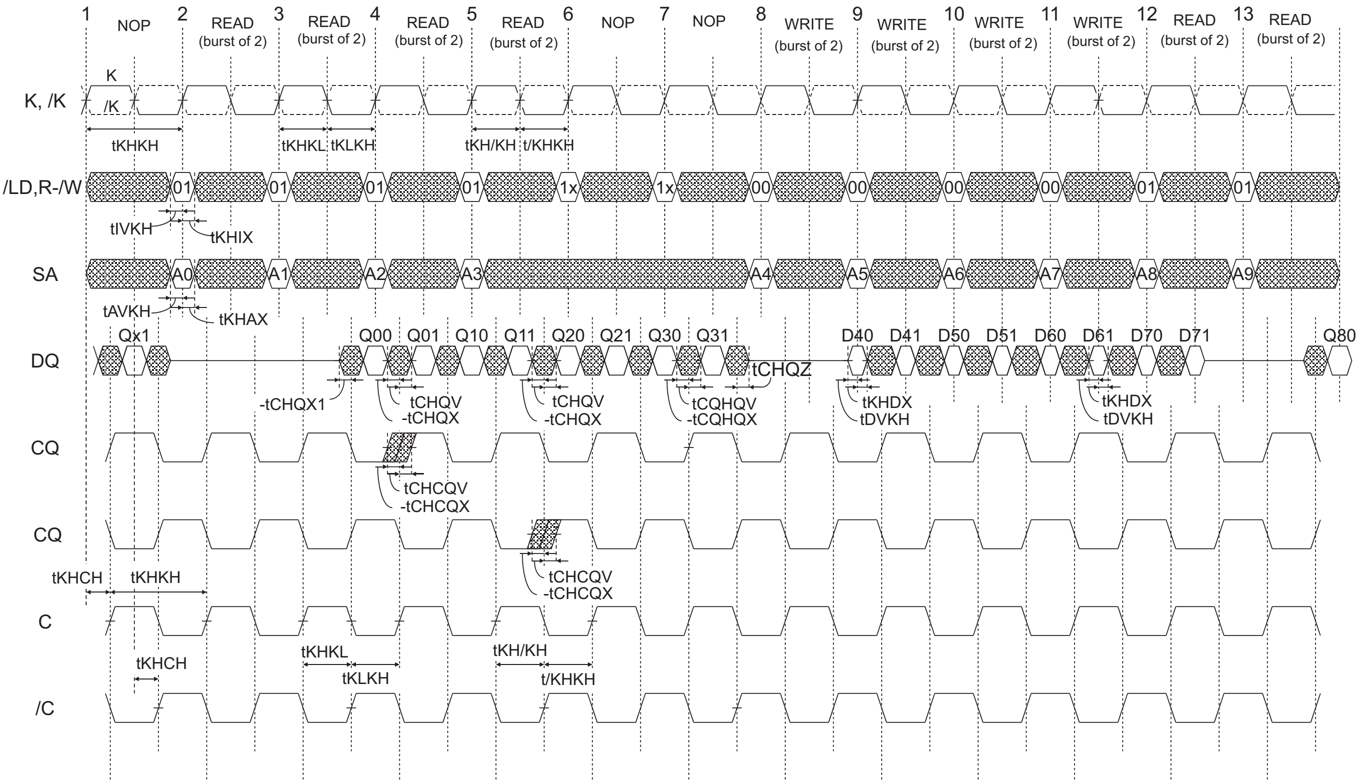
Notes:

1. This is a synchronous device. All addresses, data and control lines must meet the specified setup and hold times for all latching clock edges.
2. V_{DD} and V_{DDQ} slew rate must be less than 0.1 V DC per 50 ns for PLL lock retention. PLL lock time begins once V_{DD} , V_{DDQ} and input clock are stable.
   It is recommended that the device is kept inactive during these cycles.
3. Clock phase jitter is the variance from clock rising edge to the next expected clock rising edge.
4. Transitions are measured ±100 mV from steady-state voltage.
5. These parameters are only guaranteed by design and are not tested in production.

