



**CY7C145**  
**CY7C144**

## 8K x 8/9 Dual-Port Static RAM with Sem, Int, Busy

### Features

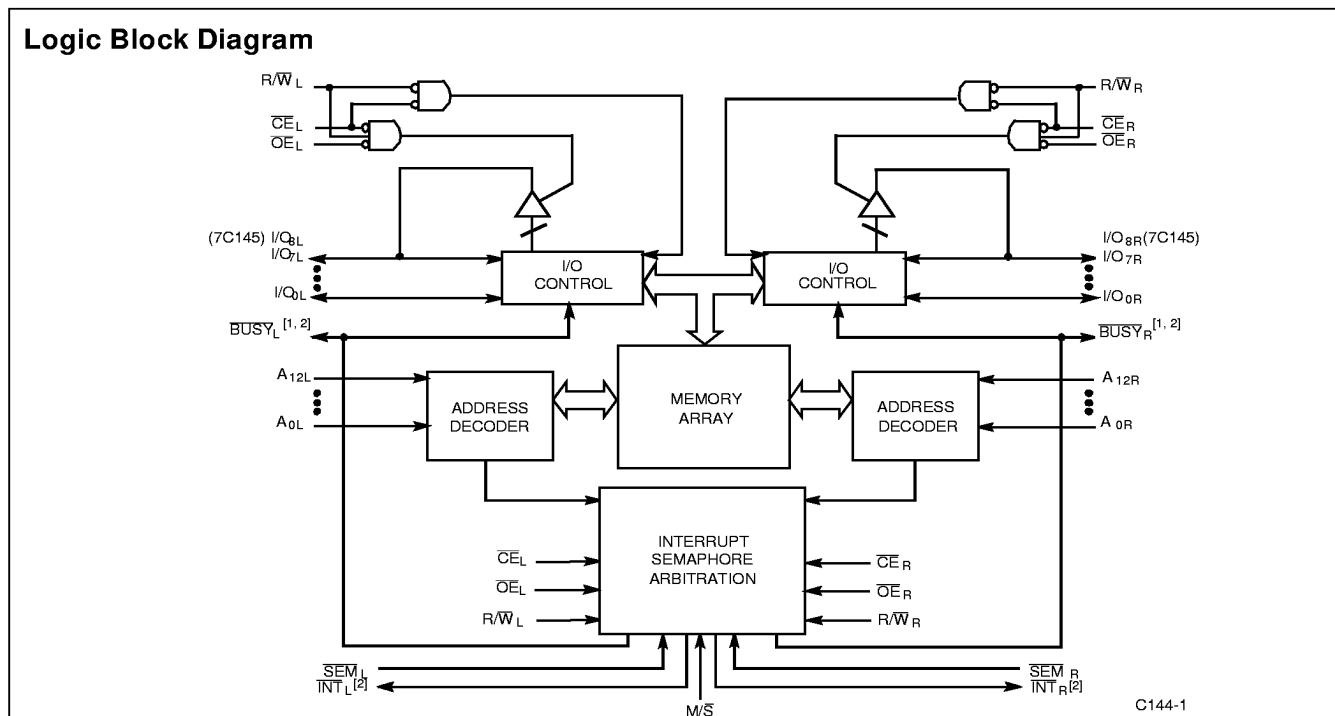
- True Dual-Ported memory cells which allow simultaneous reads of the same memory location
- 8K x 8 organization (CY7C144)
- 8K x 9 organization (CY7C145)
- 0.65-micron CMOS for optimum speed/power
- High-speed access: 15ns
- Low operating power:  $I_{CC} = 160$  mA (max.)
- Fully asynchronous operation
- Automatic power-down
- TTL compatible
- Master/Slave select pin allows bus width expansion to 16/18 bits or more
- Busy arbitration scheme provided
- Semaphores included to permit software handshaking between ports
- INT flag for port-to-port communication
- Available in 68-pin PLCC, 64-pin and 80-pin TQFP
- Pin compatible and functionally equivalent to IDT7005/IDT7015

are included on the CY7C144/5 to handle situations when multiple processors access the same piece of data. Two ports are provided permitting independent, asynchronous access for reads and writes to any location in memory. The CY7C144/5 can be utilized as a standalone 64/72-Kbit dual-port static RAM or multiple devices can be combined in order to function as a 16/18-bit or wider master/slave dual-port static RAM. An  $M/\bar{S}$  pin is provided for implementing 16/18-bit or wider memory applications without the need for separate master and slave devices or additional discrete logic. Application areas include interprocessor/multiprocessor designs, communications status buffering, and dual-port video/graphics memory.

Each port has independent control pins: chip enable ( $\bar{CE}$ ), read or write enable ( $R/\bar{W}$ ), and output enable ( $\bar{OE}$ ). Two flags,  $BUSY$  and  $INT$ , are provided on each port.  $BUSY$  signals that the port is trying to access the same location currently being accessed by the other port. The interrupt flag ( $INT$ ) permits communication between ports or systems by means of a mail box. The semaphores are used to pass a flag, or token, from one port to the other to indicate that a shared resource is in use. The semaphore logic is comprised of eight shared latches. Only one side can control the latch (semaphore) at any time. Control of a semaphore indicates that a shared resource is in use. An automatic power-down feature is controlled independently on each port by a chip enable ( $\bar{CE}$ ) pin or  $SEM$  pin.

### Functional Description

The CY7C144 and CY7C145 are high-speed CMOS 8K x 8 and 8K x 9 dual-port static RAMs. Various arbitration schemes

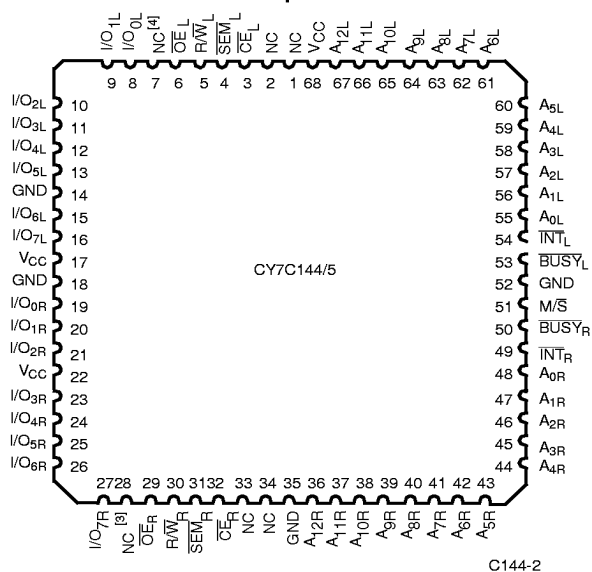


#### Notes:

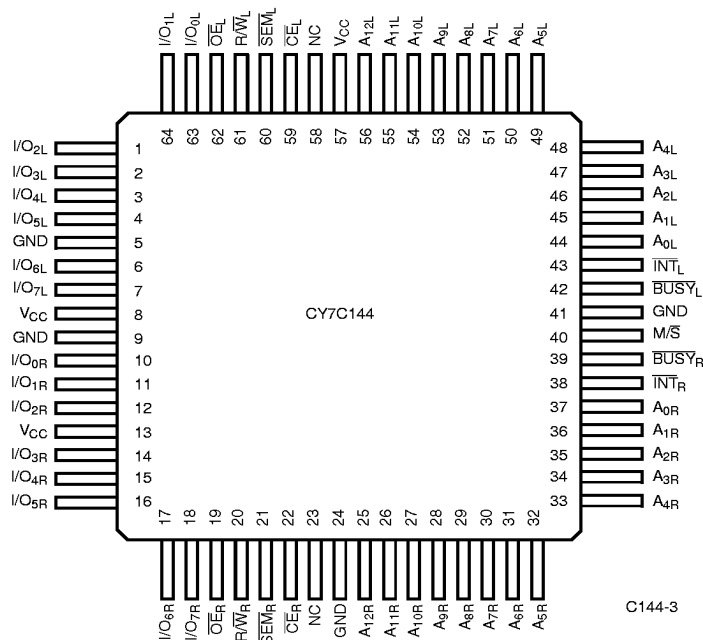
1.  $BUSY$  is an output in master mode and an input in slave mode.
2. Interrupt: push-pull output and requires no pull-up resistor.

## Pin Configurations

**68-Pin PLCC**  
**Top View**



**64-Pin TQFP**  
**Top View**

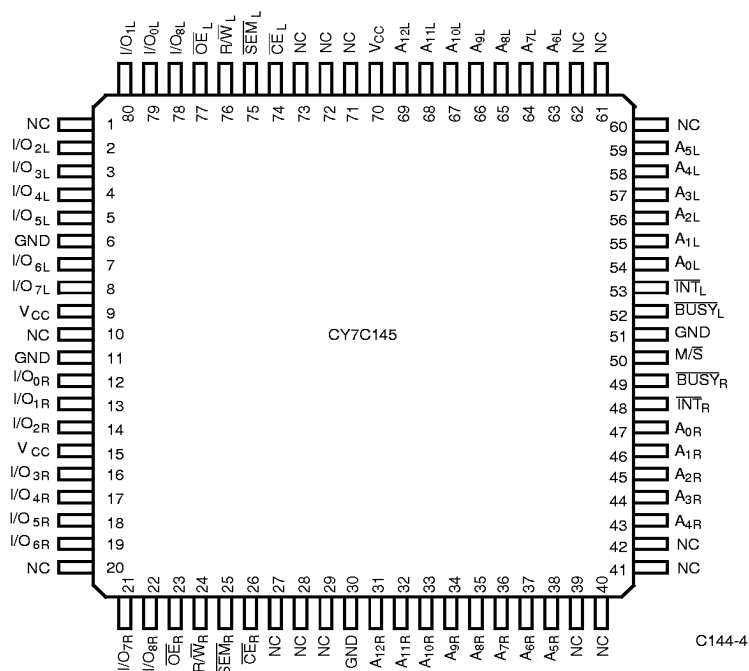


**Notes:**

3. I/O<sub>8R</sub> on the CY7C145.
4. I/O<sub>8L</sub> on the CY7C145.

## Pin Configurations (continued)

**80-Pin TQFP**  
**Top View**



## Pin Definitions

| Left Port                 | Right Port                | Description  |
|---------------------------|---------------------------|--|
| I/O <sub>0L-7L</sub> (8L) | I/O <sub>0R-7R</sub> (8R) | Data bus Input/Output  |
| A <sub>0L-12L</sub>       | A <sub>0R-12R</sub>       | Address Lines  |
| CE <sub>L</sub>           | CE <sub>R</sub>           | Chip Enable  |
| OE <sub>L</sub>           | OE <sub>R</sub>           | Output Enable  |
| R/W <sub>L</sub>          | R/W <sub>R</sub>          | Read/Write Enable  |
| SEM <sub>L</sub>          | SEM <sub>R</sub>          | Semaphore Enable. When asserted LOW, allows access to eight semaphores. The three least significant bits of the address lines will determine which semaphore to write or read. The I/O <sub>0</sub> pin is used when writing to a semaphore. Semaphores are requested by writing a 0 into the respective location. |
| INT <sub>L</sub>          | INT <sub>R</sub>          | Interrupt Flag. INT <sub>L</sub> is set when right port writes location 1FFE and is cleared when left port reads location 1FFE. INT <sub>R</sub> is set when left port writes location 1FFF and is cleared when right port reads location 1FFF.  |
| BUSY <sub>L</sub>         | BUSY <sub>R</sub>         | Busy Flag  |
| M/S                       |                           | Master or Slave Select   |
| V <sub>CC</sub>           |                           | Power  |
| GND                       |                           | Ground   |



