

# 18-Mbit (512K x 36/1M x 18) Pipelined SRAM with NoBL™ Architecture

## Features

- Pin-compatible and functionally equivalent to ZBT™
- Supports 250-MHz bus operations with zero wait states
  - Available speed grades are 250, 200 and 167 MHz
- Internally self-timed output buffer control to eliminate the need to use asynchronous OE
- Fully registered (inputs and outputs) for pipelined operation
- Byte Write capability
- 3.3V core power supply ( $V_{DD}$ )
- 3.3V/2.5V I/O power supply ( $V_{DDQ}$ )
- Fast clock-to-output times
  - 2.6 ns (for 250-MHz device)
- Clock Enable ( $\overline{CEN}$ ) pin to suspend operation
- Synchronous self-timed writes
- Available in JEDEC-standard lead-free 100-pin TQFP, lead-free and non-lead-free 119-Ball BGA and 165-Ball FBGA package
- IEEE 1149.1 JTAG-Compatible Boundary Scan
- Burst capability—linear or interleaved burst order
- “ZZ” Sleep Mode option and Stop Clock option

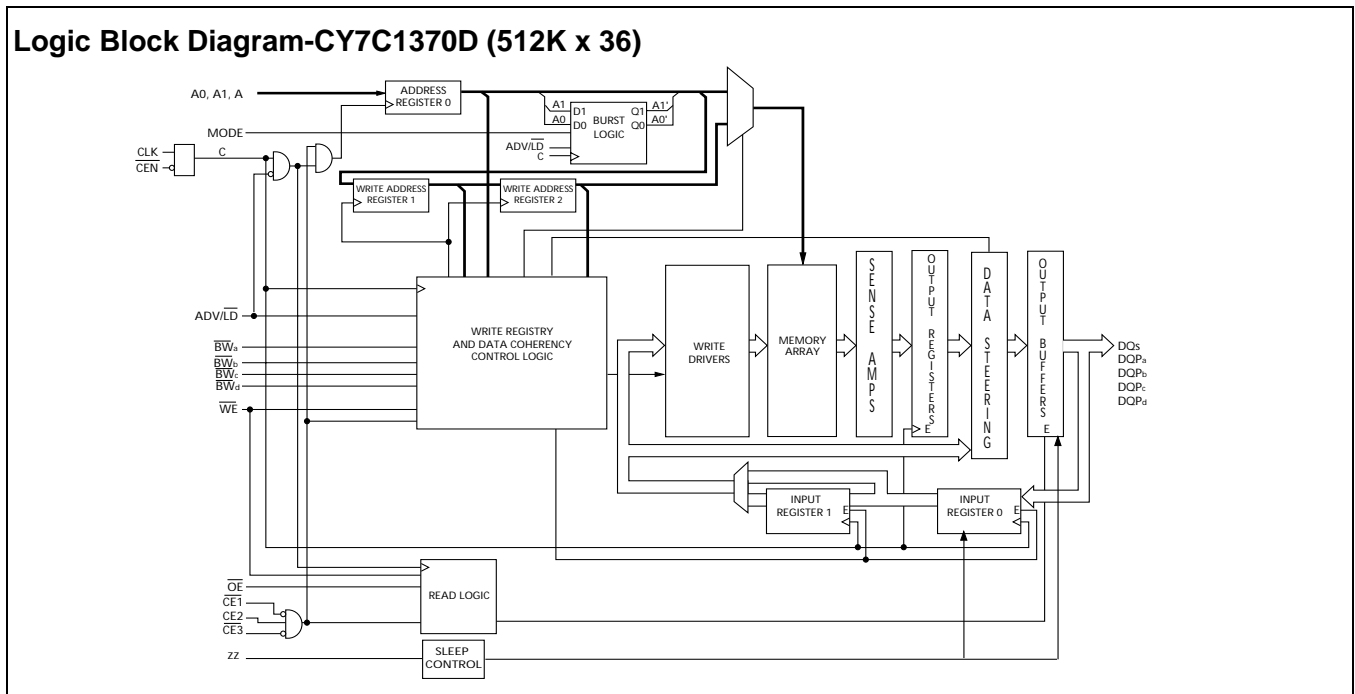
## Functional Description

The CY7C1370D and CY7C1372D are 3.3V, 512K x 36 and 1M x 18 Synchronous pipelined burst SRAMs with No Bus Latency™ (NoBL™) logic, respectively. They are designed to support unlimited true back-to-back Read/Write operations with no wait states. The CY7C1370D and CY7C1372D are equipped with the advanced (NoBL) logic required to enable consecutive Read/Write operations with data being transferred on every clock cycle. This feature dramatically improves the throughput of data in systems that require frequent Write/Read transitions. The CY7C1370D and CY7C1372D are pin compatible and functionally equivalent to ZBT devices.

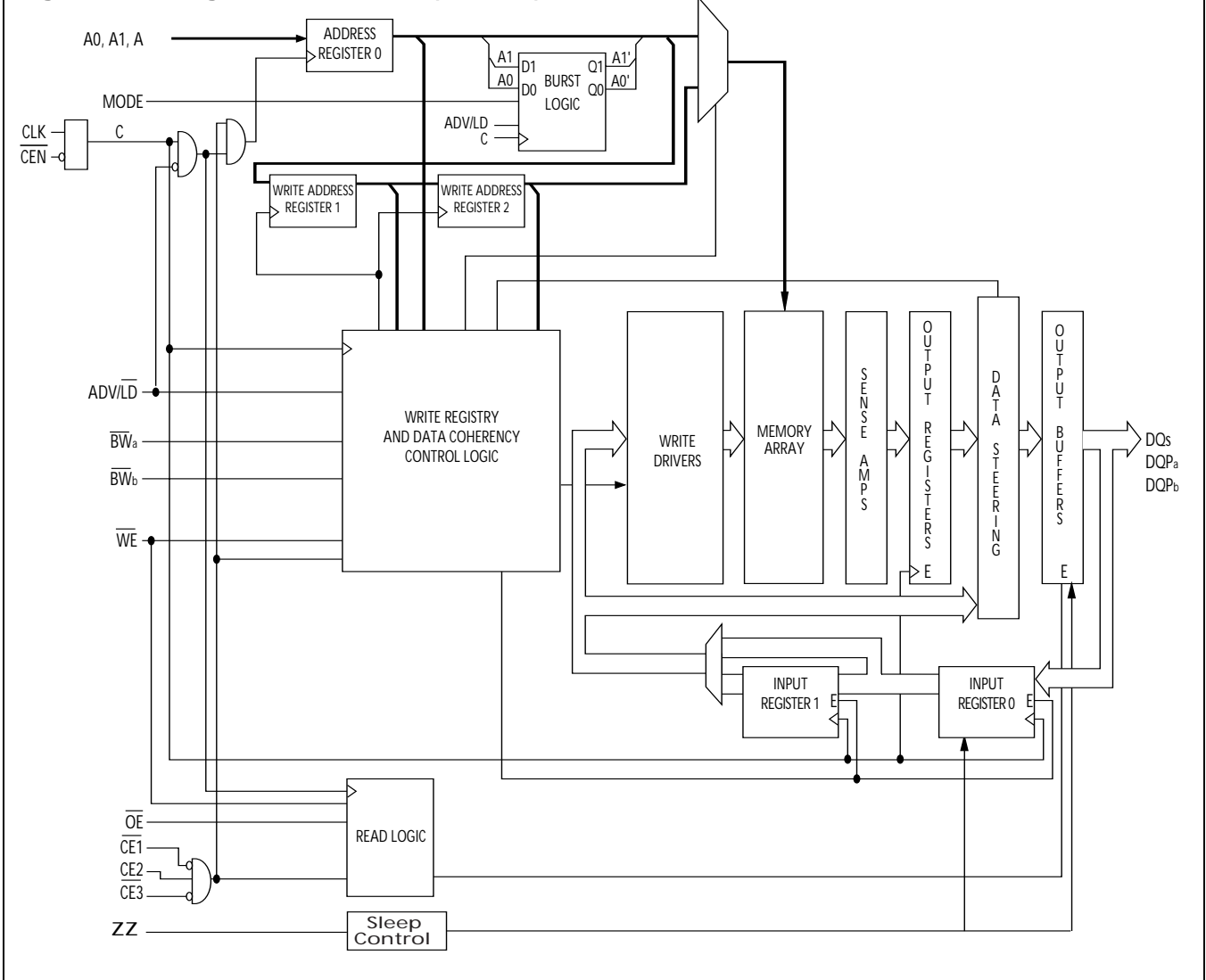
All synchronous inputs pass through input registers controlled by the rising edge of the clock. All data outputs pass through output registers controlled by the rising edge of the clock. The clock input is qualified by the Clock Enable ( $\overline{CEN}$ ) signal, which when deasserted suspends operation and extends the previous clock cycle.

Write operations are controlled by the Byte Write Selects ( $BW_a$ – $BW_d$  for CY7C1370D and  $BW_a$ – $BW_b$  for CY7C1372D) and a Write Enable ( $\overline{WE}$ ) input. All writes are conducted with on-chip synchronous self-timed write circuitry.

Three synchronous Chip Enables ( $\overline{CE}_1$ ,  $\overline{CE}_2$ ,  $\overline{CE}_3$ ) and an asynchronous Output Enable ( $\overline{OE}$ ) provide for easy bank selection and output tri-state control. In order to avoid bus contention, the output drivers are synchronously tri-stated during the data portion of a write sequence.



**Logic Block Diagram-CY7C1372D (1M x 18)**

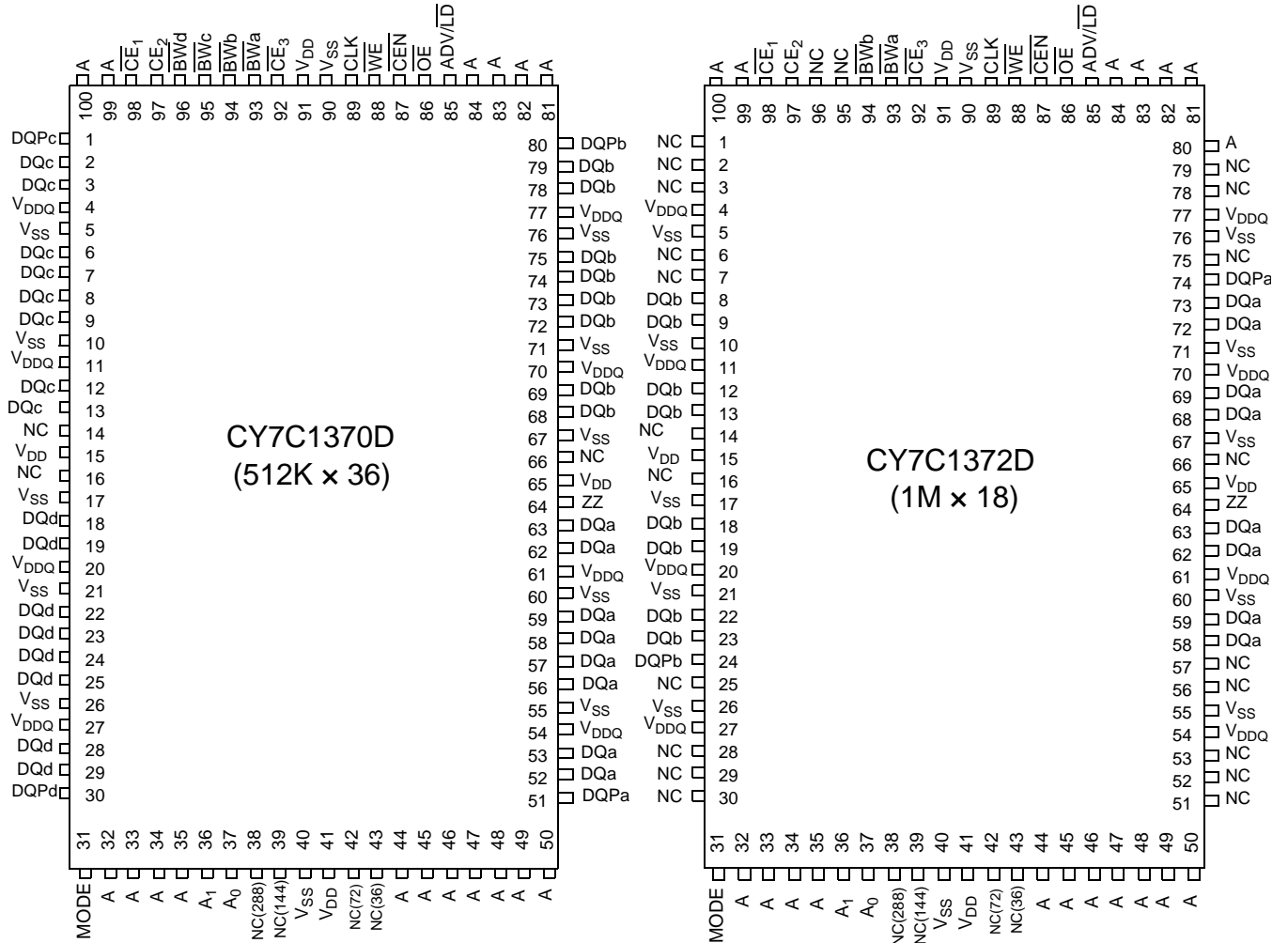


**Selection Guide**

	250 MHz	200 MHz	167 MHz	Unit
Maximum Access Time	2.6	3.0	3.4	ns
Maximum Operating Current	350	300	275	mA
Maximum CMOS Standby Current	70	70	70	mA