Remarks:

1. Test conditions as specified with the output loading as shown in AC Test Conditions unless otherwise noted.
2. Control input signals may not be operated with pulse widths less than t_{KHKL} (min).
3. If C, /C are tied high, K, /K become the references for C, /C timing parameters.
4. V_{DDQ} is +1.5 V DC. V_{REF} is +0.75 V DC.
5. Control signals are /R and /W.
   Setup and hold times of /BWx signals must be the same as those of Data-in signals.
6. In the case of running frequency between 250MHz and 300MHz, all the AC/DC parameters follow 300MHz.
   In the case of running frequency between 300MHz and 333MHz, all the AC/DC parameters follow 333MHz.

Read and Write Timing



Notes:

1. Q00 refers to output from address A0. Q01 refers to output from the next internal burst address following A0, etc.
2. In this example, if address A8 = A7, then data Q80 = D70, Q81 = D71, etc. Write data is forwarded immediately as read results.
3. To control read and write operations, /BW signals must operate at the same timing as Data-in signals.
4. It recommends two NOP cycles during transition from READ to WRITE cycle for correct device operation.

JTAG Specification

These products support a limited set of JTAG functions as in IEEE standard 1149.1.

Disabling the Test Access Port

It is possible to use this device without utilizing the TAP. To disable the TAP controller without interfering with normal operation of the device, TCK must be tied to V_{SS} to preclude mid level inputs.
TDI and TMS are internally pulled up and may be unconnected, or may be connected to V_{DD} through a pull up resistor.
TDO should be left unconnected.

Test Access Port (TAP) Pins

Symbol I/O	Pin assignments	Description	Notes
TCK	2R	Test clock input. All inputs are captured on the rising edge of TCK and all outputs propagate from the falling edge of TCK.	
TMS	10R	Test mode select. This is the command input for the TAP controller state machine.	
TDI	11R	Test data input. This is the input side of the serial registers placed between TDI and TDO. The register placed between TDI and TDO is determined by the state of the TAP controller state machine and the instruction that is currently loaded in the TAP instruction.	
TDO	1R	Test data output. Output changes in response to the falling edge of TCK. This is the output side of the serial registers placed between TDI and TDO.	

Notes:

The device does not have TRST (TAP reset). The Test-Logic Reset state is entered while TMS is held high for five rising edges of TCK. The TAP controller state is also reset on SRAM POWER-UP.

TAP DC Operating Characteristics

(T_A = -40 to +85°C , V_{DD} = 1.8V ±0.1V)

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Input high voltage	V_{IH}	+1.3	-	V_{DD} + 0.3	V	
Input low voltage	V_{IL}	-0.3	-	+0.5	V	
Input leakage current	I_{LI}	-5.0	-	+5.0	μA	0 V ≤ V_{IN} ≤ V_{DD}
Output leakage current	I_{LO}	-5.0	-	+5.0	μA	0 V ≤ V_{IN} ≤ V_{DD}, output disabled
Output low voltage	V_{OL1}	-	-	0.2	V	I_{OLC} = 100 μA
	V_{OL2}	-	-	0.4	V	I_{OLT} = 2 mA
Output high voltage	V_{OH1}	1.6	-	-	V	$\|I_{OHC}\|$ = 100 μA
	V_{OH2}	1.4	-	-	V	$\|I_{OHT}\|$ = 2 mA

Notes:

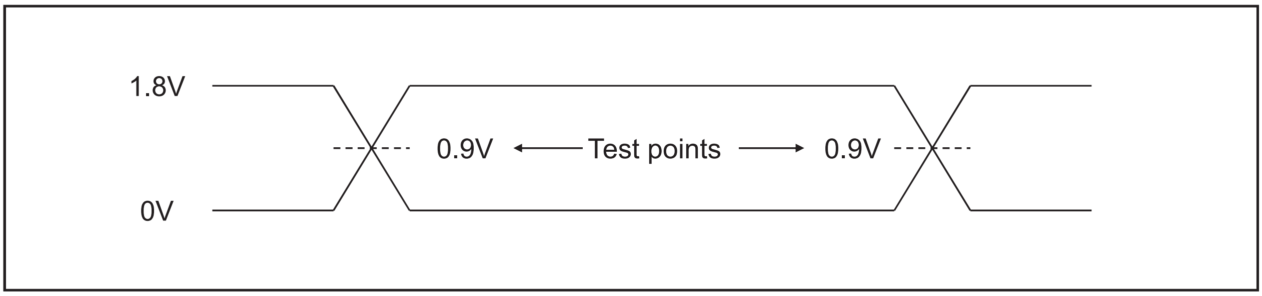
1. All voltages referenced to V_{SS} (GND).
2. At power-up, V_{DD} and V_{DDQ} are assumed to be a linear ramp from 0V to V_{DD}(min.) or V_{DDQ}(min.) within 200ms. During this time, $V_{DDQ} < V_{DD}$ and $V_{IH} < V_{DDQ}$.

   During normal operation, V_{DDQ} must not exceed V_{DD}.

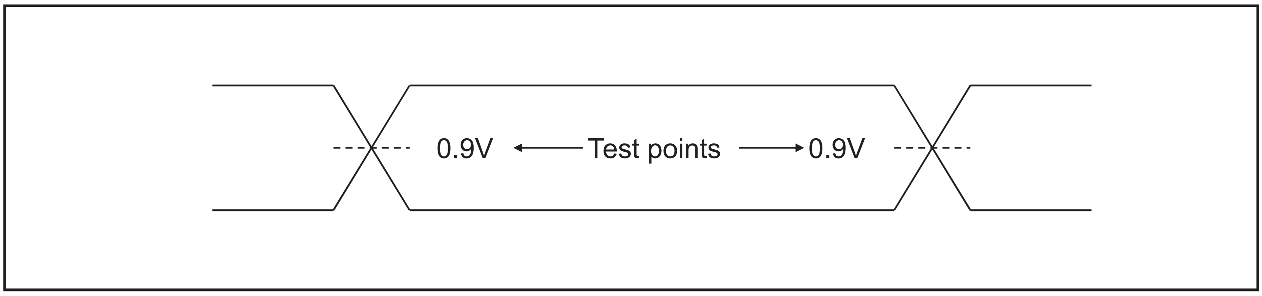
TAP AC Test Conditions

Parameter	Symbol	Conditions	Unit	Notes
Input timing measurement reference levels	V_{REF}	0.9	V	
Input pulse levels	V_{IL}, V_{IH}	0 to 1.8	V	
Input rise/fall time	tr, tf	≤ 1.0	ns	
Output timing measurement reference levels		0.9	V	
Test load termination supply voltage (V_{TT})		0.9	V	
Output load		See figures		