## Selection Guide

|   | 7C144-15<br>7C145-15 | 7C144-25<br>7C145-25 | 7C144-35<br>7C145-35 | 7C144-55<br>7C145-55 |
|---|----------------------|----------------------|----------------------|----------------------|
| Maximum Access Time (ns)                          | 15                   | 25                   | 35                   | 55                   |
| Maximum Operating Current (mA)                    | 220                  | 180                  | 160                  | 160                  |
| Maximum Standby Current for I <sub>SB1</sub> (mA) | 60                   | 40                   | 30                   | 30                   |

## 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 to Ground Potential ..... -0.5V to +7.0V

DC Voltage Applied to Outputs

in High Z State..... -0.5V to +7.0V

DC Input Voltage<sup>[5]</sup>..... -0.5V to +7.0V

Output 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>CC</sub> |
|------------|---------------------|-----------------|
| Commercial | 0°C to +70°C        | 5V ± 10%        |
| Industrial | -40°C to +85°C      | 5V ± 10%        |

## Electrical Characteristics Over the Operating Range

| Parameter        | Description                                 | Test Conditions  | 7C144-15<br>7C145-15 |      | 7C144-25<br>7C145-25 |      | Unit |
|------------------|---|--|----------------------|------|----------------------|------|------|
|                  |   |  | Min.                 | Max. | Min.                 | Max. |      |
| V <sub>OH</sub>  | Output HIGH Voltage                         | V <sub>CC</sub> = Min., I <sub>OH</sub> = -4.0 mA  | 2.4                  |      | 2.4                  |      | V    |
| V <sub>OL</sub>  | Output LOW Voltage                          | V <sub>CC</sub> = Min., I <sub>OL</sub> = 4.0 mA   |                      | 0.4  |                      | 0.4  | V    |
| V <sub>IH</sub>  | Input HIGH Voltage                          |  | 2.2                  |      | 2.2                  |      | V    |
| V <sub>IL</sub>  | Input LOW Voltage                           |  |                      | 0.8  |                      | 0.8  | V    |
| I <sub>Ix</sub>  | Input Leakage Current                       | GND ≤ V <sub>I</sub> ≤ V <sub>CC</sub>   | -10                  | +10  | -10                  | +10  | μA   |
| I <sub>OZ</sub>  | Output Leakage Current                      | Outputs Disabled, GND ≤ V <sub>O</sub> ≤ V <sub>CC</sub>   | -10                  | +10  | -10                  | +10  | μA   |
| I <sub>CC</sub>  | Operating Current                           | V <sub>CC</sub> = Max., I <sub>OUT</sub> = 0 mA<br>Outputs Disabled  | Com'l                | 220  |                      | 180  | mA   |
|                  |   |  | Ind                  |      |                      | 190  |      |
| I <sub>SB1</sub> | Standby Current<br>(Both Ports TTL Levels)  | CE <sub>L</sub> and CE <sub>R</sub> ≥ V <sub>IH</sub> ,<br>f = f <sub>MAX</sub> <sup>[7]</sup>   | Com'l                | 60   |                      | 40   | mA   |
|                  |   |  | Ind                  |      |                      | 50   |      |
| I <sub>SB2</sub> | Standby Current<br>(One Port TTL Level)     | CE <sub>L</sub> or CE <sub>R</sub> ≥ V <sub>IH</sub> ,<br>f = f <sub>MAX</sub> <sup>[7]</sup>  | Com'l                | 130  |                      | 110  | mA   |
|                  |   |  | Ind                  |      |                      | 120  |      |
| I <sub>SB3</sub> | Standby Current<br>(Both Ports CMOS Levels) | Both Ports<br>CE and CE <sub>R</sub> ≥ V <sub>CC</sub> - 0.2V,<br>V <sub>IN</sub> ≥ V <sub>CC</sub> - 0.2V<br>or V <sub>IN</sub> ≤ 0.2V, f = 0 <sup>[7]</sup>  | Com'l                | 15   |                      | 15   | mA   |
|                  |   |  | Ind                  |      |                      | 30   |      |
| I <sub>SB4</sub> | Standby Current<br>(One Port CMOS Level)    | One Port<br>CE <sub>L</sub> or CE <sub>R</sub> ≥ V <sub>CC</sub> - 0.2V,<br>V <sub>IN</sub> ≥ V <sub>CC</sub> - 0.2V or<br>V <sub>IN</sub> ≤ 0.2V, Active<br>Port Outputs, f = f <sub>MAX</sub> <sup>[7]</sup> | Com'l                | 125  |                      | 100  | mA   |
|                  |   |  | Ind                  |      |                      | 115  |      |

### Notes:

5. Pulse width < 20 ns.

6. T<sub>A</sub> is the "instant on" case temperature.

7. f<sub>MAX</sub> = 1/t<sub>RC</sub> = All inputs cycling at f = 1/t<sub>RC</sub> (except output enable). f = 0 means no address or control lines change. This applies only to inputs at CMOS level standby I<sub>SB3</sub>.

**Electrical Characteristics** Over the Operating Range (continued)

| Parameter | Description                                 | Test Conditions   | 7C144-35<br>7C145-35 |      | 7C144-55<br>7C145-55 |      | Unit          |
|-----------|---|---|----------------------|------|----------------------|------|---------------|
|           |   |   | Min.                 | Max. | Min.                 | Max. |               |
| $V_{OH}$  | Output HIGH Voltage                         | $V_{CC} = \text{Min.}, I_{OH} = -4.0 \text{ mA}$  | 2.4                  |      | 2.4                  |      | V             |
| $V_{OL}$  | Output LOW Voltage                          | $V_{CC} = \text{Min.}, I_{OL} = 4.0 \text{ mA}$   |                      | 0.4  |                      | 0.4  | V             |
| $V_{IH}$  | Input HIGH Voltage                          |   | 2.2                  |      | 2.2                  |      | V             |
| $V_{IL}$  | Input LOW Voltage                           |   |                      | 0.8  |                      | 0.8  | V             |
| $I_{IX}$  | Input Leakage Current                       | $GND \leq V_I \leq V_{CC}$  | -10                  | +10  | -10                  | +10  | $\mu\text{A}$ |
| $I_{OZ}$  | Output Leakage Current                      | Outputs Disabled, $GND \leq V_O \leq V_{CC}$  | -10                  | +10  | -10                  | +10  | $\mu\text{A}$ |
| $I_{CC}$  | Operating Current                           | $V_{CC} = \text{Max.}, I_{OUT} = 0 \text{ mA}$<br>Outputs Disabled  | Com'l                | 160  |                      | 160  | mA            |
|           |   |   | Ind                  | 180  |                      | 180  |               |
| $I_{SB1}$ | Standby Current<br>(Both Ports TTL Levels)  | $\overline{CE}_L$ and $\overline{CE}_R \geq V_{IH}$ ,<br>$f = f_{MAX}^{[7]}$  | Com'l                | 30   |                      | 30   | mA            |
|           |   |   | Ind                  | 40   |                      | 40   |               |
| $I_{SB2}$ | Standby Current<br>(One Port TTL Level)     | $\overline{CE}_L$ or $\overline{CE}_R \geq V_{IH}$ ,<br>$f = f_{MAX}^{[7]}$   | Com'l                | 100  |                      | 100  | mA            |
|           |   |   | Ind                  | 110  |                      | 110  |               |
| $I_{SB3}$ | Standby Current<br>(Both Ports CMOS Levels) | Both Ports<br>$\overline{CE}$ and $\overline{CE}_R \geq V_{CC} - 0.2V$ ,<br>$V_{IN} \geq V_{CC} - 0.2V$<br>or $V_{IN} \leq 0.2V, f = 0^{[7]}$                                 | Com'l                | 15   |                      | 15   | mA            |
|           |   |   | Ind                  | 30   |                      | 30   |               |
| $I_{SB4}$ | Standby Current<br>(One Port CMOS Level)    | One Port<br>$\overline{CE}_L$ or $\overline{CE}_R \geq V_{CC} - 0.2V$ ,<br>$V_{IN} \geq V_{CC} - 0.2V$ or<br>$V_{IN} \leq 0.2V$ , Active<br>Port Outputs, $f = f_{MAX}^{[7]}$ | Com'l                | 90   |                      | 90   | mA            |
|           |   |   | Ind                  | 100  |                      | 100  |               |

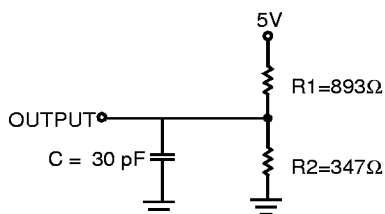
**Capacitance<sup>[8]</sup>**

| Parameter | Description        | Test Conditions   | Max. | Unit |
|-----------|--------------------|---|------|------|
| $C_{IN}$  | Input Capacitance  | $T_A = 25^\circ\text{C}, f = 1 \text{ MHz},$<br>$V_{CC} = 5.0V$ | 10   | pF   |
| $C_{OUT}$ | Output Capacitance |   | 15   | pF   |

**Note:**

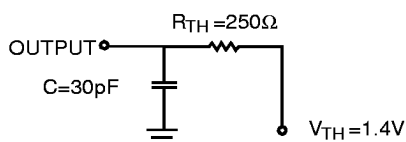
8. Tested initially and after any design or process changes that may affect these parameters.

