

APPLICATION NOTE

A V A I L A B L E

AN56

# High Speed NOVRAM

# X20CZ16

## FEATURES

- **Fast access time: 35ns**
- **High reliability**
  - Endurance:  $10^5$  nonvolatile store operations
  - Retention: 10 years minimum
- **Power-on recall**
  - EEPROM data automatically recalled into RAM upon power-up
- **Low power CMOS**
  - Standby: 1mA
- **Infinite EEPROM array recall, and RAM read and write cycles**
- **Hardware store initiation (store cycle time < 10ms)**
- **Available in the 32-lead plastic leadless chip carrier package**

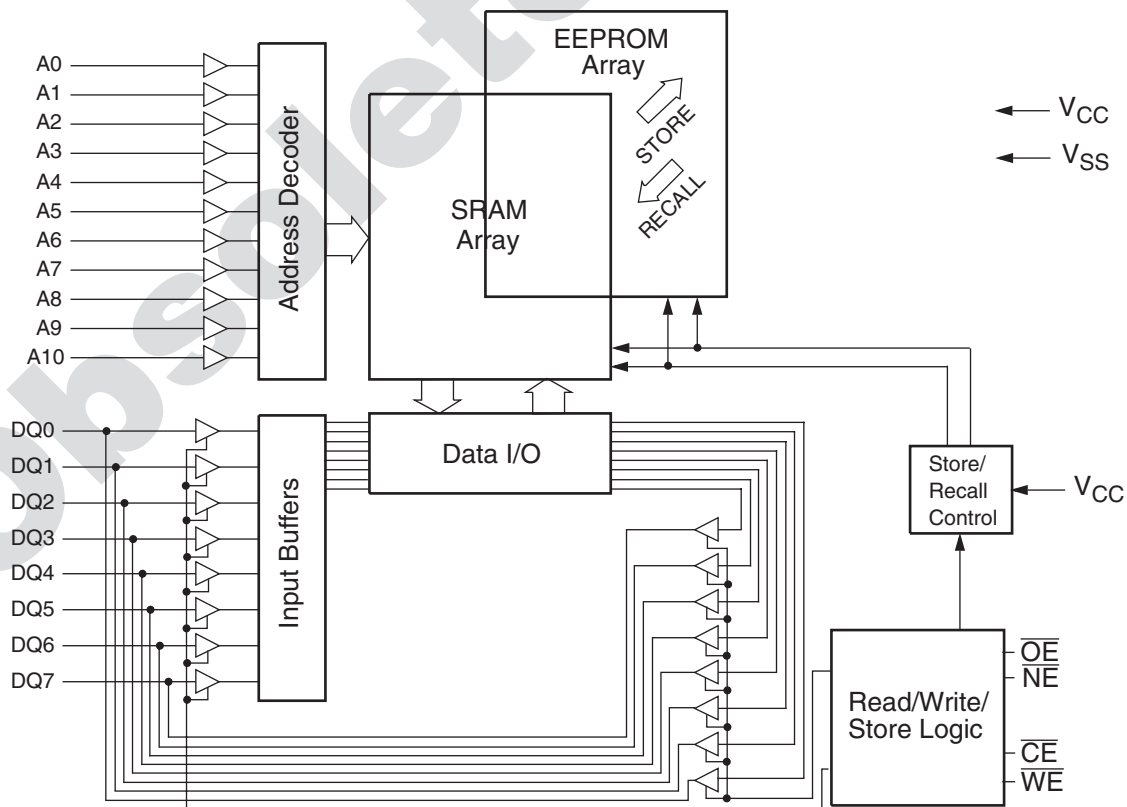
## DESCRIPTION

The Xicor X20CZ16 is a 2K x 8 NOVRAM featuring a high-speed static RAM overlaid bit-for-bit with a non-volatile electrically erasable PROM (EEPROM). The X20CZ16 is fabricated with advanced CMOS floating gate technology to achieve high speed with low power and wide power-supply margin.

The NOVRAM design allows data to be easily transferred from RAM to EEPROM (store) and EEPROM to RAM (recall). The store operation is completed in 10ms or less and the recall operation is completed in 20 $\mu$ s or less. An automatic array recall operation reloads the contents of the EEPROM into RAM upon power-up.