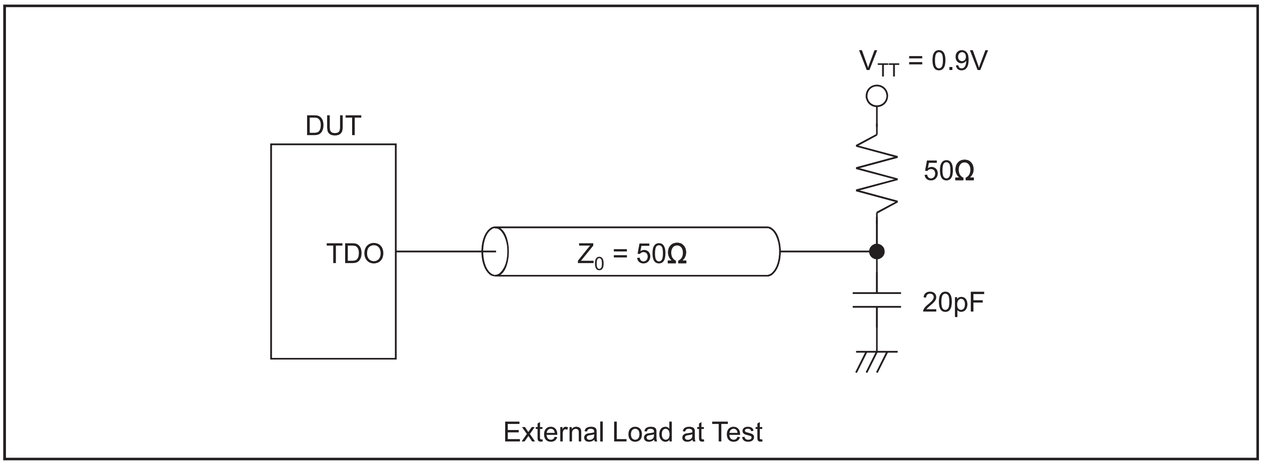
Input waveform



Output waveform



Output load condition



TAP AC Operating Characteristics

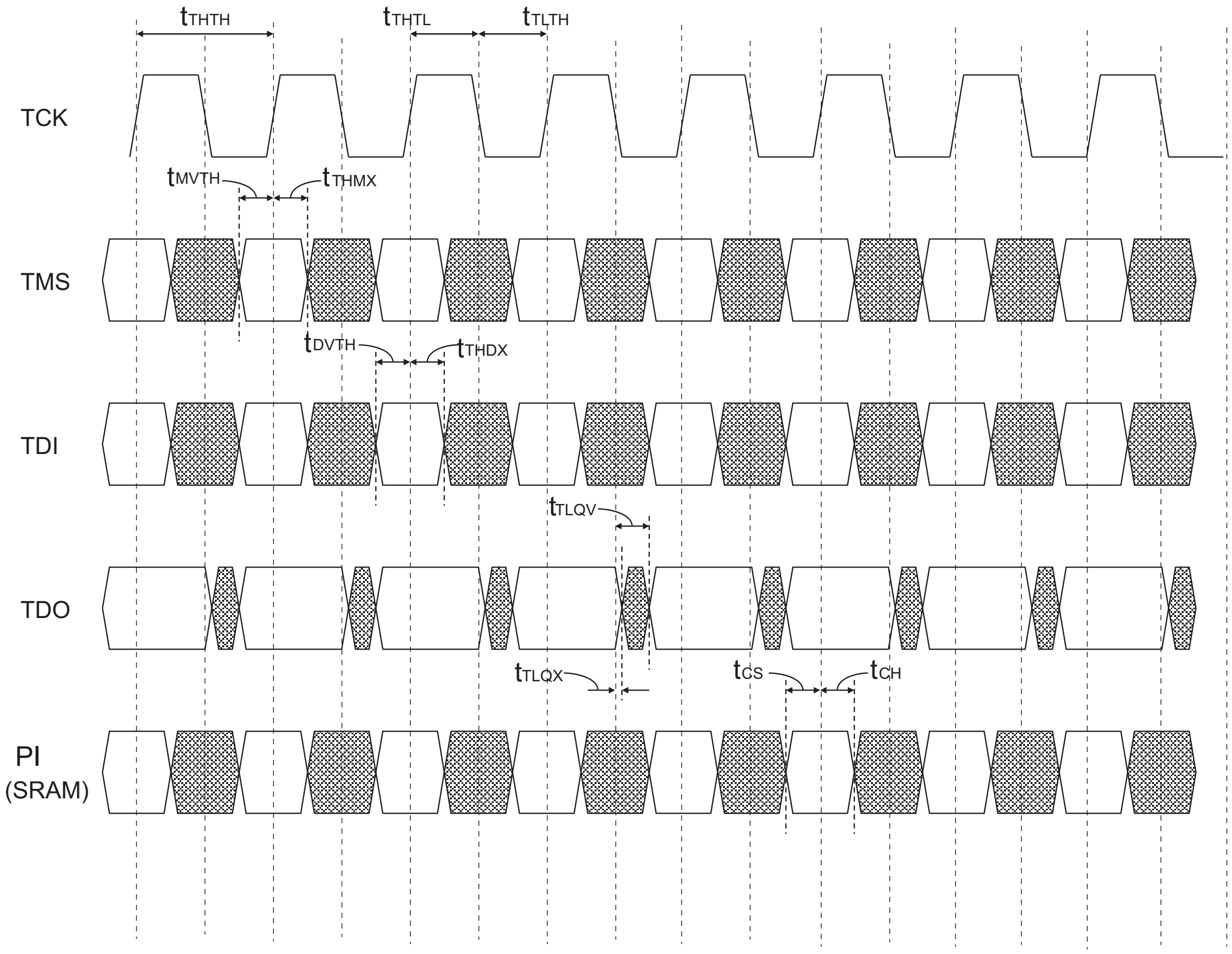
(T_A = -40 to +85°C , V_{DD} = 1.8V ±0.1V)