**Pin Configurations**

**100-pin TQFP Pinout**



**Pin Configurations** (continued)

**119-Ball BGA Pinout**  
**CY7C1370D (512K x 36)**

	1	2	3	4	5	6	7
<b>A</b>	V <sub>DDQ</sub>	A	A	A	A	A	V <sub>DDQ</sub>
<b>B</b>	NC/576M	CE <sub>2</sub>	A	ADV/LD	A	CE <sub>3</sub>	NC
<b>C</b>	NC/1G	A	A	V <sub>DD</sub>	A	A	NC
<b>D</b>	DQ <sub>c</sub>	DQP <sub>c</sub>	V <sub>SS</sub>	NC	V <sub>SS</sub>	DQP <sub>b</sub>	DQ <sub>b</sub>
<b>E</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>SS</sub>	CE <sub>1</sub>	V <sub>SS</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>F</b>	V <sub>DDQ</sub>	DQ <sub>c</sub>	V <sub>SS</sub>	OE	V <sub>SS</sub>	DQ <sub>b</sub>	V <sub>DDQ</sub>
<b>G</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	BW <sub>c</sub>	A	BW <sub>b</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>H</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>SS</sub>	WE	V <sub>SS</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>J</b>	V <sub>DDQ</sub>	V <sub>DD</sub>	NC	V <sub>DD</sub>	NC	V <sub>DD</sub>	V <sub>DDQ</sub>
<b>K</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>SS</sub>	CLK	V <sub>SS</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>L</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	BW <sub>d</sub>	NC	BW <sub>a</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>M</b>	V <sub>DDQ</sub>	DQ <sub>d</sub>	V <sub>SS</sub>	CEN	V <sub>SS</sub>	DQ <sub>a</sub>	V <sub>DDQ</sub>
<b>N</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>SS</sub>	A1	V <sub>SS</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>P</b>	DQ <sub>d</sub>	DQP <sub>d</sub>	V <sub>SS</sub>	A0	V <sub>SS</sub>	DQP <sub>a</sub>	DQ <sub>a</sub>
<b>R</b>	NC/144M	A	MODE	V <sub>DD</sub>	NC	A	NC/288M
<b>T</b>	NC	NC/72M	A	A	A	NC/36M	ZZ
<b>U</b>	V <sub>DDQ</sub>	TMS	TDI	TCK	TDO	NC	V <sub>DDQ</sub>

**CY7C1372D (1M x 18)**

	1	2	3	4	5	6	7
<b>A</b>	V <sub>DDQ</sub>	A	A	A	A	A	V <sub>DDQ</sub>
<b>B</b>	NC/576M	CE <sub>2</sub>	A	ADV/LD	A	CE <sub>3</sub>	NC
<b>C</b>	NC/1G	A	A	V <sub>DD</sub>	A	A	NC
<b>D</b>	DQ <sub>b</sub>	NC	V <sub>SS</sub>	NC	V <sub>SS</sub>	DQP <sub>a</sub>	NC
<b>E</b>	NC	DQ <sub>b</sub>	V <sub>SS</sub>	CE <sub>1</sub>	V <sub>SS</sub>	NC	DQ <sub>a</sub>
<b>F</b>	V <sub>DDQ</sub>	NC	V <sub>SS</sub>	OE	V <sub>SS</sub>	DQ <sub>a</sub>	V <sub>DDQ</sub>
<b>G</b>	NC	DQ <sub>b</sub>	BW <sub>b</sub>	A	NC	NC	DQ <sub>a</sub>
<b>H</b>	DQ <sub>b</sub>	NC	V <sub>SS</sub>	WE	V <sub>SS</sub>	DQ <sub>a</sub>	NC
<b>J</b>	V <sub>DDQ</sub>	V <sub>DD</sub>	NC	V <sub>DD</sub>	NC	V <sub>DD</sub>	V <sub>DDQ</sub>
<b>K</b>	NC	DQ <sub>b</sub>	V <sub>SS</sub>	CLK	V <sub>SS</sub>	NC	DQ <sub>a</sub>
<b>L</b>	DQ <sub>b</sub>	NC	NC	NC	BW <sub>a</sub>	DQ <sub>a</sub>	NC
<b>M</b>	V <sub>DDQ</sub>	DQ <sub>b</sub>	V <sub>SS</sub>	CEN	V <sub>SS</sub>	NC	V <sub>DDQ</sub>
<b>N</b>	DQ <sub>b</sub>	NC	V <sub>SS</sub>	A1	V <sub>SS</sub>	DQ <sub>a</sub>	NC
<b>P</b>	NC	DQP <sub>b</sub>	V <sub>SS</sub>	A0	V <sub>SS</sub>	NC	DQ <sub>a</sub>
<b>R</b>	NC/144M	A	MODE	V <sub>DD</sub>	NC	A	NC/288M
<b>T</b>	NC/72M	A	A	NC/36M	A	A	ZZ
<b>U</b>	V <sub>DDQ</sub>	TMS	TDI	TCK	TDO	NC	V <sub>DDQ</sub>

**Pin Configurations** (continued)

**165-Ball FBGA Pinout**

**CY7C1370D (512K x 36)**

	1	2	3	4	5	6	7	8	9	10	11
<b>A</b>	NC/576M	A	$\overline{CE}_1$	$\overline{BW}_c$	$\overline{BW}_b$	$\overline{CE}_3$	$\overline{CEN}$	ADV/LD	A	A	NC
<b>B</b>	NC/1G	A	CE2	$\overline{BW}_d$	$\overline{BW}_a$	CLK	$\overline{WE}$	$\overline{OE}$	A	A	NC
<b>C</b>	DQP <sub>c</sub>	NC	V <sub>DDQ</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DDQ</sub>	NC	DQP <sub>b</sub>
<b>D</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>E</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>F</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>G</b>	DQ <sub>c</sub>	DQ <sub>c</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>b</sub>	DQ <sub>b</sub>
<b>H</b>	NC	NC	NC	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	NC	NC	ZZ
<b>J</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>K</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>L</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>M</b>	DQ <sub>d</sub>	DQ <sub>d</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	DQ <sub>a</sub>
<b>N</b>	DQP <sub>d</sub>	NC	V <sub>DDQ</sub>	V <sub>SS</sub>	NC	NC	NC	V <sub>SS</sub>	V <sub>DDQ</sub>	NC	DQP <sub>a</sub>
<b>P</b>	NC/144M	NC/72M	A	A	TDI	A1	TDO	A	A	A	NC/288M
<b>R</b>	MODE	NC/36M	A	A	TMS	A0	TCK	A	A	A	A

**CY7C1372D (1M x 18)**

	1	2	3	4	5	6	7	8	9	10	11
<b>A</b>	NC/576M	A	$\overline{CE}_1$	$\overline{BW}_b$	NC	$\overline{CE}_3$	$\overline{CEN}$	ADV/LD	A	A	A
<b>B</b>	NC/1G	A	CE2	NC	$\overline{BW}_a$	CLK	$\overline{WE}$	$\overline{OE}$	A	A	NC
<b>C</b>	NC	NC	V <sub>DDQ</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DDQ</sub>	NC	DQP <sub>a</sub>
<b>D</b>	NC	DQ <sub>b</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	NC	DQ <sub>a</sub>
<b>E</b>	NC	DQ <sub>b</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	NC	DQ <sub>a</sub>
<b>F</b>	NC	DQ <sub>b</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	NC	DQ <sub>a</sub>
<b>G</b>	NC	DQ <sub>b</sub>	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	NC	DQ <sub>a</sub>
<b>H</b>	NC	NC	NC	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	NC	NC	ZZ
<b>J</b>	DQ <sub>b</sub>	NC	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	NC
<b>K</b>	DQ <sub>b</sub>	NC	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	NC
<b>L</b>	DQ <sub>b</sub>	NC	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	NC
<b>M</b>	DQ <sub>b</sub>	NC	V <sub>DDQ</sub>	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DDQ</sub>	DQ <sub>a</sub>	NC
<b>N</b>	DQP <sub>b</sub>	NC	V <sub>DDQ</sub>	V <sub>SS</sub>	NC	NC	NC	V <sub>SS</sub>	V <sub>DDQ</sub>	NC	NC
<b>P</b>	NC/144M	NC/72M	A	A	TDI	A1	TDO	A	A	A	NC/288M
<b>R</b>	MODE	NC/36M	A	A	TMS	A0	TCK	A	A	A	A

## Pin Definitions

Pin Name	I/O Type	Pin Description
A0 A1 A	Input-Synchronous	<b>Address Inputs used to select one of the address locations.</b> Sampled at the rising edge of the CLK.
$\overline{BW}_a$ $\overline{BW}_b$ $\overline{BW}_c$ $\overline{BW}_d$	Input-Synchronous	<b>Byte Write Select Inputs, active LOW.</b> Qualified with $\overline{WE}$ to conduct writes to the SRAM. Sampled on the rising edge of CLK. $\overline{BW}_a$ controls $DQ_a$ and $DQP_a$ , $\overline{BW}_b$ controls $DQ_b$ and $DQP_b$ , $\overline{BW}_c$ controls $DQ_c$ and $DQP_c$ , $\overline{BW}_d$ controls $DQ_d$ and $DQP_d$ .
$\overline{WE}$	Input-Synchronous	<b>Write Enable Input, active LOW.</b> Sampled on the rising edge of CLK if $\overline{CEN}$ is active LOW. This signal must be asserted LOW to initiate a write sequence.
$\overline{ADV/LD}$	Input-Synchronous	<b>Advance/Load Input used to advance the on-chip address counter or load a new address.</b> When HIGH (and $\overline{CEN}$ is asserted LOW) the internal burst counter is advanced. When LOW, a new address can be loaded into the device for an access. After being deselected, $\overline{ADV/LD}$ should be driven LOW in order to load a new address.
CLK	Input-Clock	<b>Clock Input.</b> Used to capture all synchronous inputs to the device. CLK is qualified with $\overline{CEN}$ . CLK is only recognized if $\overline{CEN}$ is active LOW.
$\overline{CE}_1$	Input-Synchronous	<b>Chip Enable 1 Input, active LOW.</b> Sampled on the rising edge of CLK. Used in conjunction with $\overline{CE}_2$ and $\overline{CE}_3$ to select/deselect the device.
$\overline{CE}_2$	Input-Synchronous	<b>Chip Enable 2 Input, active HIGH.</b> Sampled on the rising edge of CLK. Used in conjunction with $\overline{CE}_1$ and $\overline{CE}_3$ to select/deselect the device.
$\overline{CE}_3$	Input-Synchronous	<b>Chip Enable 3 Input, active LOW.</b> Sampled on the rising edge of CLK. Used in conjunction with $\overline{CE}_1$ and $\overline{CE}_2$ to select/deselect the device.
$\overline{OE}$	Input-Asynchronous	<b>Output Enable, active LOW.</b> Combined with the synchronous logic block inside the device to control the direction of the I/O pins. When LOW, the I/O pins are allowed to behave as outputs. When deasserted HIGH, I/O pins are tri-stated, and act as input data pins. $\overline{OE}$ is masked during the data portion of a write sequence, during the first clock when emerging from a deselected state and when the device has been deselected.
$\overline{CEN}$	Input-Synchronous	<b>Clock Enable Input, active LOW.</b> When asserted LOW the clock signal is recognized by the SRAM. When deasserted HIGH the clock signal is masked. Since deasserting $\overline{CEN}$ does not deselect the device, $\overline{CEN}$ can be used to extend the previous cycle when required.
$DQ_s$	I/O-Synchronous	<b>Bidirectional Data I/O lines.</b> As inputs, they feed into an on-chip data register that is triggered by the rising edge of CLK. As outputs, they deliver the data contained in the memory location specified by $A_{[17:0]}$ during the previous clock rise of the read cycle. The direction of the pins is controlled by $\overline{OE}$ and the internal control logic. When $\overline{OE}$ is asserted LOW, the pins can behave as outputs. When HIGH, $DQ_a-DQ_d$ are placed in a tri-state condition. The outputs are automatically tri-stated during the data portion of a write sequence, during the first clock when emerging from a deselected state, and when the device is deselected, regardless of the state of $\overline{OE}$ .
$DQP_x$	I/O-Synchronous	<b>Bidirectional Data Parity I/O lines.</b> Functionally, these signals are identical to $DQ_s$ . During write sequences, $DQP_a$ is controlled by $\overline{BW}_a$ , $DQP_b$ is controlled by $\overline{BW}_b$ , $DQP_c$ is controlled by $\overline{BW}_c$ , and $DQP_d$ is controlled by $\overline{BW}_d$ .
MODE	Input Strap Pin	<b>Mode Input.</b> Selects the burst order of the device. Tied HIGH selects the interleaved burst order. Pulled LOW selects the linear burst order. MODE should not change states during operation. When left floating MODE will default HIGH, to an interleaved burst order.
TDO	JTAG serial output Synchronous	<b>Serial data-out to the JTAG circuit.</b> Delivers data on the negative edge of TCK.
TDI	JTAG serial input Synchronous	<b>Serial data-In to the JTAG circuit.</b> Sampled on the rising edge of TCK.
TMS	Test Mode Select Synchronous	<b>This pin controls the Test Access Port state machine.</b> Sampled on the rising edge of TCK.
TCK	JTAG-Clock	<b>Clock input to the JTAG circuitry.</b>
$V_{DD}$	Power Supply	<b>Power supply inputs to the core of the device.</b>

**Pin Definitions** (continued)

Pin Name	I/O Type	Pin Description
V <sub>DDQ</sub>	I/O Power Supply	<b>Power supply for the I/O circuitry.</b>
V <sub>SS</sub>	Ground	<b>Ground for the device.</b> Should be connected to ground of the system.
NC	–	<b>No connects.</b> This pin is not connected to the die.
NC/(36M,72M, 144M, 288M, 576M, 1G)	–	<b>These pins are not connected.</b> They will be used for expansion to the 36M, 72M, 144M, 288M, 576M and 1G densities.
ZZ	Input-Asynchronous	<b>ZZ “sleep” Input.</b> This active HIGH input places the device in a non-time critical “sleep” condition with data integrity preserved. During normal operation, this pin can be connected to V <sub>SS</sub> or left floating. ZZ pin has an internal pull-down.