## AC Test Loads and Waveforms



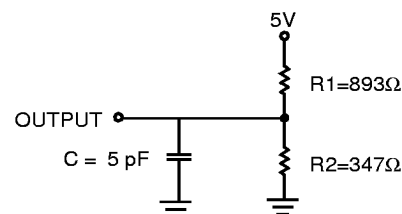
(a) Normal Load (Load 1)

C144-5



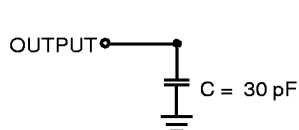
(b) Thévenin Equivalent (Load 1)

C144-6



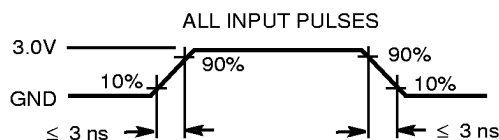
(c) Three-State Delay (Load 3)

C144-7



Load (Load 2)

C144-8



C144-9

## Switching Characteristics Over the Operating Range<sup>[9]</sup>

| Parameter                                 | Description                     | 7C144-15<br>7C145-15 |      | 7C144-25<br>7C145-25 |      | 7C144-35<br>7C145-35 |      | 7C144-55<br>7C145-55 |      | Unit |
|---|---------------------------------|----------------------|------|----------------------|------|----------------------|------|----------------------|------|------|
|   |                                 | Min.                 | Max. | Min.                 | Max. | Min.                 | Max. | Min.                 | Max. |      |
| READ CYCLE                                |                                 |                      |      |                      |      |                      |      |                      |      |      |
| t <sub>RC</sub>                           | Read Cycle Time                 | 15                   |      | 25                   |      | 35                   |      | 55                   |      | ns   |
| t <sub>AA</sub>                           | Address to Data Valid           |                      | 15   |                      | 25   |                      | 35   |                      | 55   | ns   |
| t <sub>OHA</sub>                          | Output Hold From Address Change | 3                    |      | 3                    |      | 3                    |      | 3                    |      | ns   |
| t <sub>ACE</sub>                          | CE LOW to Data Valid            |                      | 15   |                      | 25   |                      | 35   |                      | 55   | ns   |
| t <sub>DOE</sub>                          | OE LOW to Data Valid            |                      | 10   |                      | 15   |                      | 20   |                      | 25   | ns   |
| t <sub>LZOE</sub> <sup>[10, 11, 12]</sup> | OE Low to Low Z                 | 3                    |      | 3                    |      | 3                    |      | 3                    |      | ns   |
| t <sub>HZOE</sub> <sup>[10, 11, 12]</sup> | OE HIGH to High Z               |                      | 10   |                      | 15   |                      | 20   |                      | 25   | ns   |
| t <sub>LZCE</sub> <sup>[10, 11, 12]</sup> | CE LOW to Low Z                 | 3                    |      | 3                    |      | 3                    |      | 3                    |      | ns   |
| t <sub>HZCE</sub> <sup>[10, 11, 12]</sup> | CE HIGH to High Z               |                      | 10   |                      | 15   |                      | 20   |                      | 25   | ns   |
| t <sub>PU</sub> <sup>[12]</sup>           | CE LOW to Power-Up              | 0                    |      | 0                    |      | 0                    |      | 0                    |      | ns   |
| t <sub>PD</sub> <sup>[12]</sup>           | CE HIGH to Power-Down           |                      | 15   |                      | 25   |                      | 35   |                      | 55   | ns   |

### Notes:

- Test conditions assume signal transition time of 3 ns or less, timing reference levels of 1.5V, input pulse levels of 0 to 3.0V, and output loading of the specified  $I_{OL}/I_{OH}$  and 30-pF load capacitance.
- At any given temperature and voltage condition for any given device,  $t_{HZCE}$  is less than  $t_{LZCE}$  and  $t_{HZOE}$  is less than  $t_{LZOE}$ .
- Test conditions used are Load 3.
- This parameter is guaranteed but not tested.



**Switching Characteristics** Over the Operating Range<sup>[9]</sup> (continued)

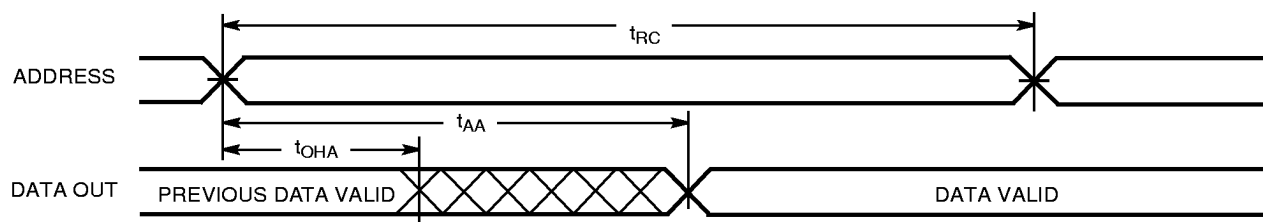
| Parameter                            | Description                         | 7C144-15<br>7C145-15 |      | 7C144-25<br>7C145-25 |      | 7C144-35<br>7C145-35 |      | 7C144-55<br>7C145-55 |      | Unit |
|--------------------------------------|-------------------------------------|----------------------|------|----------------------|------|----------------------|------|----------------------|------|------|
|                                      |                                     | Min.                 | Max. | Min.                 | Max. | Min.                 | Max. | Min.                 | Max. |      |
| WRITE CYCLE                          |                                     |                      |      |                      |      |                      |      |                      |      |      |
| t <sub>WC</sub>                      | Write Cycle Time                    | 15                   |      | 25                   |      | 35                   |      | 55                   |      | ns   |
| t <sub>SCE</sub>                     | CE LOW to Write End                 | 12                   |      | 20                   |      | 30                   |      | 45                   |      | ns   |
| t <sub>AW</sub>                      | Address Set-Up to Write End         | 12                   |      | 20                   |      | 30                   |      | 45                   |      | ns   |
| t <sub>HA</sub>                      | Address Hold From Write End         | 2                    |      | 2                    |      | 2                    |      | 2                    |      | ns   |
| t <sub>SA</sub>                      | Address Set-Up to Write Start       | 0                    |      | 0                    |      | 0                    |      | 0                    |      | ns   |
| t <sub>PWE</sub>                     | Write Pulse Width                   | 12                   |      | 20                   |      | 25                   |      | 40                   |      | ns   |
| t <sub>SD</sub>                      | Data Set-Up to Write End            | 10                   |      | 15                   |      | 15                   |      | 25                   |      | ns   |
| t <sub>HD</sub>                      | Data Hold From Write End            | 0                    |      | 0                    |      | 0                    |      | 0                    |      | ns   |
| t <sub>HZWE</sub> <sup>[11,12]</sup> | R/W LOW to High Z                   |                      | 10   |                      | 15   |                      | 20   |                      | 25   | ns   |
| t <sub>LZWE</sub> <sup>[11,12]</sup> | R/W HIGH to Low Z                   | 3                    |      | 3                    |      | 3                    |      | 3                    |      | ns   |
| t <sub>WDD</sub> <sup>[13]</sup>     | Write Pulse to Data Delay           |                      | 30   |                      | 50   |                      | 60   |                      | 70   | ns   |
| t <sub>DDD</sub> <sup>[13]</sup>     | Write Data Valid to Read Data Valid |                      | 25   |                      | 30   |                      | 35   |                      | 40   | ns   |
| BUSY TIMING <sup>[14]</sup>          |                                     |                      |      |                      |      |                      |      |                      |      |      |
| t <sub>BLA</sub>                     | BUSY LOW from Address Match         |                      | 15   |                      | 20   |                      | 20   |                      | 30   | ns   |
| t <sub>BHA</sub>                     | BUSY HIGH from Address Mismatch     |                      | 15   |                      | 20   |                      | 20   |                      | 30   | ns   |
| t <sub>BLC</sub>                     | BUSY LOW from CE LOW                |                      | 15   |                      | 20   |                      | 20   |                      | 30   | ns   |
| t <sub>BHC</sub>                     | BUSY HIGH from CE HIGH              |                      | 15   |                      | 20   |                      | 20   |                      | 30   | ns   |
| t <sub>PS</sub>                      | Port Set-Up for Priority            | 5                    |      | 5                    |      | 5                    |      | 5                    |      | ns   |
| t <sub>WB</sub>                      | R/W LOW after BUSY LOW              | 0                    |      | 0                    |      | 0                    |      | 0                    |      | ns   |
| t <sub>WH</sub>                      | R/W HIGH after BUSY HIGH            | 13                   |      | 20                   |      | 30                   |      | 30                   |      | ns   |
| t <sub>BDD</sub>                     | BUSY HIGH to Data Valid             |                      | 15   |                      | 25   |                      | 35   |                      | 55   | ns   |
| INTERRUPT TIMING <sup>[14]</sup>     |                                     |                      |      |                      |      |                      |      |                      |      |      |
| t <sub>INS</sub>                     | INT Set Time                        |                      | 15   |                      | 25   |                      | 25   |                      | 35   | ns   |
| t <sub>INR</sub>                     | INT Reset Time                      |                      | 15   |                      | 25   |                      | 25   |                      | 35   | ns   |
| SEMAPHORE TIMING                     |                                     |                      |      |                      |      |                      |      |                      |      |      |
| t <sub>SOP</sub>                     | SEM Flag Update Pulse (OE or SEM)   | 10                   |      | 10                   |      | 15                   |      | 20                   |      | ns   |
| t <sub>SWRD</sub>                    | SEM Flag Write to Read Time         | 5                    |      | 5                    |      | 5                    |      | 5                    |      | ns   |
| t <sub>SPS</sub>                     | SEM Flag Contention Window          | 5                    |      | 5                    |      | 5                    |      | 5                    |      | ns   |

**Notes:**

13. For information on part-to-part delay through RAM cells from writing port to reading port, refer to Read Timing with Port-to-Port Delay waveform.  
14. Test conditions used are Load 2.