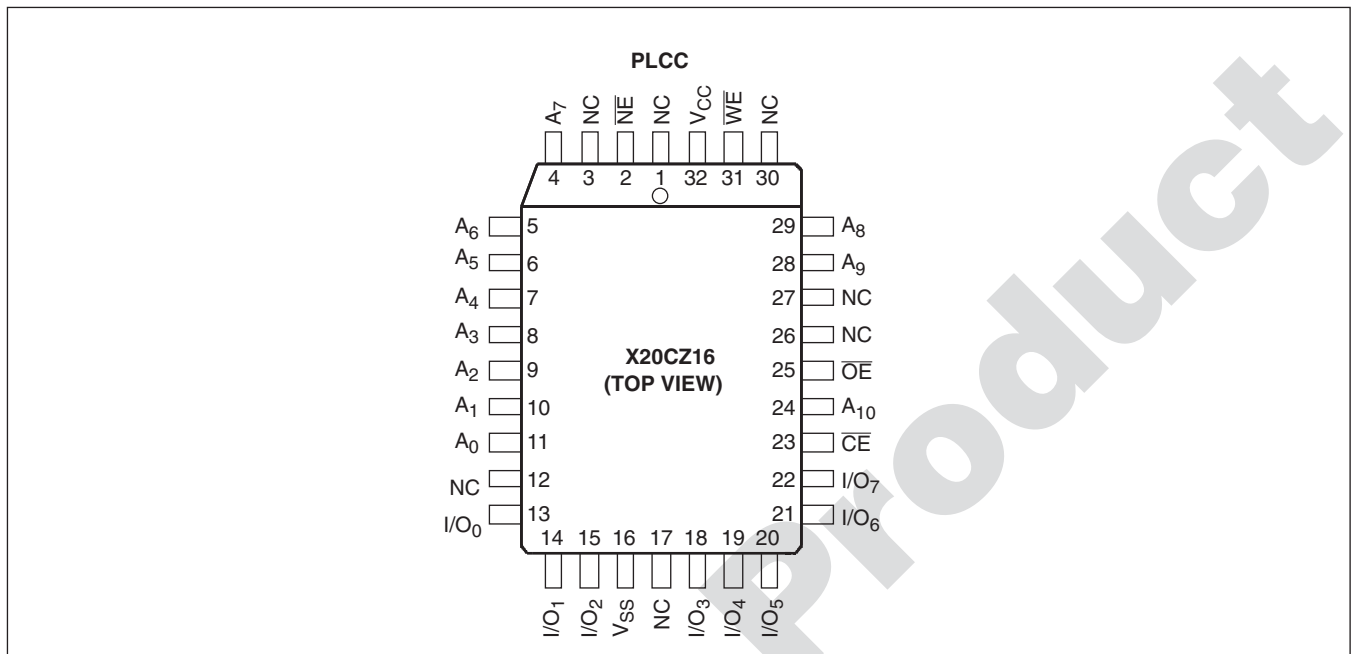
Xicor NOVRAMS are designed for unlimited write operations to RAM, either from the host or recalls from EEPROM, and a minimum 100,000 store operations to the EEPROM. Data retention is specified to be greater than 10 years.

## FUNCTIONAL DIAGRAM



## X20CZ16

### PIN CONFIGURATION



### ORDERING INFORMATION

Part Number	Access Time	Temperature Range	Package
X20CE16JI-35	-35 = 35 ns	-40°C to 85°C	J = 32-Lead PLCC

### PIN DESCRIPTIONS

PLCC	Symbol	Description
11, 10, 9, 8, 7, 6, 5, 4, 29, 28, 24	$A_0$ – $A_{10}$	Address inputs
13, 14, 15, 18, 19, 20, 21, 22	$I/O_0$ – $I/O_7$	Data input/output
31	$\overline{WE}$	Write enable
23	$\overline{CE}$	Chip enable
25	$\overline{OE}$	Output enable
2	$\overline{NE}$	Nonvolatile enable
32	$V_{CC}$	+5V
16	$V_{SS}$	Ground
1, 3, 12, 17, 26, 27, 30	NC	No connect

## X20CZ16

### ABSOLUTE MAXIMUM RATINGS\*

Temperature under bias .....  $-65^{\circ}\text{C}$  to  $+135^{\circ}\text{C}$   
 Storage temperature .....  $-65^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$   
 Voltage on any pin with  
 respect to  $V_{SS}$  .....  $-0.3\text{V}$  to  $V_{CC} + 0.5\text{V}$   
 D.C. output current ..... 10mA  
 Lead temperature (soldering, 10 seconds).....  $300^{\circ}\text{C}$   
 Power Supply Voltage ( $V_{CC}$  to  $V_{SS}$ ) .....  $-0.5\text{V}$  to  $+7.0\text{V}$