**Introduction**

**Functional Overview**

The CY7C1370D and CY7C1372D are synchronous-pipelined Burst NoBL SRAMs designed specifically to eliminate wait states during Write/Read transitions. All synchronous inputs pass through input registers controlled by the rising edge of the clock. The clock signal is qualified with the Clock Enable input signal (CEN). If CEN is HIGH, the clock signal is not recognized and all internal states are maintained. All synchronous operations are qualified with CEN. All data outputs pass through output registers controlled by the rising edge of the clock. Maximum access delay from the clock rise (t<sub>CO</sub>) is 2.6 ns (250-MHz device).

Accesses can be initiated by asserting all three Chip Enables ( $\overline{CE}_1$ , CE<sub>2</sub>,  $\overline{CE}_3$ ) active at the rising edge of the clock. If Clock Enable (CEN) is active LOW and ADV/LD is asserted LOW, the address presented to the device will be latched. The access can either be a read or write operation, depending on the status of the Write Enable (WE). BW<sub>X</sub> can be used to conduct byte write operations.

Write operations are qualified by the Write Enable ( $\overline{WE}$ ). All writes are simplified with on-chip synchronous self-timed write circuitry.

Three synchronous Chip Enables ( $\overline{CE}_1$ , CE<sub>2</sub>,  $\overline{CE}_3$ ) and an asynchronous Output Enable ( $\overline{OE}$ ) simplify depth expansion. All operations (Reads, Writes, and Deselects) are pipelined. ADV/LD should be driven LOW once the device has been deselected in order to load a new address for the next operation.

**Single Read Accesses**

A read access is initiated when the following conditions are satisfied at clock rise: (1) CEN is asserted LOW, (2)  $\overline{CE}_1$ , CE<sub>2</sub>, and  $\overline{CE}_3$  are ALL asserted active, (3) the Write Enable input signal  $\overline{WE}$  is deasserted HIGH, and (4) ADV/LD is asserted LOW. The address presented to the address inputs is latched into the Address Register and presented to the memory core and control logic. The control logic determines that a read access is in progress and allows the requested data to propagate to the input of the output register. At the rising edge of the next clock the requested data is allowed to propagate through the output register and onto the data bus within 2.6 ns (250-MHz device) provided  $\overline{OE}$  is active LOW. After the first clock of the read access the output buffers are controlled by  $\overline{OE}$  and the internal control logic.  $\overline{OE}$  must be driven LOW in order for the device to drive out the requested data. During the

second clock, a subsequent operation (Read/Write/Deselect) can be initiated. Deselecting the device is also pipelined. Therefore, when the SRAM is deselected at clock rise by one of the chip enable signals, its output will tri-state following the next clock rise.

**Burst Read Accesses**

The CY7C1370D and CY7C1372D have an on-chip burst counter that allows the user the ability to supply a single address and conduct up to four Reads without reasserting the address inputs. ADV/LD must be driven LOW in order to load a new address into the SRAM, as described in the Single Read Access section above. The sequence of the burst counter is determined by the MODE input signal. A LOW input on MODE selects a linear burst mode, a HIGH selects an interleaved burst sequence. Both burst counters use A0 and A1 in the burst sequence, and will wrap-around when incremented sufficiently. A HIGH input on ADV/LD will increment the internal burst counter regardless of the state of chip enables inputs or WE. WE is latched at the beginning of a burst cycle. Therefore, the type of access (Read or Write) is maintained throughout the burst sequence.

**Single Write Accesses**

Write access are initiated when the following conditions are satisfied at clock rise: (1) CEN is asserted LOW, (2)  $\overline{CE}_1$ , CE<sub>2</sub>, and CE<sub>3</sub> are ALL asserted active, and (3) the write signal WE is asserted LOW. The address presented is loaded into the Address Register. The write signals are latched into the Control Logic block.

On the subsequent clock rise the data lines are automatically tri-stated regardless of the state of the  $\overline{OE}$  input signal. This allows the external logic to present the data on DQ and DQP (DQ<sub>a,b,c,d</sub>/DQP<sub>a,b,c,d</sub> for CY7C1370D and DQ<sub>a,b</sub>/DQP<sub>a,b</sub> for CY7C1372D). In addition, the address for the subsequent access (Read/Write/Deselect) is latched into the Address Register (provided the appropriate control signals are asserted).

On the next clock rise the data presented to DQ and DQP (DQ<sub>a,b,c,d</sub>/DQP<sub>a,b,c,d</sub> for CY7C1370D & DQ<sub>a,b</sub>/DQP<sub>a,b</sub> for CY7C1372D) (or a subset for byte write operations, see Write Cycle Description table for details) inputs is latched into the device and the write is complete.

The data written during the write operation is controlled by  $\overline{BW}$  (BW<sub>a,b,c,d</sub> for CY7C1370D and BW<sub>a,b</sub> for CY7C1372D) signals. The CY7C1370D/CY7C1372D provides byte write capability that is described in the Write Cycle Description table.

Asserting the Write Enable input ( $\overline{WE}$ ) with the selected Byte Write Select (BW) input will selectively write to only the desired bytes. Bytes not selected during a byte write operation will remain unaltered. A synchronous self-timed write mechanism has been provided to simplify the write operations. Byte write capability has been included in order to greatly simplify Read/Modify/Write sequences, which can be reduced to simple byte write operations.

Because the CY7C1370D and CY7C1372D are common I/O devices, data should not be driven into the device while the outputs are active. The Output Enable (OE) can be deasserted HIGH before presenting data to the DQ and DQP ( $DQ_{a,b,c,d}/DQP_{a,b,c,d}$  for CY7C1370D and  $DQ_{a,b}/DQP_{a,b}$  for CY7C1372D) inputs. Doing so will tri-state the output drivers. As a safety precaution, DQ and DQP ( $DQ_{a,b,c,d}/DQP_{a,b,c,d}$  for CY7C1370D and  $DQ_{a,b}/DQP_{a,b}$  for CY7C1372D) are automatically tri-stated during the data portion of a write cycle, regardless of the state of OE.

#### Burst Write Accesses

The CY7C1370D/CY7C1372D has an on-chip burst counter that allows the user the ability to supply a single address and conduct up to four write operations without reasserting the address inputs. ADV/LD must be driven LOW in order to load the initial address, as described in the Single Write Access section above. When ADV/LD is driven HIGH on the subsequent clock rise, the chip enables ( $CE_1$ ,  $CE_2$ , and  $CE_3$ ) and WE inputs are ignored and the burst counter is incremented. The correct BW ( $BW_{a,b,c,d}$  for CY7C1370D and  $BW_{a,b}$  for CY7C1372D) inputs must be driven in each cycle of the burst write in order to write the correct bytes of data.

#### Sleep Mode

The ZZ input pin is an asynchronous input. Asserting ZZ places the SRAM in a power conservation "sleep" mode. Two clock cycles are required to enter into or exit from this "sleep" mode. While in this mode, data integrity is guaranteed. Accesses pending when entering the "sleep" mode are not considered valid nor is the completion of the operation guaranteed. The device must be deselected prior to entering the "sleep" mode.  $\overline{CE}_1$ ,  $CE_2$ , and  $CE_3$ , must remain inactive for the duration of  $t_{ZZREC}$  after the ZZ input returns LOW.

#### Interleaved Burst Address Table (MODE = Floating or $V_{DD}$ )

First Address	Second Address	Third Address	Fourth Address
A1,A0	A1,A0	A1,A0	A1,A0
00	01	10	11
01	00	11	10
10	11	00	01
11	10	01	00

#### Linear Burst Address Table (MODE = GND)

First Address	Second Address	Third Address	Fourth Address
A1,A0	A1,A0	A1,A0	A1,A0
00	01	10	11
01	10	11	00
10	11	00	01
11	00	01	10

#### ZZ Mode Electrical Characteristics

Parameter	Description	Test Conditions	Min.	Max.	Unit
$I_{DDZZ}$	Sleep mode standby current	$ZZ \geq V_{DD} - 0.2V$		80	mA
$t_{ZZS}$	Device operation to ZZ	$ZZ \geq V_{DD} - 0.2V$		$2t_{CYC}$	ns
$t_{ZZREC}$	ZZ recovery time	$ZZ \leq 0.2V$	$2t_{CYC}$		ns
$t_{ZZI}$	ZZ active to sleep current	This parameter is sampled		$2t_{CYC}$	ns
$t_{RZZI}$	ZZ Inactive to exit sleep current	This parameter is sampled	0		ns



**Truth Table**<sup>[1, 2, 3, 4, 5, 6, 7]</sup>

Operation	Address Used	$\overline{CE}$	ZZ	ADV/LD	$\overline{WE}$	$\overline{BW}_x$	$\overline{OE}$	$\overline{CEN}$	CLK	DQ
Deselect Cycle	None	H	L	L	X	X	X	L	L-H	Tri-State
Continue Deselect Cycle	None	X	L	H	X	X	X	L	L-H	Tri-State
Read Cycle (Begin Burst)	External	L	L	L	H	X	L	L	L-H	Data Out (Q)
Read Cycle (Continue Burst)	Next	X	L	H	X	X	L	L	L-H	Data Out (Q)
NOP/Dummy Read (Begin Burst)	External	L	L	L	H	X	H	L	L-H	Tri-State
Dummy Read (Continue Burst)	Next	X	L	H	X	X	H	L	L-H	Tri-State
Write Cycle (Begin Burst)	External	L	L	L	L	L	X	L	L-H	Data In (D)
Write Cycle (Continue Burst)	Next	X	L	H	X	L	X	L	L-H	Data In (D)
NOP/Write Abort (Begin Burst)	None	L	L	L	L	H	X	L	L-H	Tri-State
Write Abort (Continue Burst)	Next	X	L	H	X	H	X	L	L-H	Tri-State
Ignore Clock Edge (Stall)	Current	X	L	X	X	X	X	H	L-H	–
Sleep Mode	None	X	H	X	X	X	X	X	X	Tri-State

**Notes:**

1. X = "Don't Care", H = Logic HIGH, L = Logic LOW,  $\overline{CE}$  stands for ALL Chip Enables active.  $\overline{BW}_x = L$  signifies at least one Byte Write Select is active,  $\overline{BW}_x = \text{Valid}$  signifies that the desired byte write selects are asserted, see Write Cycle Description table for details.
2. Write is defined by  $\overline{WE}$  and  $\overline{BW}_x$ . See Write Cycle Description table for details.
3. When a write cycle is detected, all I/Os are tri-stated, even during byte writes.
4. The DQ and DQP pins are controlled by the current cycle and the  $\overline{OE}$  signal.
5.  $\overline{CEN} = H$  inserts wait states.
6. Device will power-up deselected and the I/Os in a tri-state condition, regardless of  $\overline{OE}$ .
7.  $\overline{OE}$  is asynchronous and is not sampled with the clock rise. It is masked internally during write cycles. During a read cycle  $DQ_s$  and  $DQP_x = \text{Three-state}$  when  $\overline{OE}$  is inactive or when the device is deselected, and  $DQ_s = \text{data}$  when  $\overline{OE}$  is active.