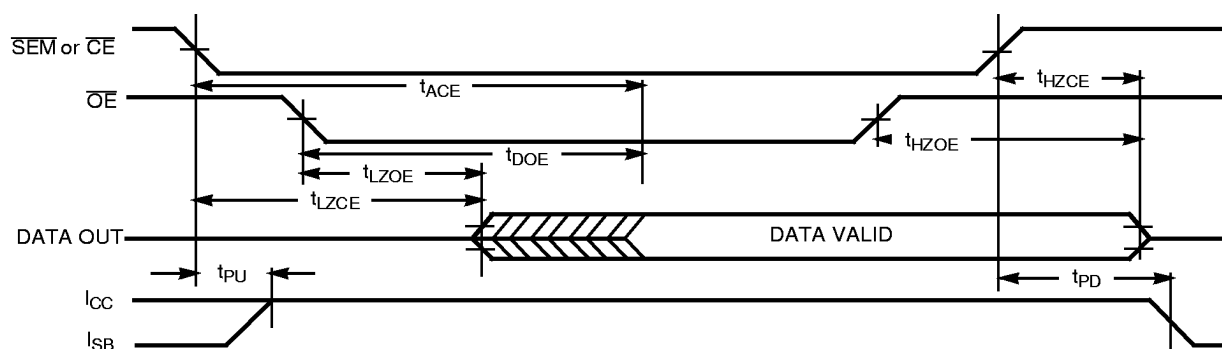
## Switching Waveforms

### Read Cycle No. 1 (Either Port Address Access)<sup>[15, 16]</sup>



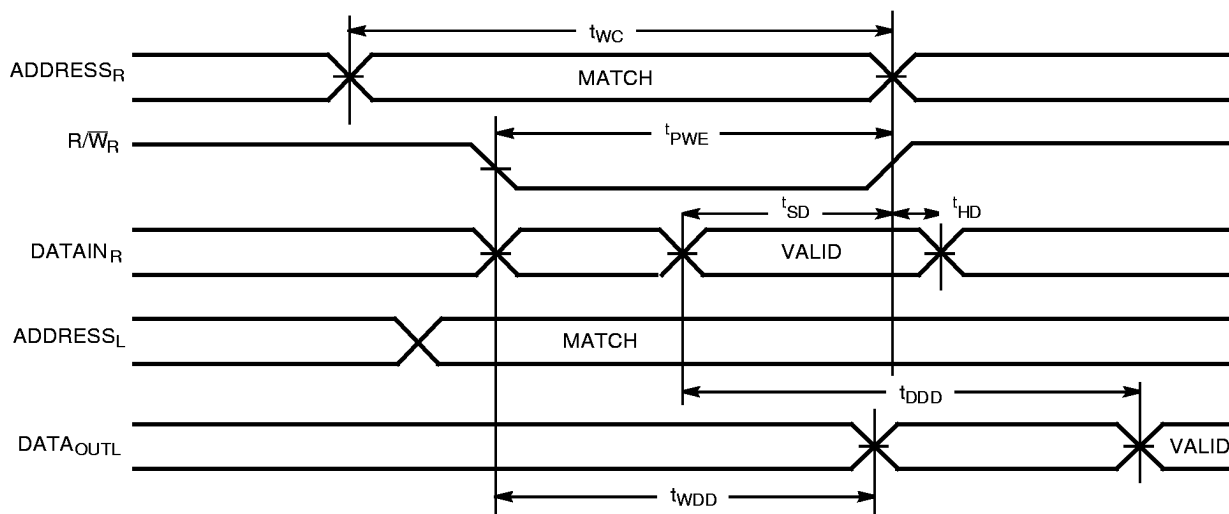
C144-10

### Read Cycle No. 2 (Either Port $\overline{CE}/\overline{OE}$ Access)<sup>[15, 17, 18]</sup>



C144-11

### Read Timing with Port-to-Port Delay ( $M/\overline{S}=L$ )<sup>[19, 20]</sup>



C144-12

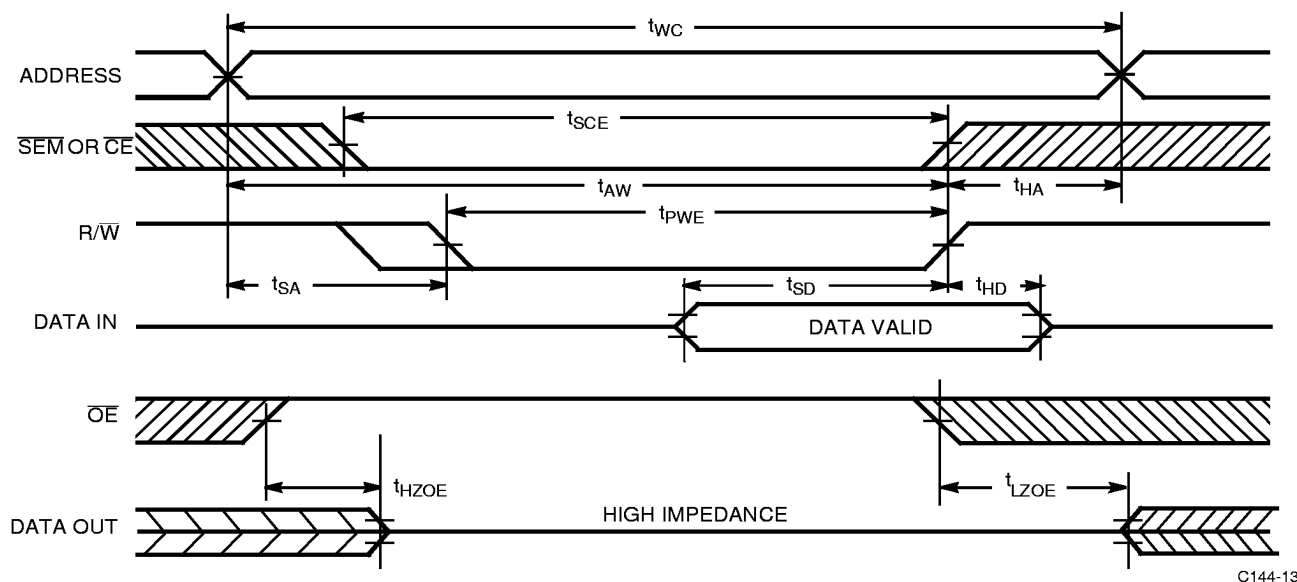
#### Notes:

15. R/W is HIGH for read cycle.
16. Device is continuously selected  $\overline{CE} = \text{LOW}$  and  $\overline{OE} = \text{LOW}$ . This waveform cannot be used for semaphore reads.
17. Address valid prior to or coincident with  $\overline{CE}$  transition LOW.
18.  $\overline{CE}_L = L$ ,  $\overline{SEM} = H$  when accessing RAM.  $\overline{CE} = H$ ,  $\overline{SEM} = L$  when accessing semaphores.
19.  $\overline{BUSY} = \text{HIGH}$  for the writing port.
20.  $\overline{CE}_L = \overline{CE}_R = \text{LOW}$ .