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Test clock (TCK) cycle time	t_{THTH}	50	-	-	ns	
TCK high pulse width	t_{THTL}	20	-	-	ns	
TCK low pulse width	t_{TLTH}	20	-	-	ns	
Test mode select (TMS) setup	t_{MVTH}	5	-	-	ns	
TMS hold	t_{THMX}	5	-	-	ns	
Capture setup	t_{CS}	5	-	-	ns	
Capture hold	t_{CH}	5	-	-	ns	
TDI valid to TCK high	t_{DVTH}	5	-	-	ns	
TCK high to TDI invalid	t_{THDX}	5	-	-	ns	
TCK low to TDO unknown	t_{TLQX}	0	-	-	ns	
TCK low to TDO valid	t_{TLQV}	-	-	10	ns	

Notes:

1. t_{CS} + t_{CH} defines the minimum pause in RAM I/O pad transitions to assure pad data capture.

TAP Controller Timing Diagram



Test Access Port Registers

Register name	Length	Symbol	Notes
Instruction register	3 bits	IR [2:0]	
Bypass register	1 bits	BP	
ID register	32 bits	ID [31:0]	
Boundary scan register	107 bit	BS [107:1]	

TAP Controller Instruction Set

IR2	IR1	IR0	Instruction	Description	Notes
0	0	0	EXTEST	The EXTEST instruction allows circuitry external to the component package to be tested. Boundary scan register cells at output balls are used to apply test vectors, while those at input balls capture test results. Typically, the first test vector to be applied using the EXTEST instruction will be shifted into the boundary scan register using the PRELOAD instruction. Thus, during the Update-IR state of EXTEST, the output driver is turned on and the PRELOAD data is driven onto the output balls.	1,2,3,4
0	0	1	IDCODE	The IDCODE instruction causes the ID ROM to be loaded into the ID register when the controller is in capture-DR mode and places the ID register between the TDI and TDO balls in shift-DR mode. The IDCODE instruction is the default instruction loaded in at power up and any time the controller is placed in the Test-Logic-Reset state.	
0	1	0	SAMPLE-Z	If the SAMPLE-Z instruction is loaded in the instruction register, all RAM outputs are forced to an inactive drive state (high-Z), moving the TAP controller into the capture-DR state loads the data in the RAMs input into the boundary scan register, and the boundary scan register is connected between TDI and TDO when the TAP controller is moved to the shift-DR state.	3,4
0	1	1	RESERVED	The RESERVED instruction is not implemented but is reserved for future use. Do not use this instruction.	
1	0	0	SAMPLE (/PRELOAD)	When the SAMPLE instruction is loaded in the instruction register, moving the TAP controller into the capture-DR state loads the data in the RAMs input and I/O buffers into the boundary scan register. Because the RAM clock(s) are independent from the TAP clock (TCK) it is possible for the TAP to attempt to capture the I/O ring contents while the input buffers are in transition (i.e., in a metastable state). Although allowing the TAP to SAMPLE metastable input will not harm the device, repeatable results cannot be expected. Moving the controller to shift-DR state then places the boundary scan register between the TDI and TDO balls.	3,4
1	0	1	RESERVED	The RESERVED instruction is not implemented but is reserved for future use. Do not use this instruction.	
1	1	0	RESERVED	The RESERVED instruction is not implemented but is reserved for future use. Do not use this instruction.	
1	1	1	BYPASS	The BYPASS instruction is loaded in the instruction register when the bypass register is placed between TDI and TDO. This occurs when the TAP controller is moved to the shift-DR state. This allows the board level scan path to be shortened to facilitate testing of other devices in the scan path.	