**Partial Write Cycle Description**<sup>[1, 2, 3, 8]</sup>

Function (CY7C1370D)	$\overline{WE}$	$\overline{BW_d}$	$\overline{BW_c}$	$\overline{BW_b}$	$\overline{BW_a}$
Read	H	X	X	X	X
Write – No bytes written	L	H	H	H	H
Write Byte a – (DQ <sub>a</sub> and DQP <sub>a</sub> )	L	H	H	H	L
Write Byte b – (DQ <sub>b</sub> and DQP <sub>b</sub> )	L	H	H	L	H
Write Bytes b, a	L	H	H	L	L
Write Byte c – (DQ <sub>c</sub> and DQP <sub>c</sub> )	L	H	L	H	H
Write Bytes c, a	L	H	L	H	L
Write Bytes c, b	L	H	L	L	H
Write Bytes c, b, a	L	H	L	L	L
Write Byte d – (DQ <sub>d</sub> and DQP <sub>d</sub> )	L	L	H	H	H
Write Bytes d, a	L	L	H	H	L
Write Bytes d, b	L	L	H	L	H
Write Bytes d, b, a	L	L	H	L	L
Write Bytes d, c	L	L	L	H	H
Write Bytes d, c, a	L	L	L	H	L
Write Bytes d, c, b	L	L	L	L	H
Write All Bytes	L	L	L	L	L

Function (CY7C1372D)	$\overline{WE}$	$\overline{BW_b}$	$\overline{BW_a}$
Read	H	x	x
Write – No Bytes Written	L	H	H
Write Byte a – (DQ <sub>a</sub> and DQP <sub>a</sub> )	L	H	L
Write Byte b – (DQ <sub>b</sub> and DQP <sub>b</sub> )	L	L	H
Write Both Bytes	L	L	L

**Note:**

8. Table only lists a partial listing of the byte write combinations. Any Combination of  $\overline{BW_x}$  is valid Appropriate write will be done based on which byte write is active.

## IEEE 1149.1 Serial Boundary Scan (JTAG)

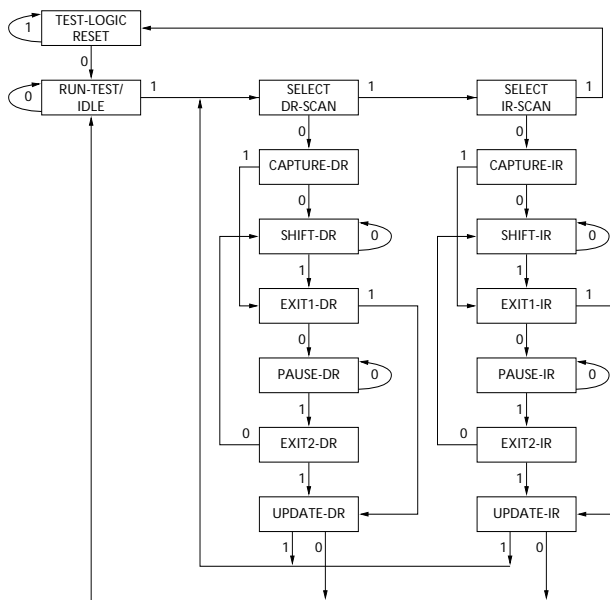
The CY7C1370D/CY7C1372D incorporates a serial boundary scan test access port (TAP). This part is fully compliant with 1149.1. The TAP operates using JEDEC-standard 3.3V or 2.5V I/O logic levels.

The CY7C1370D/CY7C1372D contains a TAP controller, instruction register, boundary scan register, bypass register, and ID register.

### Disabling the JTAG Feature

It is possible to operate the SRAM without using the JTAG feature. To disable the TAP controller, TCK must be tied LOW ( $V_{SS}$ ) to prevent clocking of the device. TDI and TMS are internally pulled up and may be unconnected. They may alternately be connected to  $V_{DD}$  through a pull-up resistor. TDO should be left unconnected. Upon power-up, the device will come up in a reset state which will not interfere with the operation of the device.

## TAP Controller State Diagram



The 0/1 next to each state represents the value of TMS at the rising edge of TCK.

### Test Access Port (TAP)

#### Test Clock (TCK)

The test clock is used only with the TAP controller. All inputs are captured on the rising edge of TCK. All outputs are driven from the falling edge of TCK.

#### Test Mode Select (TMS)

The TMS input is used to give commands to the TAP controller and is sampled on the rising edge of TCK. It is allowable to leave this ball unconnected if the TAP is not used. The ball is pulled up internally, resulting in a logic HIGH level.

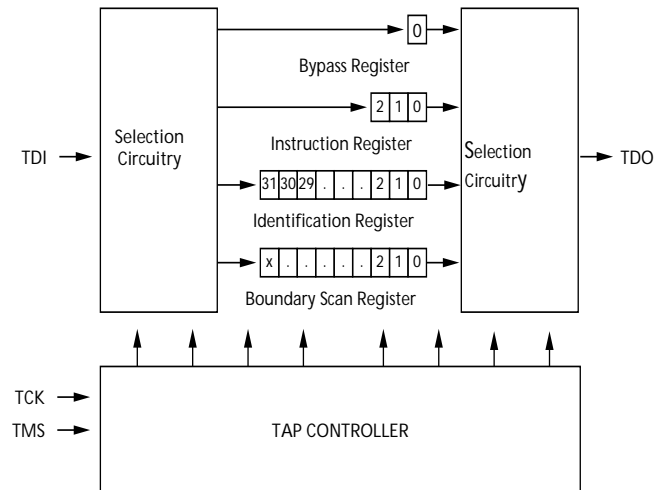
### Test Data-In (TDI)

The TDI ball is used to serially input information into the registers and can be connected to the input of any of the registers. The register between TDI and TDO is chosen by the instruction that is loaded into the TAP instruction register. TDI is internally pulled up and can be unconnected if the TAP is unused in an application. TDI is connected to the most significant bit (MSB) of any register. (See Tap Controller Block Diagram.)

### Test Data-Out (TDO)

The TDO output ball is used to serially clock data-out from the registers. The output is active depending upon the current state of the TAP state machine. The output changes on the falling edge of TCK. TDO is connected to the least significant bit (LSB) of any register. (See Tap Controller State Diagram.)

## TAP Controller Block Diagram



### Performing a TAP Reset

A Reset is performed by forcing TMS HIGH ( $V_{DD}$ ) for five rising edges of TCK. This Reset does not affect the operation of the SRAM and may be performed while the SRAM is operating.

At power-up, the TAP is reset internally to ensure that TDO comes up in a High-Z state.

### TAP Registers

Registers are connected between the TDI and TDO balls and allow data to be scanned into and out of the SRAM test circuitry. Only one register can be selected at a time through the instruction register. Data is serially loaded into the TDI ball on the rising edge of TCK. Data is output on the TDO ball on the falling edge of TCK.

#### Instruction Register

Three-bit instructions can be serially loaded into the instruction register. This register is loaded when it is placed between the TDI and TDO balls as shown in the Tap Controller Block Diagram. Upon power-up, the instruction register is loaded with the IDCODE instruction. It is also loaded with the IDCODE instruction if the controller is placed in a reset state as described in the previous section.

When the TAP controller is in the Capture-IR state, the two least significant bits are loaded with a binary “01” pattern to allow for fault isolation of the board-level serial test data path.

#### *Bypass Register*

To save time when serially shifting data through registers, it is sometimes advantageous to skip certain chips. The bypass register is a single-bit register that can be placed between the TDI and TDO balls. This allows data to be shifted through the SRAM with minimal delay. The bypass register is set LOW ( $V_{SS}$ ) when the BYPASS instruction is executed.

#### *Boundary Scan Register*

The boundary scan register is connected to all the input and bidirectional balls on the SRAM.

The boundary scan register is loaded with the contents of the RAM I/O ring when the TAP controller is in the Capture-DR state and is then placed between the TDI and TDO balls when the controller is moved to the Shift-DR state. The EXTEST, SAMPLE/PRELOAD and SAMPLE Z instructions can be used to capture the contents of the I/O ring.

The Boundary Scan Order tables show the order in which the bits are connected. Each bit corresponds to one of the bumps on the SRAM package. The MSB of the register is connected to TDI and the LSB is connected to TDO.

#### *Identification (ID) Register*

The ID register is loaded with a vendor-specific, 32-bit code during the Capture-DR state when the IDCODE command is loaded in the instruction register. The IDCODE is hardwired into the SRAM and can be shifted out when the TAP controller is in the Shift-DR state. The ID register has a vendor code and other information described in the Identification Register Definitions table.

### **TAP Instruction Set**

#### *Overview*

Eight different instructions are possible with the three bit instruction register. All combinations are listed in the Instruction Codes table. Three of these instructions are listed as RESERVED and should not be used. The other five instructions are described in detail below.

Instructions are loaded into the TAP controller during the Shift-IR state when the instruction register is placed between TDI and TDO. During this state, instructions are shifted through the instruction register through the TDI and TDO balls. To execute the instruction once it is shifted in, the TAP controller needs to be moved into the Update-IR state.

#### *EXTEST*

The EXTEST instruction enables the preloaded data to be driven out through the system output pins. This instruction also selects the boundary scan register to be connected for serial access between the TDI and TDO in the shift-DR controller state.

#### *IDCODE*

The IDCODE instruction causes a vendor-specific, 32-bit code to be loaded into the instruction register. It also places the instruction register between the TDI and TDO balls and allows

the IDCODE to be shifted out of the device when the TAP controller enters the Shift-DR state.

The IDCODE instruction is loaded into the instruction register upon power-up or whenever the TAP controller is given a test logic reset state.

#### *SAMPLE Z*

The SAMPLE Z instruction causes the boundary scan register to be connected between the TDI and TDO balls when the TAP controller is in a Shift-DR state. It also places all SRAM outputs into a High-Z state.

#### *SAMPLE/PRELOAD*

SAMPLE/PRELOAD is a 1149.1-mandatory instruction. When the SAMPLE/PRELOAD instructions are loaded into the instruction register and the TAP controller is in the Capture-DR state, a snapshot of data on the inputs and output pins is captured in the boundary scan register.

The user must be aware that the TAP controller clock can only operate at a frequency up to 20 MHz, while the SRAM clock operates more than an order of magnitude faster. Because there is a large difference in the clock frequencies, it is possible that during the Capture-DR state, an input or output will undergo a transition. The TAP may then try to capture a signal while in transition (metastable state). This will not harm the device, but there is no guarantee as to the value that will be captured. Repeatable results may not be possible.

To guarantee that the boundary scan register will capture the correct value of a signal, the SRAM signal must be stabilized long enough to meet the TAP controller's capture set-up plus hold times ( $t_{CS}$  and  $t_{CH}$ ). The SRAM clock input might not be captured correctly if there is no way in a design to stop (or slow) the clock during a SAMPLE/PRELOAD instruction. If this is an issue, it is still possible to capture all other signals and simply ignore the value of the CK and CK captured in the boundary scan register.

Once the data is captured, it is possible to shift out the data by putting the TAP into the Shift-DR state. This places the boundary scan register between the TDI and TDO pins.

PRELOAD allows an initial data pattern to be placed at the latched parallel outputs of the boundary scan register cells prior to the selection of another boundary scan test operation.

The shifting of data for the SAMPLE and PRELOAD phases can occur concurrently when required—that is, while data captured is shifted out, the preloaded data can be shifted in.

#### *BYPASS*

When the BYPASS instruction is loaded in the instruction register and the TAP is placed in a Shift-DR state, the bypass register is placed between the TDI and TDO balls. The advantage of the BYPASS instruction is that it shortens the boundary scan path when multiple devices are connected together on a board.

#### *EXTEST Output Bus Tri-State*

IEEE Standard 1149.1 mandates that the TAP controller be able to put the output bus into a tri-state mode.

The boundary scan register has a special bit located at bit #85 (for 119-BGA package) or bit #89 (for 165-FBGA package). When this scan cell, called the “extest output bus tri-state,” is latched into the preload register during the “Update-DR” state

in the TAP controller, it will directly control the state of the output (Q-bus) pins, when the EXTEST is entered as the current instruction. When HIGH, it will enable the output buffers to drive the output bus. When LOW, this bit will place the output bus into a High-Z condition.