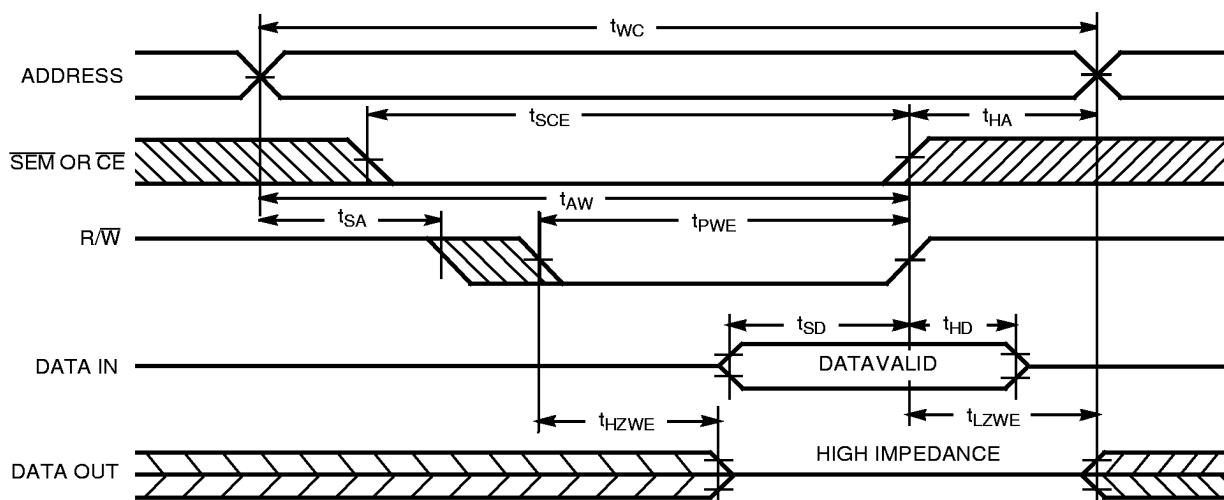


## Switching Waveforms (continued)

### Write Cycle No. 1: $\overline{OE}$ Three-State Data I/Os (Either Port)<sup>[21, 22, 23]</sup>



### Write Cycle No. 2: R/W Three-State Data I/Os (Either Port)<sup>[21, 23, 24]</sup>

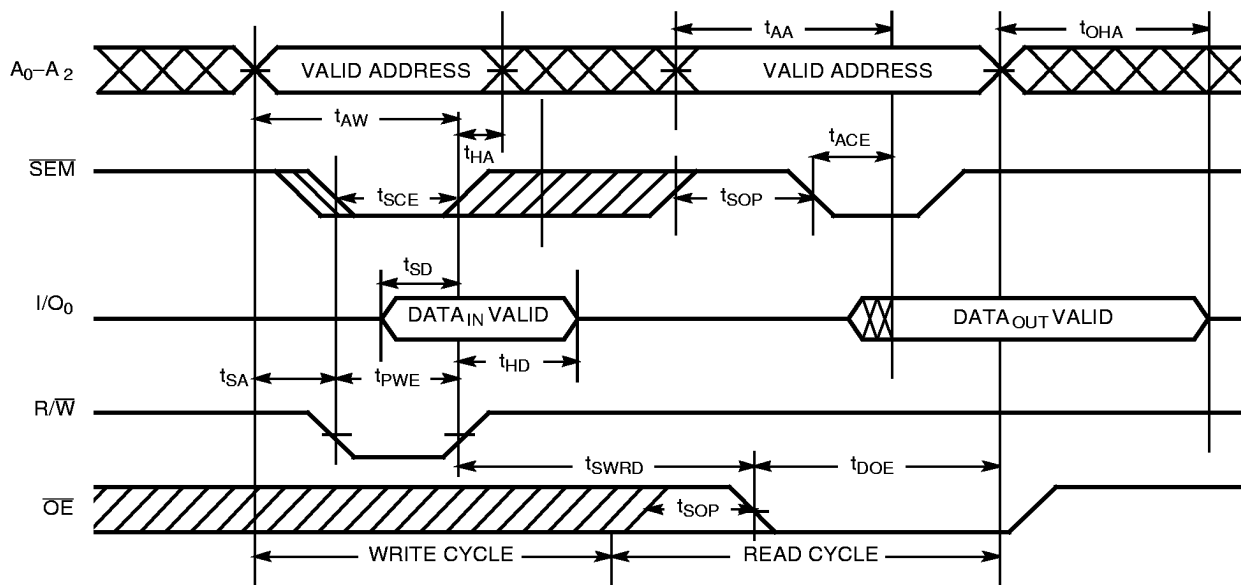


#### Notes:

21. The internal write time of the memory is defined by the overlap of  $\overline{CE}$  or  $\overline{SEM}$  LOW and  $\overline{R/W}$  LOW. Both signals must be LOW to initiate a write, and either signal can terminate a write by going HIGH. The data input set-up and hold timing should be referenced to the rising edge of the signal that terminates the write.
22. If  $\overline{OE}$  is LOW during a  $\overline{R/W}$  controlled write cycle, the write pulse width must be the larger of  $t_{PWE}$  or  $(t_{HZWE} + t_{SD})$  to allow the I/O drivers to turn off and data to be placed on the bus for the required  $t_{SD}$ . If  $\overline{OE}$  is HIGH during a  $\overline{R/W}$  controlled write cycle (as in this example), this requirement does not apply and the write pulse can be as short as the specified  $t_{PWE}$ .
23.  $\overline{R/W}$  must be HIGH during all address transitions.
24. Data I/O pins enter high impedance when  $\overline{OE}$  is held LOW during write.

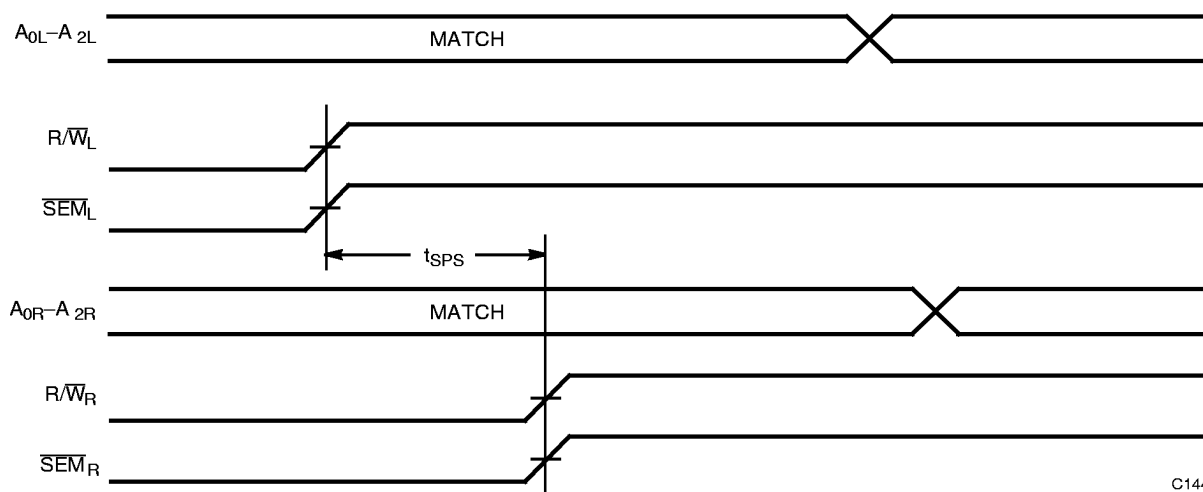
## Switching Waveforms (continued)

### Semaphore Read After Write Timing, Either Side<sup>[25]</sup>



C144-15

### Semaphore Contention<sup>[26, 27, 28]</sup>



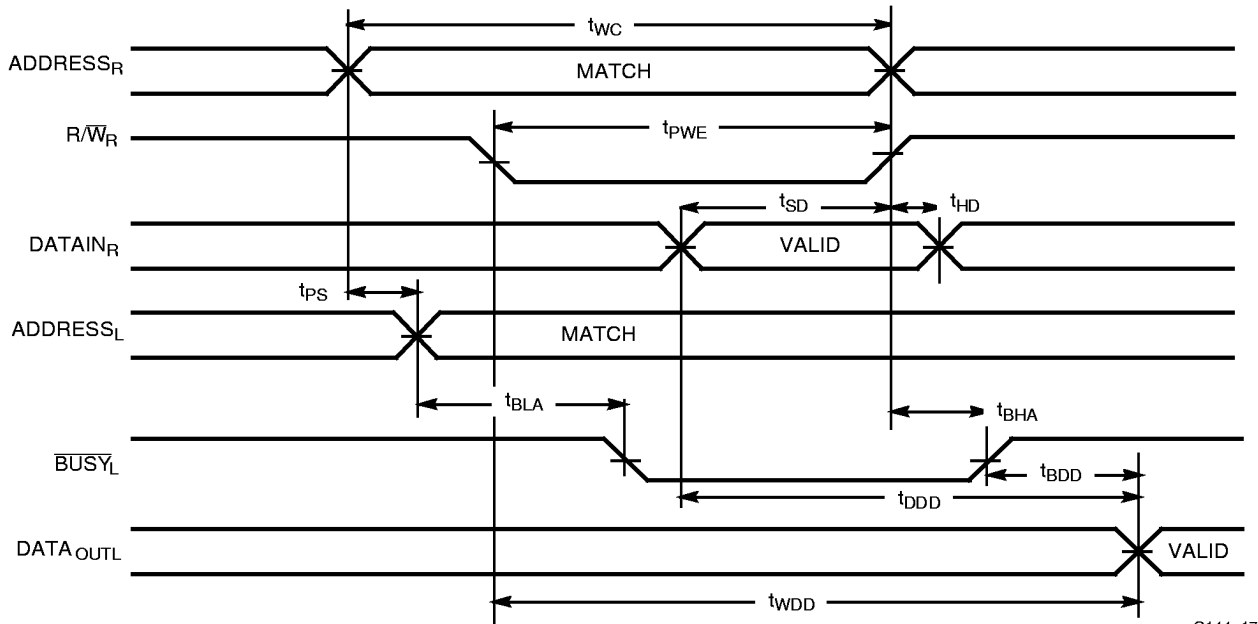
C144-16

#### Notes:

25.  $\overline{CE}$  = HIGH for the duration of the above timing (both write and read cycle).
26.  $I/O_{0R} = I/O_{0L} = \text{LOW}$  (request semaphore);  $CE_R = CE_L = \text{HIGH}$
27. Semaphores are reset (available to both ports) at cycle start.
28. If  $t_{SPS}$  is violated, the semaphore will definitely be obtained by one side or the other, but there is no guarantee which side will control the semaphore.

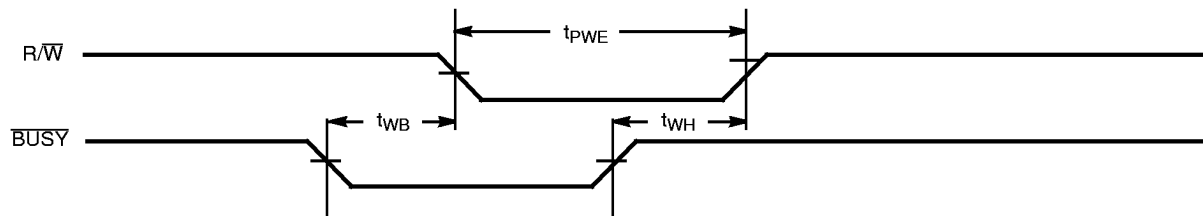
## Switching Waveforms (continued)

Read with **BUSY (M/S=HIGH)**<sup>[20]</sup>



C144-17

## Write Timing with Busy Input (M/ $\overline{S}$ =LOW)

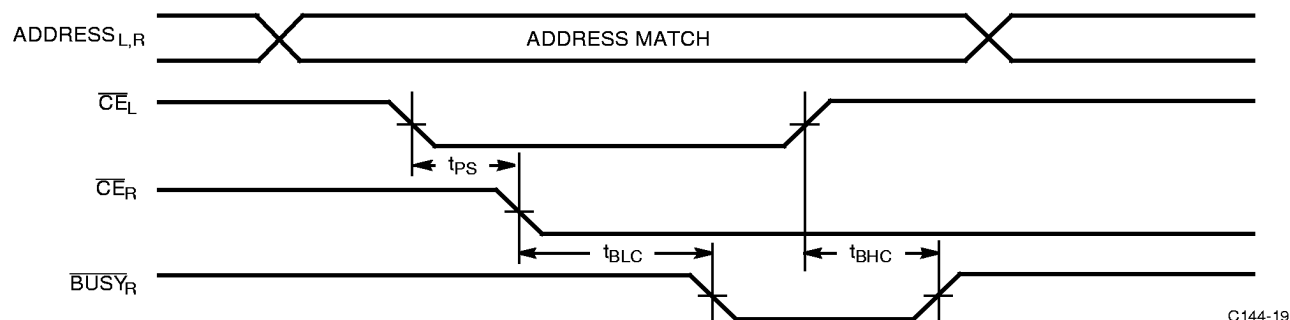


C144-18

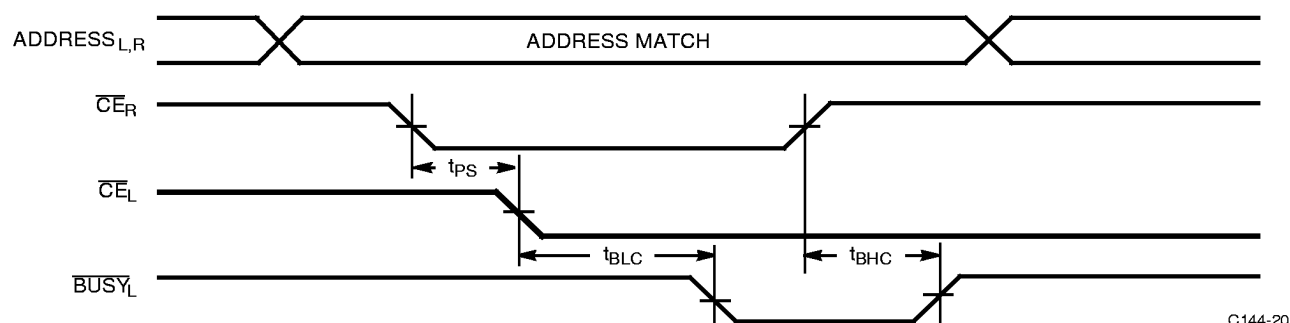
## Switching Waveforms (continued)