Notes:

1. Data in output register is not guaranteed if EXTEST instruction is loaded.
2. After performing EXTEST, power-up conditions are required in order to return part to normal operation.
3. RAM input signals must be stabilized for long enough to meet the TAPs input data capture setup plus hold time (t_{CS} plus t_{CH}). The RAMs clock inputs need not be paused for any other TAP operation except capturing the I/O ring contents into the boundary scan register.
4. Clock recovery initialization cycles are required after boundary scan.

Boundary Scan Order

Bit#	Ball ID	Signal names	
		x18	x36
1	6R	/C	/C
2	6P	C	C
3	6N	SA	SA
4	7P	SA	SA
5	7N	SA	SA
6	7R	SA	SA
7	8R	SA	SA
8	8P	SA	SA
9	9R	SA	SA
10	11P	DQ0	DQ0
11	10P	NC	DQ9
12	10N	NC	NC
13	9P	NC	NC
14	10M	DQ1	DQ11
15	11N	NC	DQ10
16	9M	NC	NC
17	9N	NC	NC
18	11L	DQ2	DQ2
19	11M	NC	DQ1
20	9L	NC	NC
21	10L	NC	NC
22	11K	DQ3	DQ3
23	10K	NC	DQ12
24	9J	NC	NC
25	9K	NC	NC
26	10J	DQ4	DQ13
27	11J	NC	DQ4
28	11H	ZQ	ZQ
29	10G	NC	NC
30	9G	NC	NC
31	11F	DQ5	DQ5
32	11G	NC	DQ14
33	9F	NC	NC
34	10F	NC	NC
35	11E	DQ6	DQ6
36	10E	NC	DQ15
37	10D	NC	NC
38	9E	NC	NC
39	10C	DQ7	DQ17
40	11D	NC	DQ16
41	9C	NC	NC
42	9D	NC	NC
43	11B	DQ8	DQ8
44	11C	NC	DQ7
45	9B	NC	NC
46	10B	NC	NC
47	11A	CQ	CQ
48	-	Internal	Internal
49	9A	SA	SA
50	8B	SA	SA
51	7C	SA	SA
52	6C	SA	SA
53	8A	/LD	/LD
54	7A	NC	/BW1
55	7B	/BW0	/BW0
56	6B	K	K
57	6A	/K	/K
58	5B	NC	/BW3
59	5A	/BW1	/BW2
60	4A	R-/W	R-/W
61	5C	SA	SA
62	4B	SA	SA
63	3A	SA	NC
64	1H	/DOFF	/DOFF
65	1A	/CQ	/CQ
66	2B	Q9	Q18
67	3B	D9	D18
68	1C	NC	D27
69	1B	NC	Q27
70	3D	Q10	Q19
71	3C	D10	D19
72	1D	NC	D28
73	2C	NC	Q28
74	3E	Q11	Q20
75	2D	D11	D20
76	2E	NC	D29
77	1E	NC	Q29
78	2F	Q12	Q21
79	3F	D12	D21
80	1G	NC	D30
81	1F	NC	Q30
82	3G	Q13	Q22
83	2G	D13	D22
84	1J	NC	D31
85	2J	NC	Q31
86	3K	Q14	Q23
87	3J	D14	D23
88	2K	NC	D32
89	1K	NC	Q32
90	2L	Q15	Q24
91	3L	D15	D24
92	1M	NC	D33
93	1L	NC	Q33
94	3N	Q16	Q25
95	3M	D16	D25
96	1N	NC	D34
97	2M	NC	Q34
98	3P	Q17	Q26
99	2N	D17	D26
100	2P	NC	D35
101	1P	NC	Q35
102	3R	SA	SA
103	4R	SA	SA
104	4P	SA	SA
105	5P	SA	SA
106	5N	SA	SA
107	5R	SA	SA