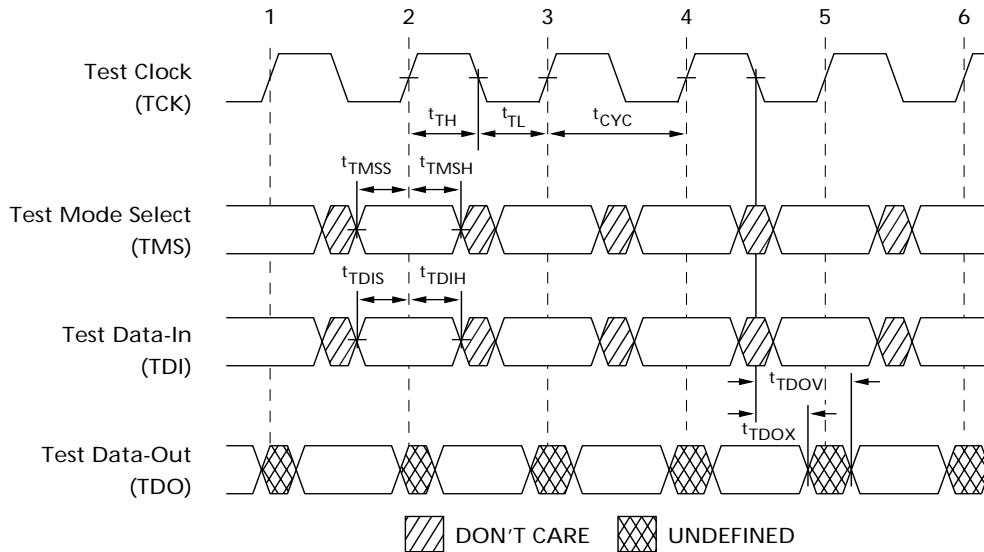
This bit can be set by entering the SAMPLE/PRELOAD or EXTEST command, and then shifting the desired bit into that cell, during the "Shift-DR" state. During "Update-DR," the value loaded into that shift-register cell will latch into the preload

register. When the EXTEST instruction is entered, this bit will directly control the output Q-bus pins. Note that this bit is preset HIGH to enable the output when the device is powered-up, and also when the TAP controller is in the "Test-Logic-Reset" state.

*Reserved*

These instructions are not implemented but are reserved for future use. Do not use these instructions.

**TAP Timing**



**TAP AC Switching Characteristics** Over the Operating Range<sup>[9, 10]</sup>

Parameter	Description	Min.	Max.	Unit
<b>Clock</b>				
$t_{TCYC}$	TCK Clock Cycle Time	50		ns
$t_{TF}$	TCK Clock Frequency		20	MHz
$t_{TH}$	TCK Clock HIGH time	20		ns
$t_{TL}$	TCK Clock LOW time	20		ns
<b>Output Times</b>				
$t_{TDOV}$	TCK Clock LOW to TDO Valid		10	ns
$t_{TDOX}$	TCK Clock LOW to TDO Invalid	0		ns
<b>Set-up Times</b>				
$t_{TMSS}$	TMS Set-up to TCK Clock Rise	5		ns
$t_{TDIS}$	TDI Set-up to TCK Clock Rise	5		ns
$t_{CS}$	Capture Set-up to TCK Rise	5		ns
<b>Hold Times</b>				
$t_{TMSH}$	TMS Hold after TCK Clock Rise	5		ns
$t_{TDIH}$	TDI Hold after Clock Rise	5		ns
$t_{CH}$	Capture Hold after Clock Rise	5		ns

**Notes:**

9.  $t_{CS}$  and  $t_{CH}$  refer to the set-up and hold time requirements of latching data from the boundary scan register.  
 10. Test conditions are specified using the load in TAP AC test Conditions.  $t_R/t_F = 1$  ns.

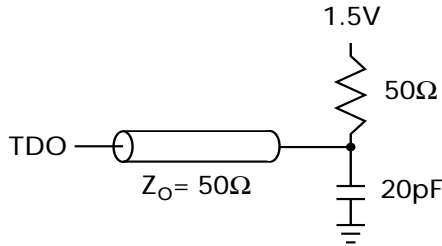
### 3.3V TAP AC Test Conditions

Input pulse levels .....  $V_{SS}$  to 3.3V  
 Input rise and fall times ..... 1 ns  
 Input timing reference levels ..... 1.5V  
 Output reference levels ..... 1.5V  
 Test load termination supply voltage ..... 1.5V

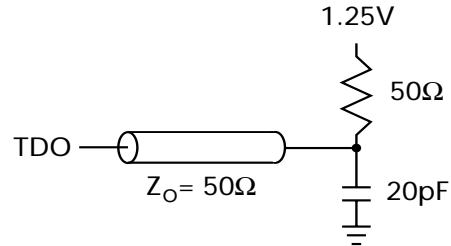
### 2.5V TAP AC Test Conditions

Input pulse levels .....  $V_{SS}$  to 2.5V  
 Input rise and fall time ..... 1 ns  
 Input timing reference levels ..... 1.25V  
 Output reference levels ..... 1.25V  
 Test load termination supply voltage ..... 1.25V

### 3.3V TAP AC Output Load Equivalent



### 2.5V TAP AC Output Load Equivalent



### TAP DC Electrical Characteristics And Operating Conditions

( $0^{\circ}\text{C} < T_A < +70^{\circ}\text{C}$ ;  $V_{DD} = 3.3\text{V} \pm 0.165\text{V}$  unless otherwise noted)<sup>[11]</sup>

Parameter	Description	Test Conditions	Min.	Max.	Unit
$V_{OH1}$	Output HIGH Voltage	$I_{OH} = -4.0\text{ mA}$ , $V_{DDQ} = 3.3\text{V}$	2.4		V
		$I_{OH} = -1.0\text{ mA}$ , $V_{DDQ} = 2.5\text{V}$	2.0		V
$V_{OH2}$	Output HIGH Voltage	$I_{OH} = -100\text{ }\mu\text{A}$ , $V_{DDQ} = 3.3\text{V}$	2.9		V
		$I_{OH} = -100\text{ }\mu\text{A}$ , $V_{DDQ} = 2.5\text{V}$	2.1		V
$V_{OL1}$	Output LOW Voltage	$I_{OL} = 8.0\text{ mA}$ , $V_{DDQ} = 3.3\text{V}$		0.4	V
		$I_{OL} = 8.0\text{ mA}$ , $V_{DDQ} = 2.5\text{V}$		0.4	V
$V_{OL2}$	Output LOW Voltage	$I_{OL} = 100\text{ }\mu\text{A}$ , $V_{DDQ} = 3.3\text{V}$		0.2	V
		$I_{OL} = 100\text{ }\mu\text{A}$ , $V_{DDQ} = 2.5\text{V}$		0.2	V
$V_{IH}$	Input HIGH Voltage	$V_{DDQ} = 3.3\text{V}$	2.0	$V_{DD} + 0.3$	V
		$V_{DDQ} = 2.5\text{V}$	1.7	$V_{DD} + 0.3$	V
$V_{IL}$	Input LOW Voltage	$V_{DDQ} = 3.3\text{V}$	-0.5	0.7	V
		$V_{DDQ} = 2.5\text{V}$	-0.3	0.7	V
$I_X$	Input Load Current	$GND \leq V_{IN} \leq V_{DDQ}$	-5	5	$\mu\text{A}$

**Note:**

11. All voltages referenced to  $V_{SS}$  (GND).

### Identification Register Definitions

Instruction Field	CY7C1372D	CY7C1370D	Description
Revision Number (31:29)	000	000	Reserved for version number.
Cypress Device ID (28:12) <sup>[12]</sup>	01011001000100101	01011001000010101	Reserved for future use.
Cypress JEDEC ID (11:1)	00000110100	00000110100	Allows unique identification of SRAM vendor.
ID Register Presence (0)	1	1	Indicate the presence of an ID register.

### Scan Register Sizes

Register Name	Bit Size (x18)	Bit Size (x36)
Instruction	3	3
Bypass	1	1
ID	32	32
Boundary Scan Order (119-ball BGA package)	85	85
Boundary Scan Order (165-ball FBGA package)	89	89

### Identification Codes

Instruction	Code	Description
EXTEST	000	Captures I/O ring contents. Places the boundary scan register between TDI and TDO. Forces all SRAM outputs to High-Z state.
IDCODE	001	Loads the ID register with the vendor ID code and places the register between TDI and TDO. This operation does not affect SRAM operations.
SAMPLE Z	010	Captures I/O ring contents. Places the boundary scan register between TDI and TDO. Forces all SRAM output drivers to a High-Z state.
RESERVED	011	Do Not Use: This instruction is reserved for future use.
SAMPLE/PRELOAD	100	Captures I/O ring contents. Places the boundary scan register between TDI and TDO. Does not affect SRAM operation.
RESERVED	101	Do Not Use: This instruction is reserved for future use.
RESERVED	110	Do Not Use: This instruction is reserved for future use.
BYPASS	111	Places the bypass register between TDI and TDO. This operation does not affect SRAM operations.

**Note:**

12. Bit #24 is "1" in the Register Definitions for both 2.5V and 3.3V versions of this device.

**119-Ball BGA Boundary Scan Order** [13, 14]

Bit #	Ball ID	Bit #	Ball ID	Bit #	Ball ID	Bit #	Ball ID
1	H4	23	F6	45	G4	67	L1
2	T4	24	E7	46	A4	68	M2
3	T5	25	D7	47	G3	69	N1
4	T6	26	H7	48	C3	70	P1
5	R5	27	G6	49	B2	71	K1
6	L5	28	E6	50	B3	72	L2
7	R6	29	D6	51	A3	73	N2
8	U6	30	C7	52	C2	74	P2
9	R7	31	B7	53	A2	75	R3
10	T7	32	C6	54	B1	76	T1
11	P6	33	A6	55	C1	77	R1
12	N7	34	C5	56	D2	78	T2
13	M6	35	B5	57	E1	79	L3
14	L7	36	G5	58	F2	80	R2
15	K6	37	B6	59	G1	81	T3
16	P7	38	D4	60	H2	82	L4
17	N6	39	B4	61	D1	83	N4
18	L6	40	F4	62	E2	84	P4
19	K7	41	M4	63	G2	85	Internal
20	J5	42	A5	64	H1		
21	H6	43	K4	65	J3		
22	G7	44	E4	66	2K		

**Notes:**

- 13. Balls which are NC (No Connect) are pre-set LOW.
- 14. Bit# 85 is pre-set HIGH.



**165-Ball BGA Boundary Scan Order** [13, 15]

Bit #	Ball ID	Bit #	Ball ID	Bit #	Ball ID
1	N6	31	D10	61	G1
2	N7	32	C11	62	D2
3	N10	33	A11	63	E2
4	P11	34	B11	64	F2
5	P8	35	A10	65	G2
6	R8	36	B10	66	H1
7	R9	37	A9	67	H3
8	P9	38	B9	68	J1
9	P10	39	C10	69	K1
10	R10	40	A8	70	L1
11	R11	41	B8	71	M1
12	H11	42	A7	72	J2
13	N11	43	B7	73	K2
14	M11	44	B6	74	L2
15	L11	45	A6	75	M2
16	K11	46	B5	76	N1
17	J11	47	A5	77	N2
18	M10	48	A4	78	P1
19	L10	49	B4	79	R1
20	K10	50	B3	80	R2
21	J10	51	A3	81	P3
22	H9	52	A2	82	R3
23	H10	53	B2	83	P2
24	G11	54	C2	84	R4
25	F11	55	B1	85	P4
26	E11	56	A1	86	N5
27	D11	57	C1	87	P6
28	G10	58	D1	88	R6
29	F10	59	E1	89	Internal
30	E10	60	F1		

**Note:**  
15. Bit# 89 is pre-set HIGH.

### Maximum Ratings

(Above which the useful life may be impaired. For user guidelines, not tested.)