### Busy Timing Diagram No. 1 ( $\overline{CE}$ Arbitration)<sup>[29]</sup>

#### $\overline{CE}_L$ Valid First:

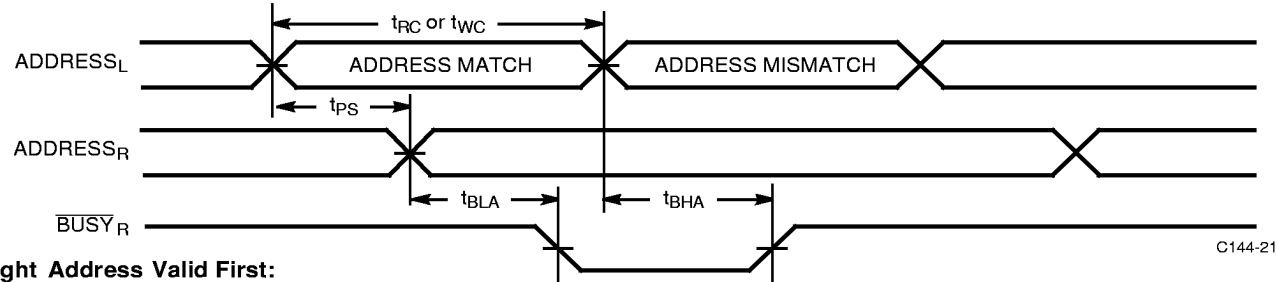


#### $\overline{CE}_R$ Valid First:

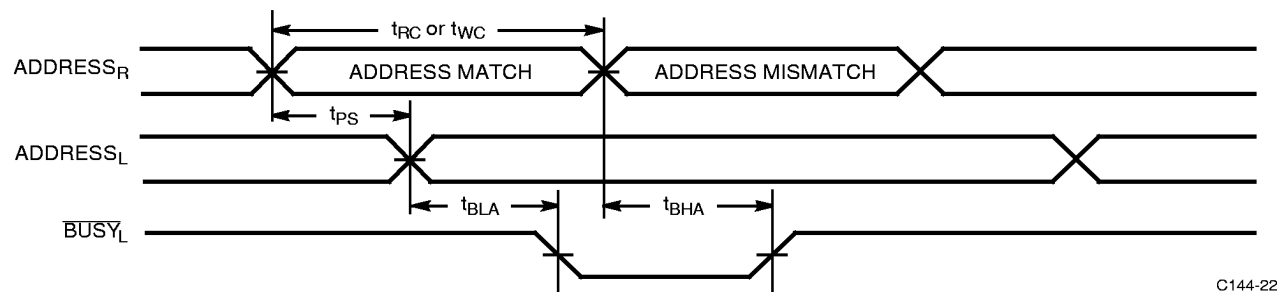


### Busy Timing Diagram No. 2 (Address Arbitration)<sup>[29]</sup>

#### Left Address Valid First:



#### Right Address Valid First:



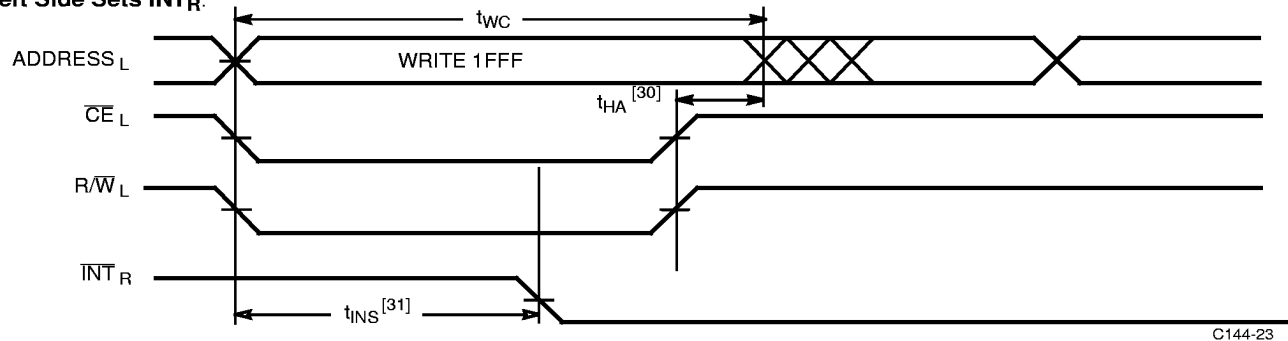
#### Notes:

29. If  $t_{PS}$  is violated, the busy signal will be asserted on one side or the other, but there is no guarantee on which side  $BUSY$  will be asserted

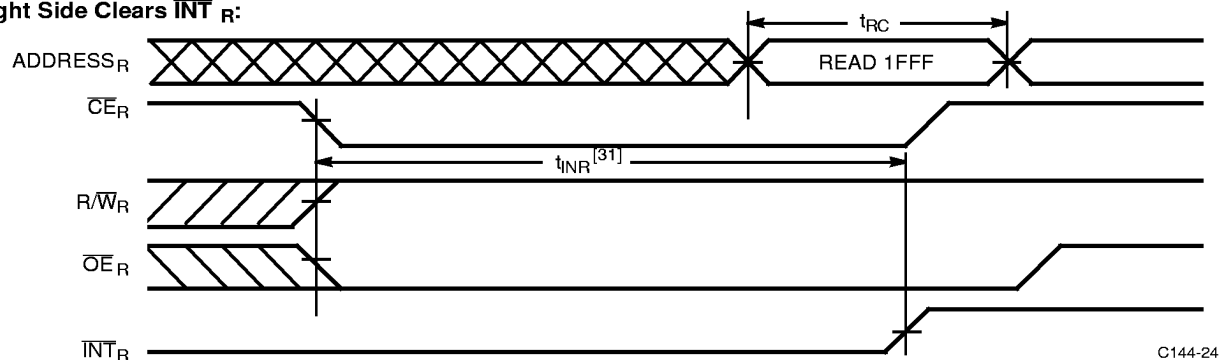
## Switching Waveforms (continued)

### Interrupt Timing Diagrams

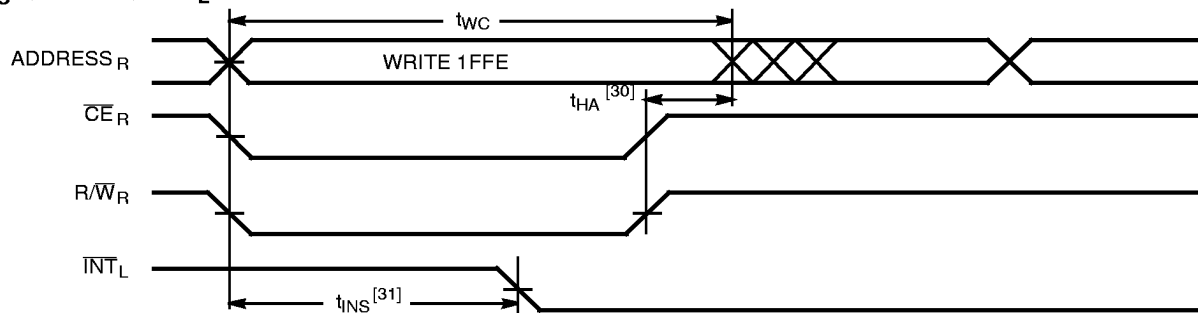
#### Left Side Sets $\text{INT}_R$ :



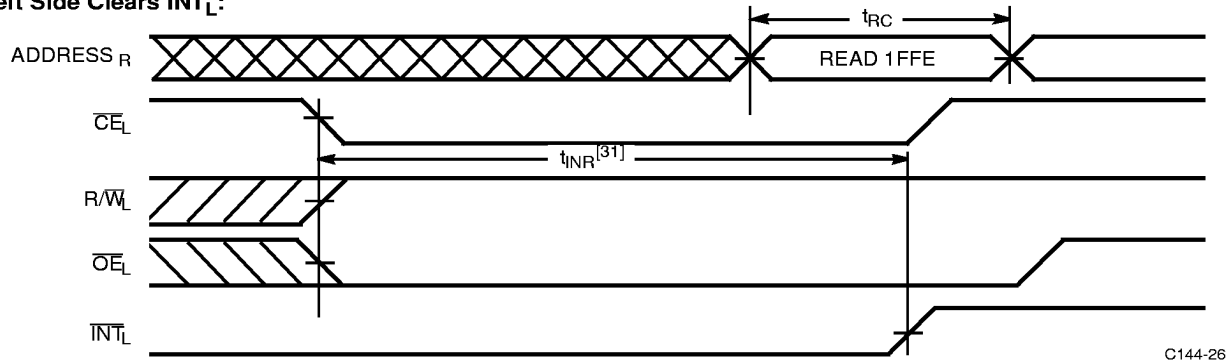
#### Right Side Clears $\text{INT}_R$ :



#### Right Side Sets $\text{INT}_L$ :



#### Left Side Clears $\text{INT}_L$ :



#### Notes:

30.  $t_{HA}$  depends on which enable pin ( $\overline{CE}_L$  or  $R/\overline{W}_L$ ) is deasserted first.  
 31.  $t_{INS}$  or  $t_{INR}$  depends on which enable pin ( $\overline{CE}_L$  or  $R/\overline{W}_L$ ) is asserted last.