Notes:

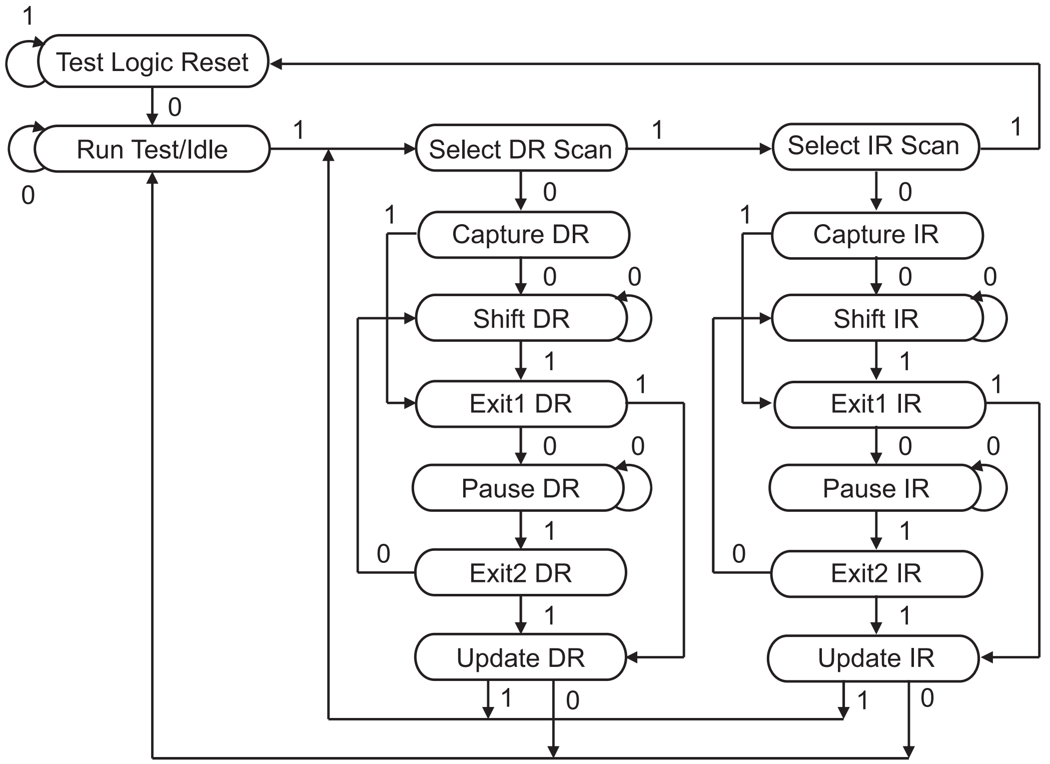
In boundary scan mode,

1. Clock balls (K, /K, C, /C) are referenced to each other and must be at opposite logic levels for reliable operation.
2. CQ and /CQ data are synchronized to the C clock (except EXTEST, SAMPLE-Z).
3. If C and /C tied high, CQ and /CQ are generated with respect to K clock instead of C clock (except EXTEST, SAMPLE-Z).