Storage Temperature ..... -65°C to +150°C  
 Ambient Temperature with Power Applied..... -55°C to +125°C  
 Supply Voltage on V<sub>DD</sub> Relative to GND..... -0.5V to +4.6V  
 Supply Voltage on V<sub>DDQ</sub> Relative to GND ..... -0.5V to +V<sub>DD</sub>  
 DC to Outputs in Tri-State ..... -0.5V to V<sub>DDQ</sub> + 0.5V  
 DC Input Voltage..... -0.5V to V<sub>DD</sub> + 0.5V

Current into Outputs (LOW)..... 20 mA  
 Static Discharge Voltage..... > 2001V (per MIL-STD-883, Method 3015)  
 Latch-up Current..... > 200 mA

### Operating Range

Range	Ambient Temperature	V <sub>DD</sub>	V <sub>DDQ</sub>
Commercial	0°C to +70°C	3.3V-5%/+10%	2.5V -5% to V <sub>DD</sub>
Industrial	-40°C to +85°C		

### Electrical Characteristics Over the Operating Range [16, 17]

Parameter	Description	Test Conditions	Min.	Max.	Unit
V <sub>DD</sub>	Power Supply Voltage		3.135	3.6	V
V <sub>DDQ</sub>	I/O Supply Voltage	for 3.3V I/O	3.135	V <sub>DD</sub>	V
		for 2.5V I/O	2.375	2.625	V
V <sub>OH</sub>	Output HIGH Voltage	for 3.3V I/O, I <sub>OH</sub> = -4.0 mA	2.4		V
		for 2.5V I/O, I <sub>OH</sub> = -1.0 mA	2.0		V
V <sub>OL</sub>	Output LOW Voltage	for 3.3V I/O, I <sub>OL</sub> = 8.0 mA		0.4	V
		for 2.5V I/O, I <sub>OL</sub> = 1.0 mA		0.4	V
V <sub>IH</sub>	Input HIGH Voltage <sup>[16]</sup>	for 3.3V I/O	2.0	V <sub>DD</sub> + 0.3V	V
		for 2.5V I/O	1.7	V <sub>DD</sub> + 0.3V	V
V <sub>IL</sub>	Input LOW Voltage <sup>[16]</sup>	for 3.3V I/O	-0.3	0.8	V
		for 2.5V I/O	-0.3	0.7	V
I <sub>X</sub>	Input Leakage Current except ZZ and MODE	GND ≤ V <sub>I</sub> ≤ V <sub>DDQ</sub>	-5	5	μA
	Input Current of MODE	Input = V <sub>SS</sub>	-30		μA
		Input = V <sub>DD</sub>		5	μA
	Input Current of ZZ	Input = V <sub>SS</sub>	-5		μA
Input = V <sub>DD</sub>			30	μA	
I <sub>OZ</sub>	Output Leakage Current	GND ≤ V <sub>I</sub> ≤ V <sub>DDQ</sub> , Output Disabled	-5	5	μA
I <sub>DD</sub>	V <sub>DD</sub> Operating Supply	V <sub>DD</sub> = Max., I <sub>OUT</sub> = 0 mA, f = f <sub>MAX</sub> = 1/t <sub>CYC</sub>	4-ns cycle, 250 MHz	350	mA
			5-ns cycle, 200 MHz	300	mA
			6-ns cycle, 167 MHz	275	mA
I <sub>SB1</sub>	Automatic CE Power-down Current—TTL Inputs	Max. V <sub>DD</sub> , Device Deselected, V <sub>IN</sub> ≥ V <sub>IH</sub> or V <sub>IN</sub> ≤ V <sub>IL</sub> , f = f <sub>MAX</sub> = 1/t <sub>CYC</sub>	4-ns cycle, 250 MHz	160	mA
			5-ns cycle, 200 MHz	150	mA
			6-ns cycle, 167 MHz	140	mA
I <sub>SB2</sub>	Automatic CE Power-down Current—CMOS Inputs	Max. V <sub>DD</sub> , Device Deselected, V <sub>IN</sub> ≤ 0.3V or V <sub>IN</sub> ≥ V <sub>DDQ</sub> - 0.3V, f = 0	All speed grades	70	mA
I <sub>SB3</sub>	Automatic CE Power-down Current—CMOS Inputs	Max. V <sub>DD</sub> , Device Deselected, V <sub>IN</sub> ≤ 0.3V or V <sub>IN</sub> ≥ V <sub>DDQ</sub> - 0.3V, f = f <sub>MAX</sub> = 1/t <sub>CYC</sub>	4-ns cycle, 250 MHz	135	mA
			5-ns cycle, 200 MHz	130	mA
			6-ns cycle, 167 MHz	125	mA
I <sub>SB4</sub>	Automatic CE Power-down Current—TTL Inputs	Max. V <sub>DD</sub> , Device Deselected, V <sub>IN</sub> ≥ V <sub>IH</sub> or V <sub>IN</sub> ≤ V <sub>IL</sub> , f = 0	All speed grades	80	mA

**Notes:**

- 16. Overshoot: V<sub>IH</sub>(AC) < V<sub>DD</sub> + 1.5V (Pulse width less than t<sub>CYC</sub>/2), undershoot: V<sub>IL</sub>(AC) > -2V (Pulse width less than t<sub>CYC</sub>/2).
- 17. T<sub>Power-up</sub>: Assumes a linear ramp from 0V to V<sub>DD</sub> (min.) within 200 ms. During this time V<sub>IH</sub> < V<sub>DD</sub> and V<sub>DDQ</sub> ≤ V<sub>DD</sub>.

**Capacitance<sup>[18]</sup>**

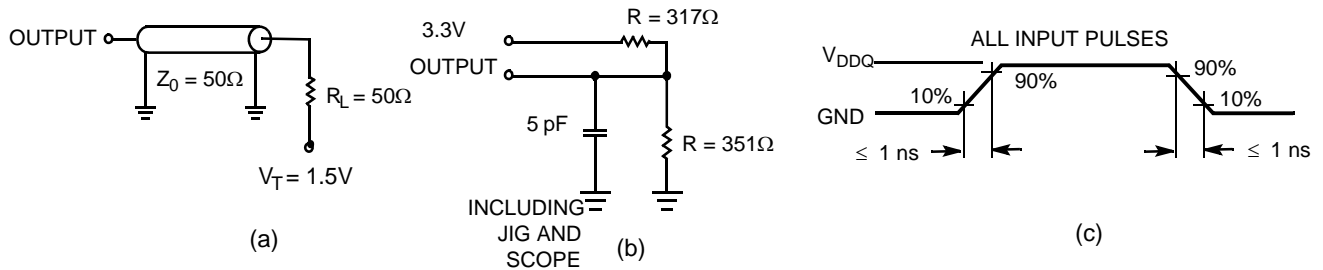
Parameter	Description	Test Conditions	100 TQFP Max.	119 BGA Max.	165 FBGA Max.	Unit
C <sub>IN</sub>	Input Capacitance	T <sub>A</sub> = 25°C, f = 1 MHz, V <sub>DD</sub> = 3.3V, V <sub>DDQ</sub> = 2.5V	5	8	9	pF
C <sub>CLK</sub>	Clock Input Capacitance		5	8	9	pF
C <sub>I/O</sub>	Input/Output Capacitance		5	8	9	pF

**Thermal Resistance<sup>[18]</sup>**

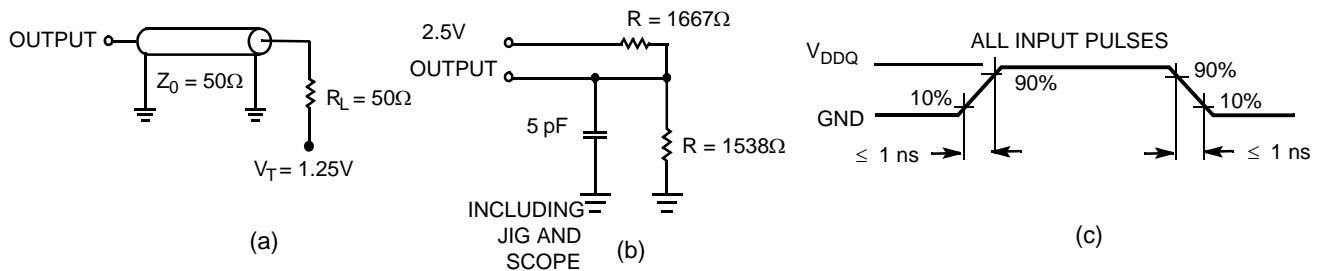
Parameter	Description	Test Conditions	100 TQFP Package	119 BGA Package	165 FBGA Package	Unit
Θ <sub>JA</sub>	Thermal Resistance (Junction to Ambient)	Test conditions follow standard test methods and procedures for measuring thermal impedance, per EIA/JESD51.	28.66	23.8	20.7	°C/W
Θ <sub>JC</sub>	Thermal Resistance (Junction to Case)		4.08	6.2	4.0	°C/W

**AC Test Loads and Waveforms**

**3.3V I/O Test Load**



**2.5V I/O Test Load**



**Note:**  
18. Tested initially and after any design or process change that may affect these parameters.

**Switching Characteristics** Over the Operating Range [23, 24]

Parameter	Description	-250		-200		-167		Unit
		Min.	Max.	Min.	Max.	Min.	Max.	
$t_{Power}^{[19]}$	$V_{CC}$ (typical) to the first access read or write	1		1		1		ms
<b>Clock</b>								
$t_{CYC}$	Clock Cycle Time	4.0		5		6		ns
$F_{MAX}$	Maximum Operating Frequency		250		200		167	MHz
$t_{CH}$	Clock HIGH	1.7		2.0		2.2		ns
$t_{CL}$	Clock LOW	1.7		2.0		2.2		ns
<b>Output Times</b>								
$t_{CO}$	Data Output Valid After CLK Rise		2.6		3.0		3.4	ns
$t_{EOV}$	$\overline{OE}$ LOW to Output Valid		2.6		3.0		3.4	ns
$t_{DOH}$	Data Output Hold After CLK Rise	1.0		1.3		1.3		ns
$t_{CHZ}$	Clock to High-Z <sup>[20, 21, 22]</sup>		2.6		3.0		3.4	ns
$t_{CLZ}$	Clock to Low-Z <sup>[20, 21, 22]</sup>	1.0		1.3		1.3		ns
$t_{EOHZ}$	$\overline{OE}$ HIGH to Output High-Z <sup>[20, 21, 22]</sup>		2.6		3.0		3.4	ns
$t_{EOLZ}$	$\overline{OE}$ LOW to Output Low-Z <sup>[20, 21, 22]</sup>	0		0		0		ns
<b>Set-up Times</b>								
$t_{AS}$	Address Set-up Before CLK Rise	1.2		1.4		1.5		ns
$t_{DS}$	Data Input Set-up Before CLK Rise	1.2		1.4		1.5		ns
$t_{CENS}$	$\overline{CEN}$ Set-up Before CLK Rise	1.2		1.4		1.5		ns
$t_{WES}$	$\overline{WE}$ , $\overline{BW}_x$ Set-up Before CLK Rise	1.2		1.4		1.5		ns
$t_{ALS}$	$\overline{ADV/LD}$ Set-up Before CLK Rise	1.2		1.4		1.5		ns
$t_{CES}$	Chip Select Set-up	1.2		1.4		1.5		ns
<b>Hold Times</b>								
$t_{AH}$	Address Hold After CLK Rise	0.3		0.4		0.5		ns
$t_{DH}$	Data Input Hold After CLK Rise	0.3		0.4		0.5		ns
$t_{CENH}$	$\overline{CEN}$ Hold After CLK Rise	0.3		0.4		0.5		ns
$t_{WEH}$	$\overline{WE}$ , $\overline{BW}_x$ Hold After CLK Rise	0.3		0.4		0.5		ns
$t_{ALH}$	$\overline{ADV/LD}$ Hold after CLK Rise	0.3		0.4		0.5		ns
$t_{CEH}$	Chip Select Hold After CLK Rise	0.3		0.4		0.5		ns

**Notes:**

19. This part has a voltage regulator internally;  $t_{Power}$  is the time power needs to be supplied above  $V_{DD}$  minimum initially, before a Read or Write operation can be initiated.

20.  $t_{CHZ}$ ,  $t_{CLZ}$ ,  $t_{EOLZ}$ , and  $t_{EOHZ}$  are specified with AC test conditions shown in (b) of AC Test Loads. Transition is measured  $\pm 200$  mV from steady-state voltage.

21. At any given voltage and temperature,  $t_{EOHZ}$  is less than  $t_{EOLZ}$  and  $t_{CHZ}$  is less than  $t_{CLZ}$  to eliminate bus contention between SRAMs when sharing the same data bus. These specifications do not imply a bus contention condition, but reflect parameters guaranteed over worst case user conditions. Device is designed to achieve High-Z prior to Low-Z under the same system conditions.

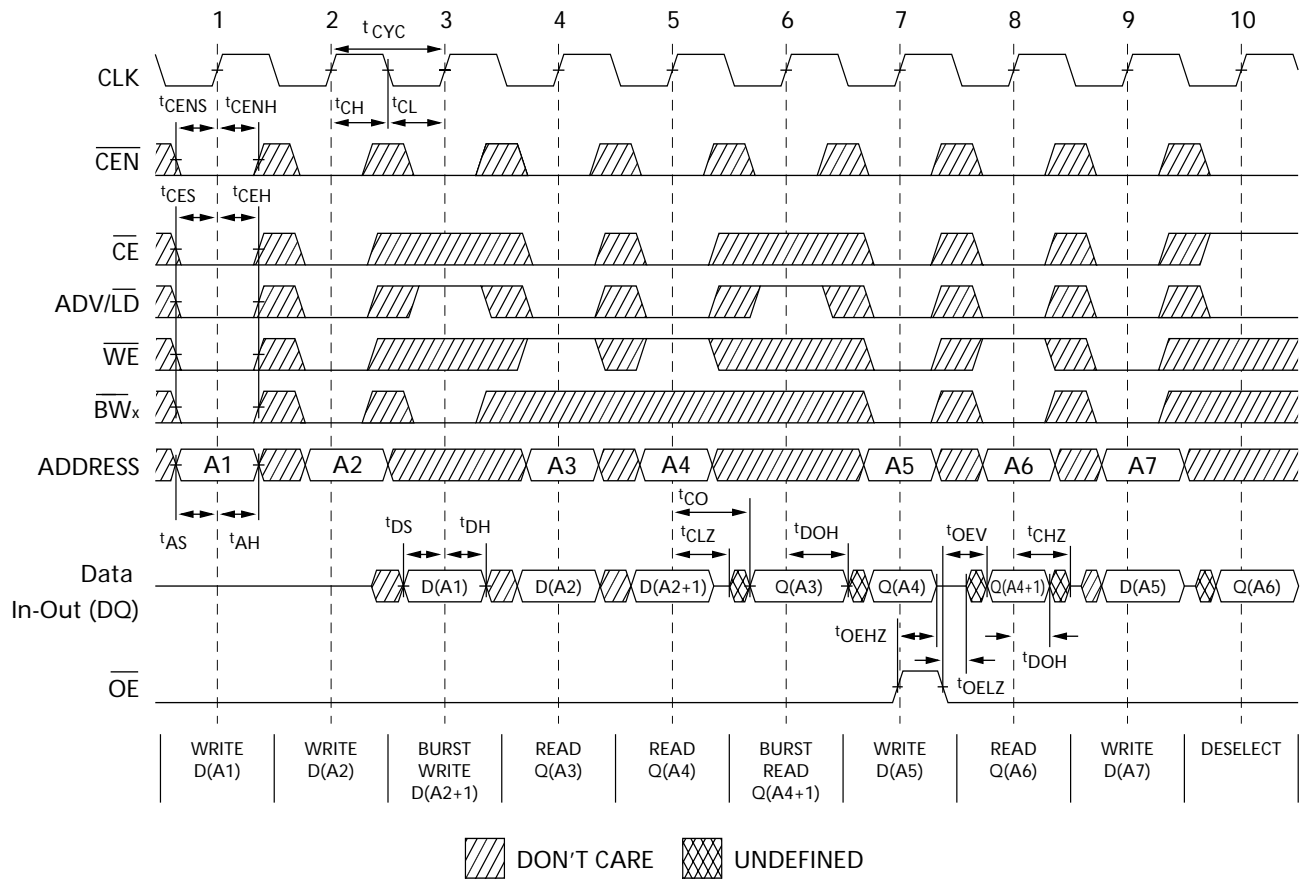
22. This parameter is sampled and not 100% tested.