## Architecture

The CY7C144/5 consists of an array of 8K words of 8/9 bits each of dual-port RAM cells, I/O and address lines, and control signals ( $\overline{CE}$ ,  $\overline{OE}$ , R/W). These control pins permit independent access for reads or writes to any location in memory. To handle simultaneous writes/reads to the same location, a  $\overline{BUSY}$  pin is provided on each port. Two interrupt (INT) pins can be utilized for port-to-port communication. Two semaphore ( $\overline{SEM}$ ) control pins are used for allocating shared resources. With the M/S pin, the CY7C144/5 can function as a Master ( $\overline{BUSY}$  pins are outputs) or as a slave ( $\overline{BUSY}$  pins are inputs). The CY7C144/5 has an automatic power-down feature controlled by  $\overline{CE}$ . Each port is provided with its own output enable control ( $\overline{OE}$ ), which allows data to be read from the device.

## Functional Description

### Write Operation

Data must be set up for a duration of  $t_{SD}$  before the rising edge of R/W in order to guarantee a valid write. A write operation is controlled by either the  $\overline{OE}$  pin (see Write Cycle No. 1 waveform) or the R/W pin (see Write Cycle No. 2 waveform). Data can be written to the device  $t_{HZOE}$  after the  $\overline{OE}$  is deasserted or  $t_{HZWE}$  after the falling edge of R/W. Required inputs for non-contention operations are summarized in *Table 1*.

If a location is being written to by one port and the opposite port attempts to read that location, a port-to-port flowthrough delay must be met before the data is read on the output; otherwise the data read is not deterministic. Data will be valid on the port  $t_{DDO}$  after the data is presented on the other port.

### Read Operation

When reading the device, the user must assert both the  $\overline{OE}$  and  $\overline{CE}$  pins. Data will be available  $t_{ACE}$  after  $\overline{CE}$  or  $t_{DOE}$  after  $\overline{OE}$  are asserted. If the user of the CY7C144/5 wishes to access a semaphore flag, then the  $\overline{SEM}$  pin must be asserted instead of the  $\overline{CE}$  pin.

### Interrupts

The interrupt flag (INT) permits communications between ports. When the left port writes to location 1FFF, the right port's interrupt flag (INT<sub>R</sub>) is set. This flag is cleared when the right port reads that same location. Setting the left port's interrupt flag (INT<sub>L</sub>) is accomplished when the right port writes to location 1FFE. This flag is cleared when the left port reads location 1FFE. The message at 1FFF or 1FFE is user-defined. See *Table 2* for input requirements for INT. INT<sub>R</sub> and INT<sub>L</sub> are push-pull outputs and do not require pull-up resistors to operate.

### Busy

The CY7C144/5 provides on-chip arbitration to alleviate simultaneous memory location access (contention). If both ports'  $\overline{CE}$ s are asserted and an address match occurs within  $t_{PS}$  of each other the Busy logic will determine which port has access. If  $t_{PS}$  is violated, one port will definitely gain permission to the location, but it is not guaranteed which one.  $\overline{BUSY}$  will be asserted  $t_{BLA}$  after an address match or  $t_{BLC}$  after  $\overline{CE}$  is taken LOW.  $\overline{BUSY}_L$  and  $\overline{BUSY}_R$

in master mode are push-pull outputs and do not require pull-up resistors to operate.

### Master/Slave

An M/S pin is provided in order to expand the word width by configuring the device as either a master or a slave. The  $\overline{BUSY}$  output of the master is connected to the  $\overline{BUSY}$  input of the slave. This will allow the device to interface to a master device with no external components. Writing of slave devices must be delayed until after the  $\overline{BUSY}$  input has settled. Otherwise, the slave chip may begin a write cycle during a contention situation. When presented a HIGH input, the M/S pin allows the device to be used as a master and therefore the  $\overline{BUSY}$  line is an output.  $\overline{BUSY}$  can then be used to send the arbitration outcome to a slave.

### Semaphore Operation

The CY7C144/5 provides eight semaphore latches which are separate from the dual-port memory locations. Semaphores are used to reserve resources that are shared between the two ports. The state of the semaphore indicates that a resource is in use. For example, if the left port wants to request a given resource, it sets a latch by writing a 0 to a semaphore location. The left port then verifies its success in setting the latch by reading it. After writing to the semaphore,  $\overline{SEM}$  or  $\overline{OE}$  must be deasserted for  $t_{SOP}$  before attempting to read the semaphore. The semaphore value will be available  $t_{SWRD} + t_{DOE}$  after the rising edge of the semaphore write. If the left port was successful (reads a 0), it assumes control over the shared resource, otherwise (reads a 1) it assumes the right port has control and continues to poll the semaphore. When the right side has relinquished control of the semaphore (by writing a 1), the left side will succeed in gaining control of the semaphore. If the left side no longer requires the semaphore, a 1 is written to cancel its request.


Semaphores are accessed by asserting  $\overline{SEM}$  LOW. The  $\overline{SEM}$  pin functions as a chip enable for the semaphore latches ( $\overline{CE}$  must remain HIGH during  $\overline{SEM}$  LOW).  $A_{0-2}$  represents the semaphore address.  $\overline{OE}$  and R/W are used in the same manner as a normal memory access. When writing or reading a semaphore, the other address pins have no effect.

When writing to the semaphore, only I/O<sub>0</sub> is used. If a 0 is written to the left port of an unused semaphore, a 1 will appear at the same semaphore address on the right port. That semaphore can now only be modified by the side showing 0 (the left port in this case). If the left port now relinquishes control by writing a 1 to the semaphore, the semaphore will be set to 1 for both sides. However, if the right port had requested the semaphore (written a 0) while the left port had control, the right port would immediately own the semaphore as soon as the left port released it. *Table 3* shows sample semaphore operations.

When reading a semaphore, all eight/nine data lines output the semaphore value. The read value is latched in an output register to prevent the semaphore from changing state during a write from the other port. If both ports attempt to access the semaphore within  $t_{SPS}$  of each other, the semaphore will definitely be obtained by one side or the other, but there is no guarantee which side will control the semaphore.

Initialization of the semaphore is not automatic and must be reset during initialization program at power-up. All Semaphores on both sides should have a one written into them at initialization from both sides to assure that they will be free when needed.

**Table 1. Non-Contending Read/Write.**

| Inputs |   |    |     | Outputs              | Operation              |
|--------|---|----|-----|----------------------|------------------------|
| CE     | R/W   | OE | SEM | I/O <sub>0-7/8</sub> |                        |
| H      | X   | X  | H   | High Z               | Power-Down             |
| H      | H   | L  | L   | Data Out             | Read Data in Semaphore |
| X      | X   | H  | X   | High Z               | I/O Lines Disabled     |
| H      |  | X  | L   | Data In              | Write to Semaphore     |
| L      | H   | L  | H   | Data Out             | Read                   |
| L      | L   | X  | H   | Data In              | Write                  |
| L      | X   | X  | L   |                      | Illegal Condition      |

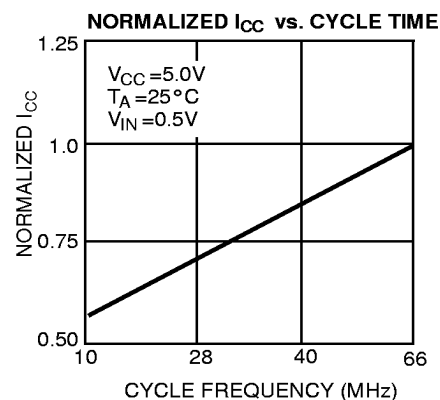
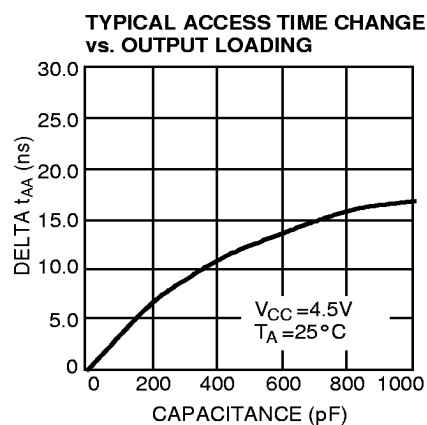
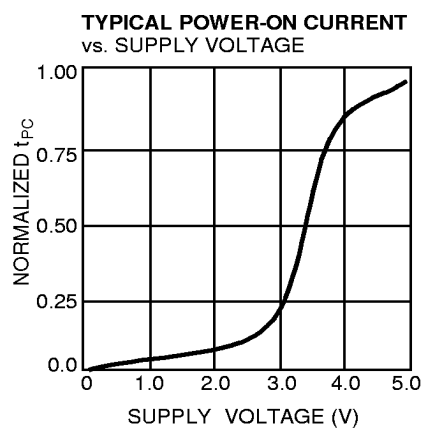
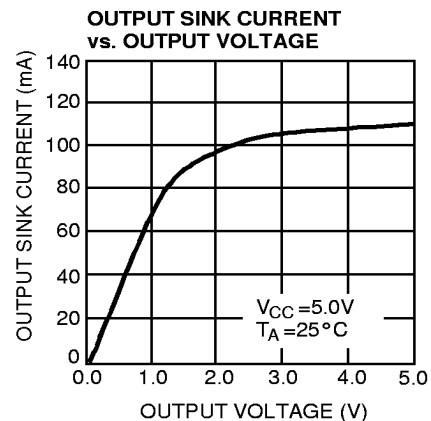
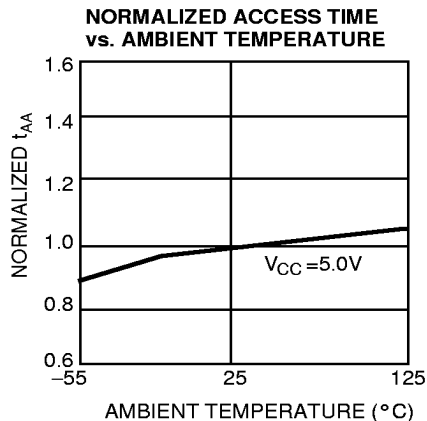
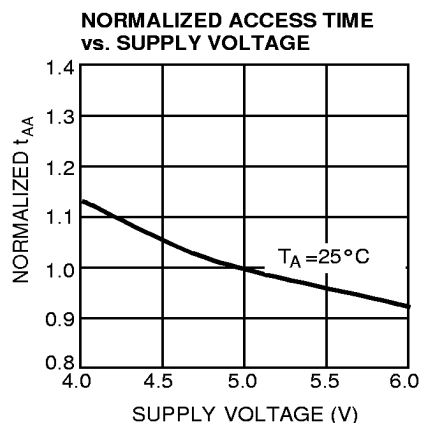
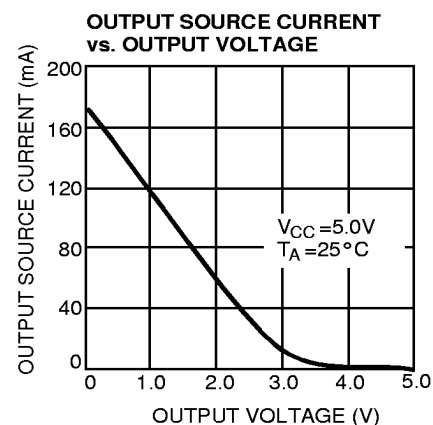
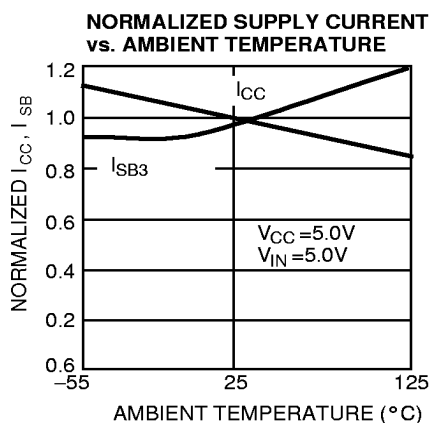
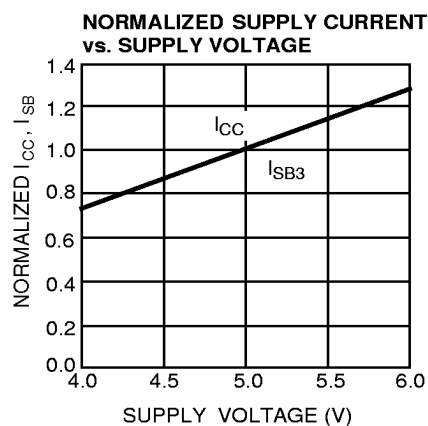
**Table 2. Interrupt Operation Example (assumes BUSY<sub>L</sub>=BUSY<sub>R</sub>=HIGH).**