ID Register

	Revision number (31:28)				Type number (27:12)																Vendor JEDEC code (11:1)											Start bit (0) → → ↓ ↓
#	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RMQC4A1836DGBA	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	1
RMQC4A1818DGBA	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	1	0	1	0	1	0	0	0	1	0	0	0	1	1	1

TAP Controller State Diagram



Notes:

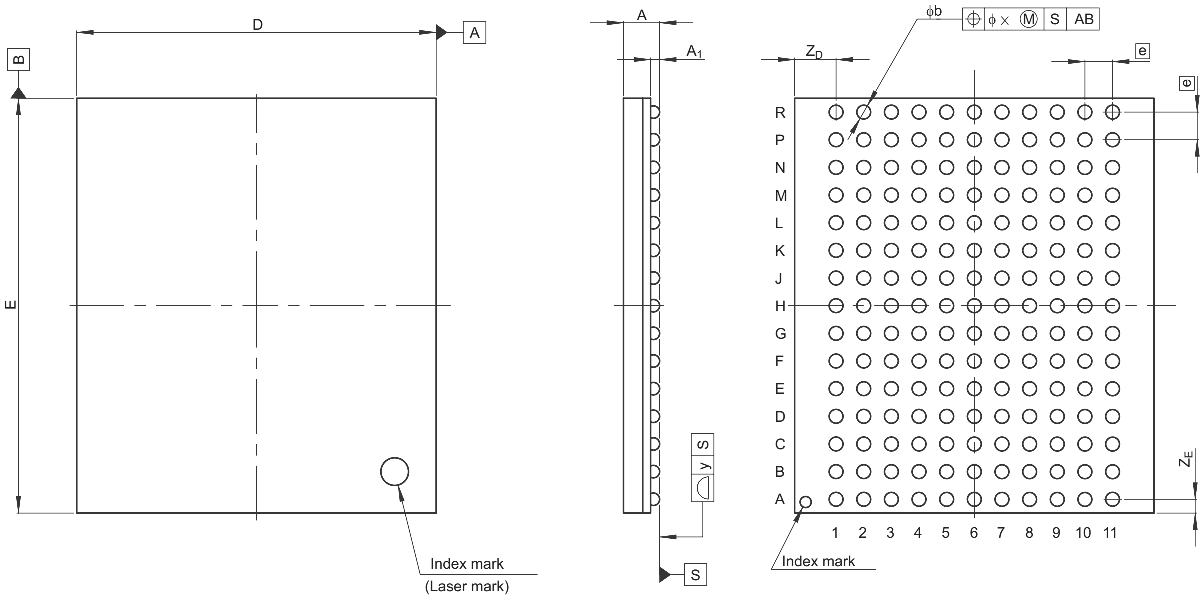
The value adjacent to each state transition in this figure represents the signal present at TMS at the time of a rising edge at TCK.

No matter what the original state of the controller, it will enter Test-Logic-Reset when TMS is held high for at least five rising edges of TCK.

Package Dimensions

165-pin FBGA (13 x 15 x 1.4 mm)

JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-LBGA165-13x15-1.00	PLBG0165FE-A	165FHG-A	0.5g



Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	12.9	13.0	13.1
E	14.9	15.0	15.1
A	—	—	1.4
A_1	0.31	0.36	0.41
e	—	1.0	—
b	0.45	0.5	0.6
x	—	—	0.2
y	—	—	0.15
Z_D	—	1.5	—
Z_E	—	0.5	—

Revision History	**RMQC4A1836DGBA, RMQC4A1818DGBA**

Rev.	**Date**	**Description**	
		Page	**Summary**
Rev.0.01	’14.04.25	-	New Preliminary Datasheet.
Rev.0.02	’14.12.01	P.15, 16	Modify the “Supply Current” and “Thermal Resistance”.
Rev.1.00	’15.01.13	-	New Datasheet.

QDR RAMs and Quad Data Rate RAMs comprise a new family of products developed by Cypress Semiconductor, and Renesas Electronics Corporation.
http://www.qdrconsortium.org/

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2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HALII Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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