23. Timing reference is 1.5V when  $V_{DDQ} = 3.3V$  and is 1.25V when  $V_{DDQ} = 2.5V$ .

24. Test conditions shown in (a) of AC Test Loads unless otherwise noted.

## Switching Waveforms

Read/Write/Timing<sup>[25, 26, 27]</sup>



**Notes:**

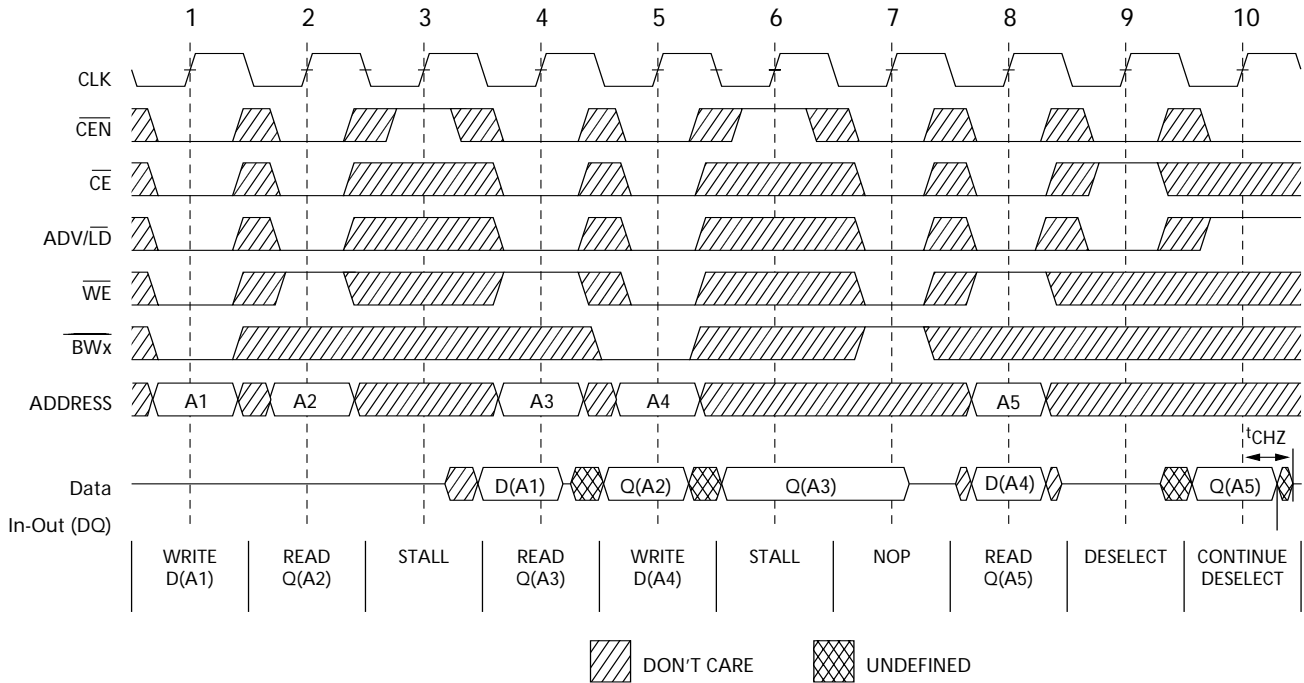
25. For this waveform ZZ is tied LOW.

26. When  $\overline{CE}$  is LOW,  $\overline{CE}_1$  is LOW,  $\overline{CE}_2$  is HIGH and  $\overline{CE}_3$  is LOW. When  $\overline{CE}$  is HIGH,  $\overline{CE}_1$  is HIGH or  $\overline{CE}_2$  is LOW or  $\overline{CE}_3$  is HIGH.

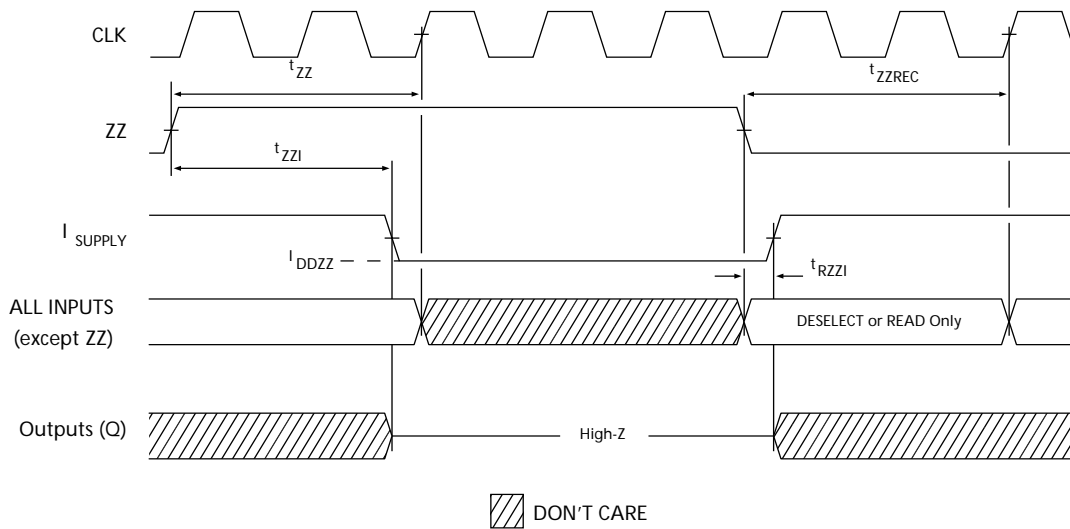
27. Order of the Burst sequence is determined by the status of the MODE (0 = Linear, 1 = Interleaved). Burst operations are optional.

**Switching Waveforms (continued)**

**NOP, STALL and DESELECT Cycles**<sup>[25, 26, 28]</sup>



**ZZ Mode Timing**<sup>[29, 30]</sup>



**Notes:**

- 28. The Ignore Clock Edge or Stall cycle (Clock 3) illustrated  $\overline{CEN}$  being used to create a pause. A write is not performed during this cycle.
- 29. Device must be deselected when entering ZZ mode. See cycle description table for all possible signal conditions to deselect the device.
- 30. I/Os are in High-Z when exiting ZZ sleep mode.

**Ordering Information**

Not all of the speed, package and temperature ranges are available. Please contact your local sales representative or visit [www.cypress.com](http://www.cypress.com) for actual products offered.

Speed (MHz)	Ordering Code	Package Diagram	Part and Package Type	Operating Range	
167	CY7C1370D-167AXC	51-85050	100-pin Thin Quad Flat Pack (14 x 20 x 1.4 mm) Lead-Free	Commercial	
	CY7C1372D-167AXC				
	CY7C1370D-167BGC	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm)		
	CY7C1372D-167BGC				
	CY7C1370D-167BGXC	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm) Lead-Free		
	CY7C1372D-167BGXC				
	CY7C1370D-167BZC	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm)		
	CY7C1372D-167BZC				
	CY7C1370D-167BZXC	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm) Lead-Free		
	CY7C1372D-167BZXC				
	CY7C1370D-167AXI	51-85050	100-pin Thin Quad Flat Pack (14 x 20 x 1.4 mm) Lead-Free		Industrial
	CY7C1372D-167AXI				
	CY7C1370D-167BGI	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm)		
	CY7C1372D-167BGI				
	CY7C1370D-167BGXI	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm) Lead-Free		
	CY7C1372D-167BGXI				
CY7C1370D-167BZI	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm)			
CY7C1372D-167BZI					
CY7C1370D-167BZXI	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm) Lead-Free			
CY7C1372D-167BZXI					
200	CY7C1370D-200AXC	51-85050	100-pin Thin Quad Flat Pack (14 x 20 x 1.4 mm) Lead-Free	Commercial	
	CY7C1372D-200AXC				
	CY7C1370D-200BGC	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm)		
	CY7C1372D-200BGC				
	CY7C1370D-200BGXC	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm) Lead-Free		
	CY7C1372D-200BGXC				
	CY7C1370D-200BZC	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm)		
	CY7C1372D-200BZC				
	CY7C1370D-200BZXC	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm) Lead-Free		
	CY7C1372D-200BZXC				
	CY7C1370D-200AXI	51-85050	100-pin Thin Quad Flat Pack (14 x 20 x 1.4 mm) Lead-Free		Industrial
	CY7C1372D-200AXI				
	CY7C1370D-200BGI	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm)		
	CY7C1372D-200BGI				
	CY7C1370D-200BGXI	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm) Lead-Free		
	CY7C1372D-200BGXI				
CY7C1370D-200BZI	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm)			
CY7C1372D-200BZI					
CY7C1370D-200BZXI	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm) Lead-Free			
CY7C1372D-200BZXI					

**Ordering Information** (continued)

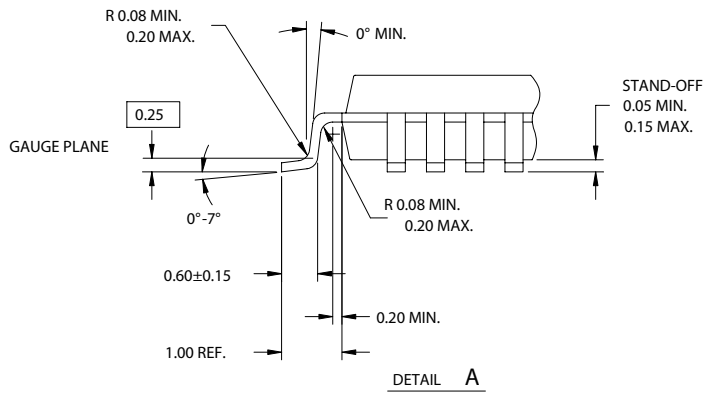
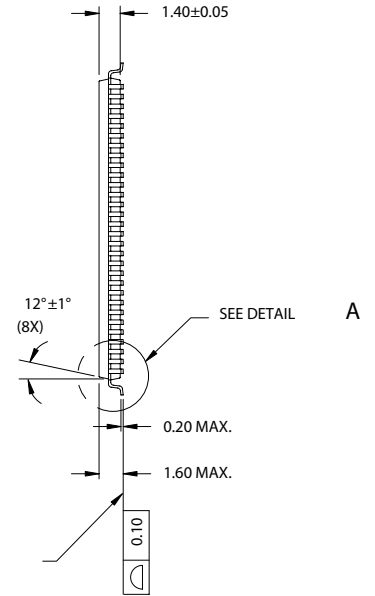
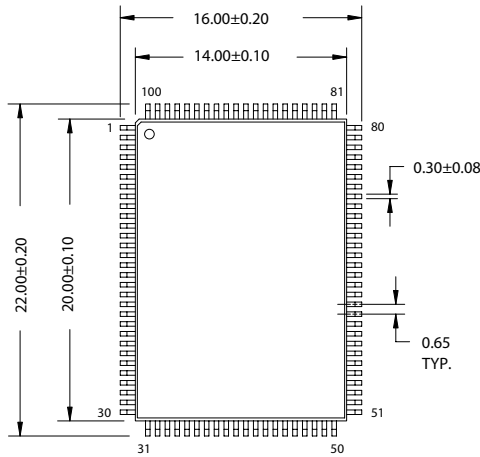
Not all of the speed, package and temperature ranges are available. Please contact your local sales representative or visit [www.cypress.com](http://www.cypress.com) for actual products offered.