| Function        | Left Port |    |    |                   |     | Right Port |    |    |                   |     |
|-----------------|-----------|----|----|-------------------|-----|------------|----|----|-------------------|-----|
|                 | R/W       | CE | OE | A <sub>0-12</sub> | INT | R/W        | CE | OE | A <sub>0-12</sub> | INT |
| Set Left INT    | X         | X  | X  | X                 | L   | L          | L  | X  | 1FFE              | X   |
| Reset Left INT  | X         | L  | L  | 1FFE              | H   | X          | L  | L  | X                 | X   |
| Set Right INT   | L         | L  | X  | 1FFF              | X   | X          | X  | X  | X                 | L   |
| Reset Right INT | X         | X  | X  | X                 | X   | X          | L  | L  | 1FFF              | H   |

**Table 3. Semaphore Operation Example.**

| Function                         | I/O <sub>0-7/8</sub> Left | I/O <sub>0-7/8</sub> Right | Status                                    |
|----------------------------------|---------------------------|----------------------------|---|
| No action                        | 1                         | 1                          | Semaphore free                            |
| Left port writes semaphore       | 0                         | 1                          | Left port obtains semaphore               |
| Right port writes 0 to semaphore | 0                         | 1                          | Right side is denied access               |
| Left port writes 1 to semaphore  | 1                         | 0                          | Right port is granted access to semaphore |
| Left port writes 0 to semaphore  | 1                         | 0                          | No change. Left port is denied access     |
| Right port writes 1 to semaphore | 0                         | 1                          | Left port obtains semaphore               |
| Left port writes 1 to semaphore  | 1                         | 1                          | No port accessing semaphore address       |
| Right port writes 0 to semaphore | 1                         | 0                          | Right port obtains semaphore              |
| Right port writes 1 to semaphore | 1                         | 1                          | No port accessing semaphore               |
| Left port writes 0 to semaphore  | 0                         | 1                          | Left port obtains semaphore               |
| Left port writes 1 to semaphore  | 1                         | 1                          | No port accessing semaphore               |

## Typical DC and AC Characteristics







## Ordering Information

### 8K x8 Dual-Port SRAM

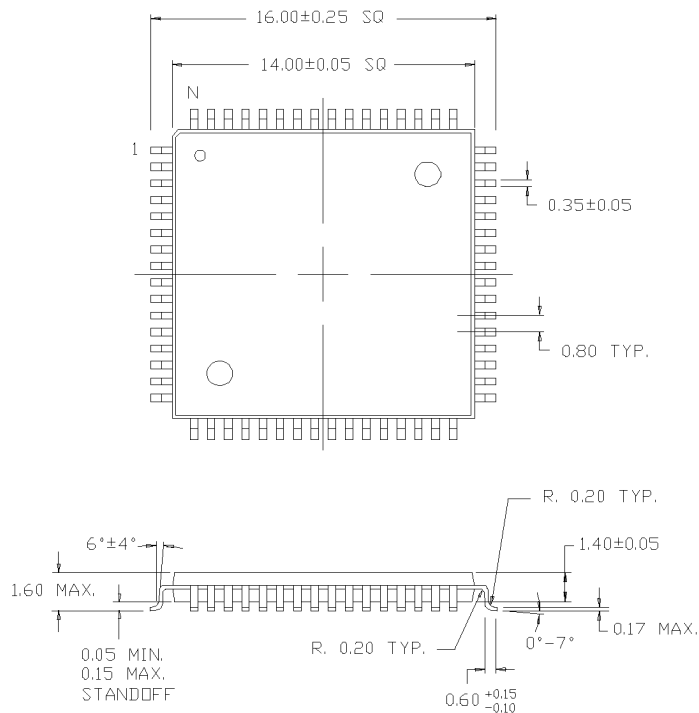
| Speed (ns) | Ordering Code | Package Name | Package Type                        | Operating Range |
|------------|---------------|--------------|-------------------------------------|-----------------|
| 15         | CY7C144-15AC  | A65          | 64-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C144-15JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
| 25         | CY7C144-25AC  | A65          | 64-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C144-25JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
|            | CY7C144-25AI  | A65          | 64-Lead Thin Quad Flat Pack         | Industrial      |
|            | CY7C144-25JI  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
| 35         | CY7C144-35AC  | A65          | 64-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C144-35JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
|            | CY7C144-35AI  | A65          | 64-Lead Thin Quad Flat Pack         | Industrial      |
|            | CY7C144-35JI  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
| 55         | CY7C144-55AC  | A65          | 64-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C144-55JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
|            | CY7C144-55AI  | A65          | 64-Lead Thin Quad Flat Pack         | Industrial      |
|            | CY7C144-55JI  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |

### 8K x9 Dual-Port SRAM

| Speed (ns) | Ordering Code | Package Name | Package Type                        | Operating Range |
|------------|---------------|--------------|-------------------------------------|-----------------|
| 15         | CY7C145-15AC  | A80          | 80-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C145-15JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
| 25         | CY7C145-25AC  | A80          | 80-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C145-25JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
|            | CY7C145-25AI  | A80          | 80-Lead Thin Quad Flat Pack         | Industrial      |
|            | CY7C145-25JI  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
| 35         | CY7C145-35AC  | A80          | 80-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C145-35JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
|            | CY7C145-35AI  | A80          | 80-Lead Thin Quad Flat Pack         | Industrial      |
|            | CY7C145-35JI  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
| 55         | CY7C145-55AC  | A80          | 80-Lead Thin Quad Flat Pack         | Commercial      |
|            | CY7C145-55JC  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |
|            | CY7C145-55AI  | A80          | 80-Lead Thin Quad Flat Pack         | Industrial      |
|            | CY7C145-55JI  | J81          | 68-Lead Plastic Leaded Chip Carrier |                 |

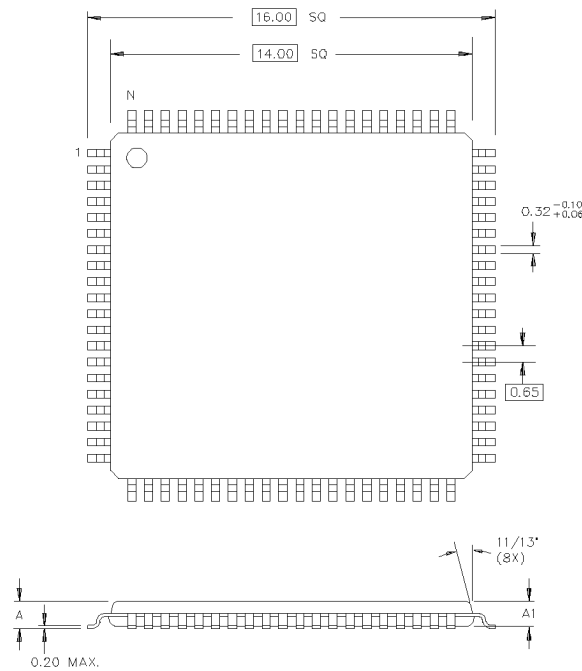
## Package Diagrams

### 64-Pin Thin Plastic Quad Flat Pack A65

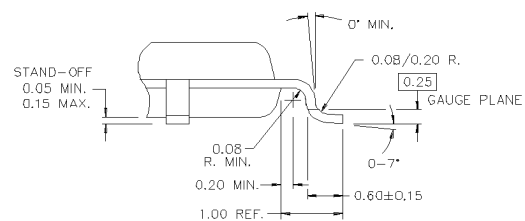


DIMENSIONS IN MILLIMETERS  
 LEAD COPLANARITY 0.100 MAX.

### 80-Pin Thin Plastic Quad Flat Pack A80



DIMENSIONS IN MILLIMETERS  
 LEAD COPLANARITY 0.080 MAX.



| DIM. A    | DIM. A1              |
|-----------|----------------------|
| 1.60 MAX. | 1.40±0.05 PKG. THICK |
| 1.20 MAX. | 1.00±0.05 PKG. THICK |

**Package Diagrams (continued)**

**68-Lead Plastic Leaded ChipCarrierJ81**