250	CY7C1370D-250AXC	51-85050	100-pin Thin Quad Flat Pack (14 x 20 x 1.4 mm) Lead-Free	Commercial
	CY7C1372D-250AXC			
	CY7C1370D-250BGC	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm)	
	CY7C1372D-250BGC			
	CY7C1370D-250BGXC	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm) Lead-Free	
	CY7C1372D-250BGXC			
	CY7C1370D-250BZC	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm)	
	CY7C1372D-250BZC			
	CY7C1370D-250BZXC	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm) Lead-Free	
	CY7C1372D-250BZXC			
250	CY7C1370D-250AXI	51-85050	100-pin Thin Quad Flat Pack (14 x 20 x 1.4 mm) Lead-Free	Industrial
	CY7C1372D-250AXI			
	CY7C1370D-250BGI	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm)	
	CY7C1372D-250BGI			
	CY7C1370D-250BGXI	51-85115	119-ball Ball Grid Array (14 x 22 x 2.4 mm) Lead-Free	
	CY7C1372D-250BGXI			
	CY7C1370D-250BZI	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm)	
	CY7C1372D-250BZI			
	CY7C1370D-250BZXI	51-85180	165-ball Fine-Pitch Ball Grid Array (13 x 15 x 1.4 mm) Lead-Free	
	CY7C1372D-250BZXI			



**Package Diagrams**

**100-Pin Thin Plastic Quad Flatpack (14 x 20 x 1.4 mm) (51-85050)**



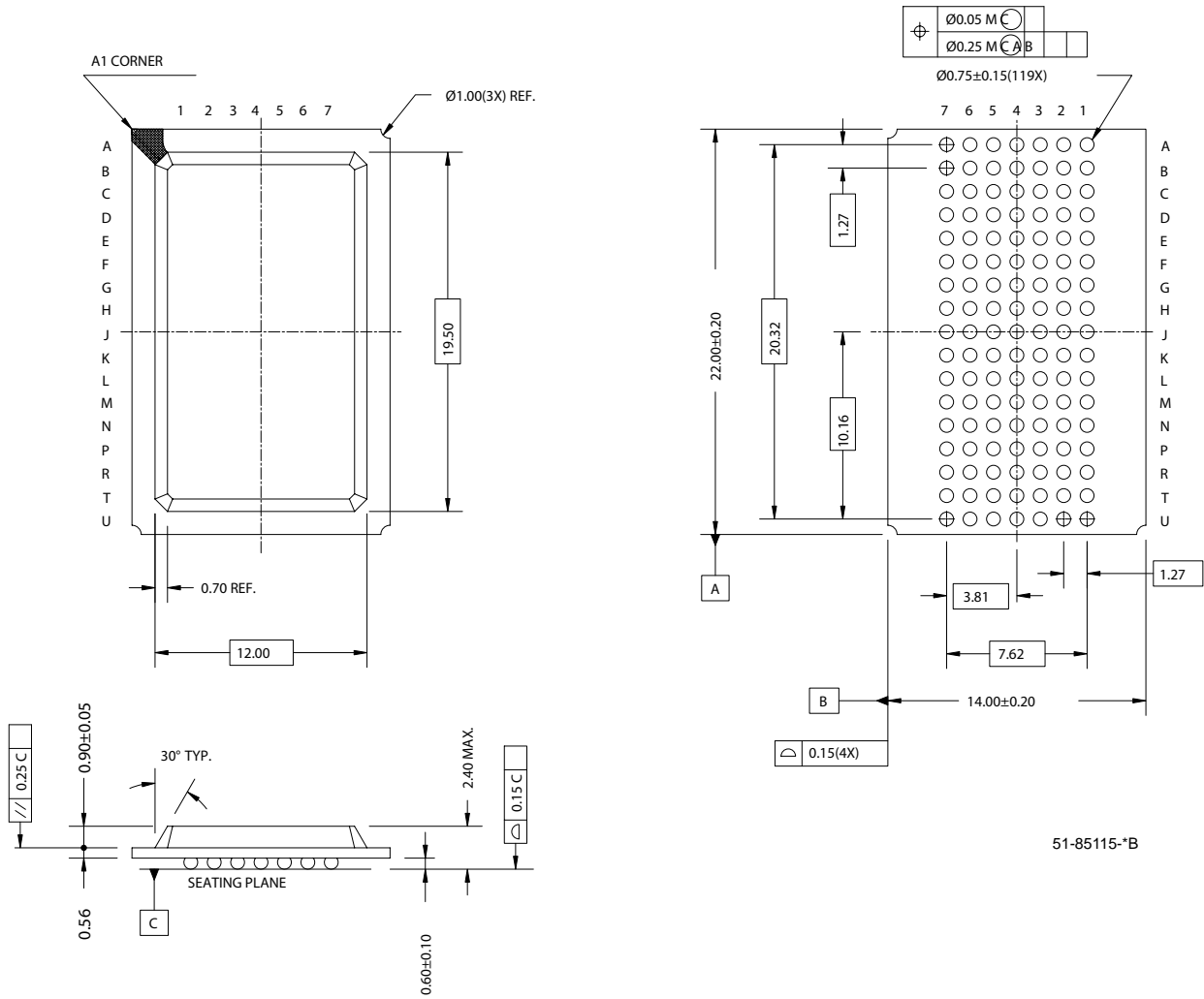
NOTE:

1. JEDEC STD REF MS-026
2. BODY LENGTH DIMENSION DOES NOT INCLUDE MOLD PROTRUSION/END FLASH  
MOLD PROTRUSION/END FLASH SHALL NOT EXCEED 0.0098 in (0.25 mm) PER SIDE  
BODY LENGTH DIMENSIONS ARE MAX PLASTIC BODY SIZE INCLUDING MOLD MISMATCH
3. DIMENSIONS IN MILLIMETERS

51-85050-\*B

**Package Diagrams (continued)**

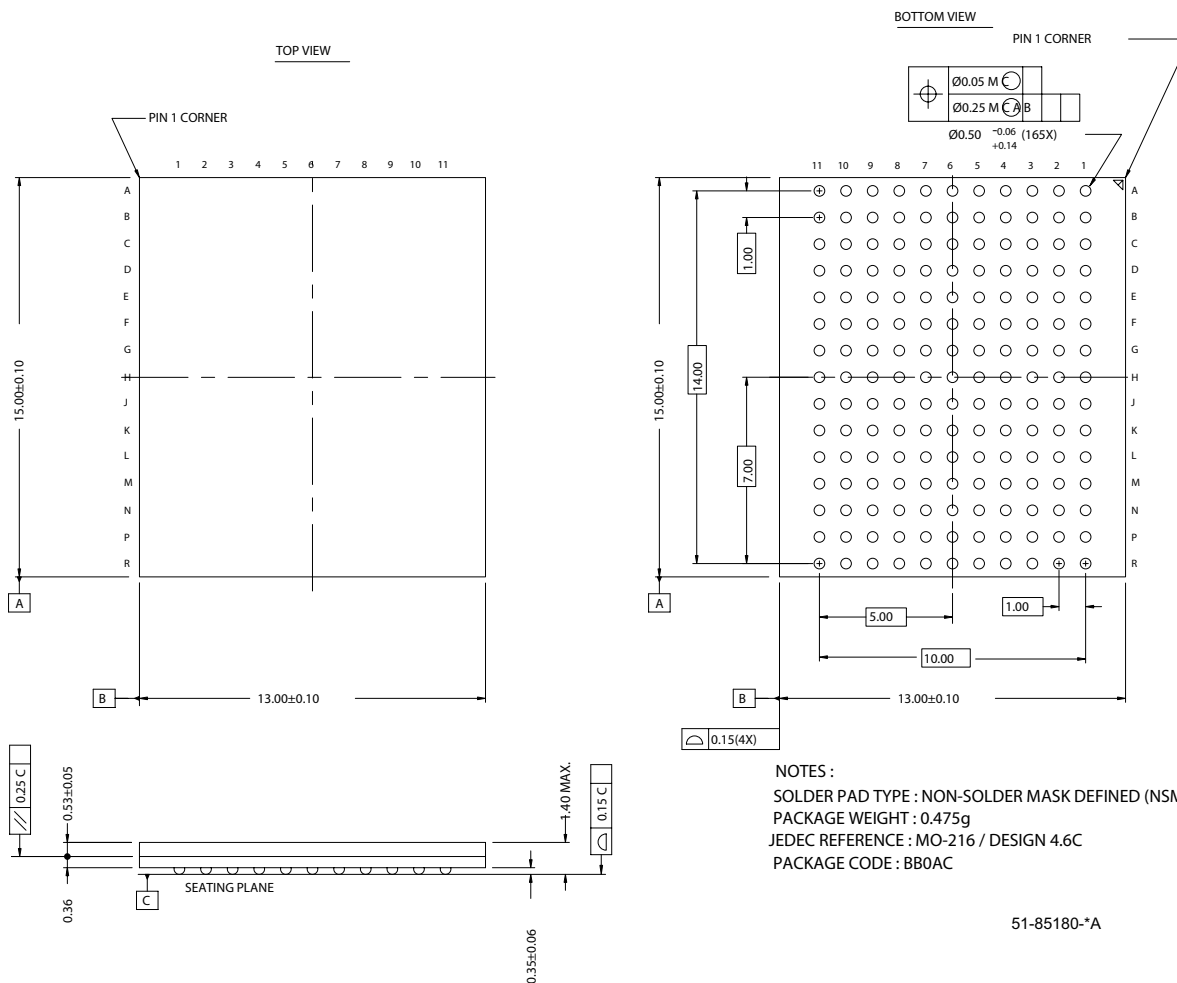
**119-Ball BGA (14 x 22 x 2.4 mm) (51-85115)**



51-85115-\*B

**Package Diagrams** (continued)

**165-Ball FBGA (13 x 15 x 1.4 mm) (51-85180)**



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Document History Page

Document Title: CY7C1372D/CY7C1370D 18-Mbit (512K x 36/1M x 18) Pipelined SRAM with NoBL™ Architecture				
Document Number: 38-05555				
REV.	ECN No.	Issue Date	Orig. of Change	Description of Change
**	254509	See ECN	RKF	New data sheet
*A	276690	See ECN	VBL	Changed TQFP pkg to Lead-free TQFP in Ordering Information section Added comment of Lead-free BG and BZ packages availability
*B	288531	See ECN	SYT	Edited description under "IEEE 1149.1 Serial Boundary Scan (JTAG)" for non-compliance with 1149.1 Added lead-free information for 100-pin TQFP, 119 BGA and 165 FBGA Packages
*C	326078	See ECN	PCI	Address expansion pins/balls in the pinouts for all packages are modified as per JEDEC standard Added description on EXTEST Output Bus Tri-State Changed description on the Tap Instruction Set Overview and Extest Changed $\theta_{JA}$ and $\theta_{JC}$ for TQFP Package from 31 and 6 °C/W to 28.66 and 4.08 °C/W respectively Changed $\theta_{JA}$ and $\theta_{JC}$ for BGA Package from 45 and 7 °C/W to 23.8 and 6.2 °C/W respectively Changed $\theta_{JA}$ and $\theta_{JC}$ for FBGA Package from 46 and 3 °C/W to 20.7 and 4.0 °C/W respectively Modified $V_{OL}$ , $V_{OH}$ test conditions Removed shading from AC/DC Table and Selection Guide Removed comment of 'Lead-free BG packages availability' below the Ordering Information Updated Ordering Information Table Changed from Preliminary to final
*D	370734	See ECN	PCI	Modified test condition in note# 17 from $V_{DDQ} < V_{DD}$ to $V_{DDQ} \leq V_{DD}$
*E	416321	See ECN	NXR	Converted from preliminary to final Changed address of Cypress Semiconductor Corporation on Page# 1 from "3901 North First Street" to "198 Champion Court" Modified "Input Load" to "Input Leakage Current except ZZ and MODE" in the Electrical Characteristics Table Changed three-state to tri-state Changed the $I_X$ current values of MODE on page # 18 from -5 $\mu$ A and 30 $\mu$ A to -30 $\mu$ A and 5 $\mu$ A Changed the $I_X$ current values of ZZ on page # 18 from -30 $\mu$ A and 5 $\mu$ A to -5 $\mu$ A and 30 $\mu$ A Changed $V_{IH} \leq V_{DD}$ to $V_{IH} < V_{DD}$ on page # 18 Replaced Package Name column with Package Diagram in the Ordering Information table Updated Ordering Information Table
*F	475677	See ECN	VKN	Added the Maximum Rating for Supply Voltage on $V_{DDQ}$ Relative to GND Changed $t_{TH}$ , $t_{TL}$ from 25 ns to 20 ns and $t_{DOV}$ from 5 ns to 10 ns in TAP AC Switching Characteristics table. Updated the Ordering Information table.