### \*COMMENT

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

### RECOMMENDED OPERATING CONDITIONS

Temperature	Min.	Max.
Industrial	$-40^{\circ}\text{C}$	$+85^{\circ}\text{C}$

Supply Voltage	Limits
X20CZ16	$5\text{V} \pm 10\%$

### D.C. OPERATING CHARACTERISTICS (Over recommended operating conditions unless otherwise specified.)

Symbol	Parameter	Limits			Test Conditions
		Min.	Max.	Unit	
$I_{CC1}$	$V_{CC}$ current (active)		100	mA	$\overline{NE} = \overline{WE} = V_{IH}$ , $\overline{CE} = \overline{OE} = V_{IL}$ Address inputs = 0.4V/2.4V levels @ $f = 20\text{MHz}$ All I/Os = open
$I_{CC2}$	$V_{CC}$ current during store		7	mA	All inputs = $V_{IH}$ All I/Os = open
$I_{SB1}$	$V_{CC}$ standby current (TTL input)		27	mA	$\overline{CE} = V_{IH}$ , All other inputs = $V_{IH}$ All I/Os = open
$I_{SB2}$	$V_{CC}$ standby current (CMOS input)		1	mA	All inputs = $V_{CC} - 0.3\text{V}$ All I/Os = open
$I_{LI}$	Input leakage current		10	$\mu\text{A}$	$V_{IN} = V_{SS}$ to $V_{CC}$
$I_{LO}$	Output leakage current		10	$\mu\text{A}$	$V_{OUT} = V_{SS}$ to $V_{CC}$ , $\overline{CE} = V_{IH}$
$V_{IL}^{(1)}$	Input LOW voltage	-0.3	0.8	V	
$V_{IH}^{(1)}$	Input HIGH voltage	2.2	$V_{CC} + 0.3$	V	
$V_{OL}$	Output LOW voltage		0.4	V	$I_{OL} = 4\text{mA}$
$V_{OH}$	Output HIGH voltage	2.4		V	$I_{OH} = -4\text{mA}$

### CAPACITANCE $T_A = +25^{\circ}\text{C}$ , $f = 1\text{MHz}$ , $V_{CC} = 5\text{V}$

Symbol	Test	Max.	Unit	Conditions
$C_{I/O}^{(2)}$	Input/output capacitance	7	pF	$V_{I/O} = 0\text{V}$
$C_{IN}^{(2)}$	Input capacitance	8	pF	$V_{IN} = 0\text{V}$

Notes: (1)  $V_{IL}$  min. and  $V_{IH}$  max. are for reference only and are not tested.  
 (2) This parameter is periodically sampled and not 100% tested.

## X20CZ16

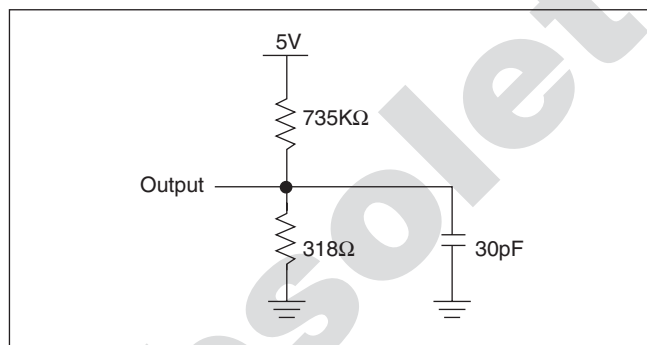
### ENDURANCE AND DATA RETENTION

Parameter	Min.	Unit
Store cycles	100,000	Store cycles
Data retention	10	Years

### MODE SELECTION

CE	WE	NE	OE	Mode	I/O	Power
H	X	X	X	Not selected	Output high Z	Standby
L	H	H	L	Read RAM	Output data	Active
L	L	H	H	Write "1" RAM	Input data high	Active
L	L	H	H	Write "0" RAM	Input data low	Active
L	H	L	L	Array recall	Output high Z	Active
L	L	L	H	Nonvolatile store	Output high Z	Active
L	H	H	H	Output disabled	Output high Z	Active
L	L	L	L	Not allowed	Output high Z	Active
L	H	L	H	No operation	Output high Z	Active

### EQUIVALENT A.C. LOAD CIRCUIT



### A.C. CONDITIONS OF TEST

Input pulse levels	0V to 3V
Input rise and fall times	5ns
Input and output timing levels	1.5V

### SYMBOL TABLE

WAVEFORM	INPUTS	OUTPUTS
	Must be steady	Will be steady
	May change from LOW to HIGH	Will change from LOW to HIGH
	May change from HIGH to LOW	Will change from HIGH to LOW
	Don't Care: Changes Allowed	Changing: State Not Known
	N/A	Center Line is High Impedance

## X20CZ16

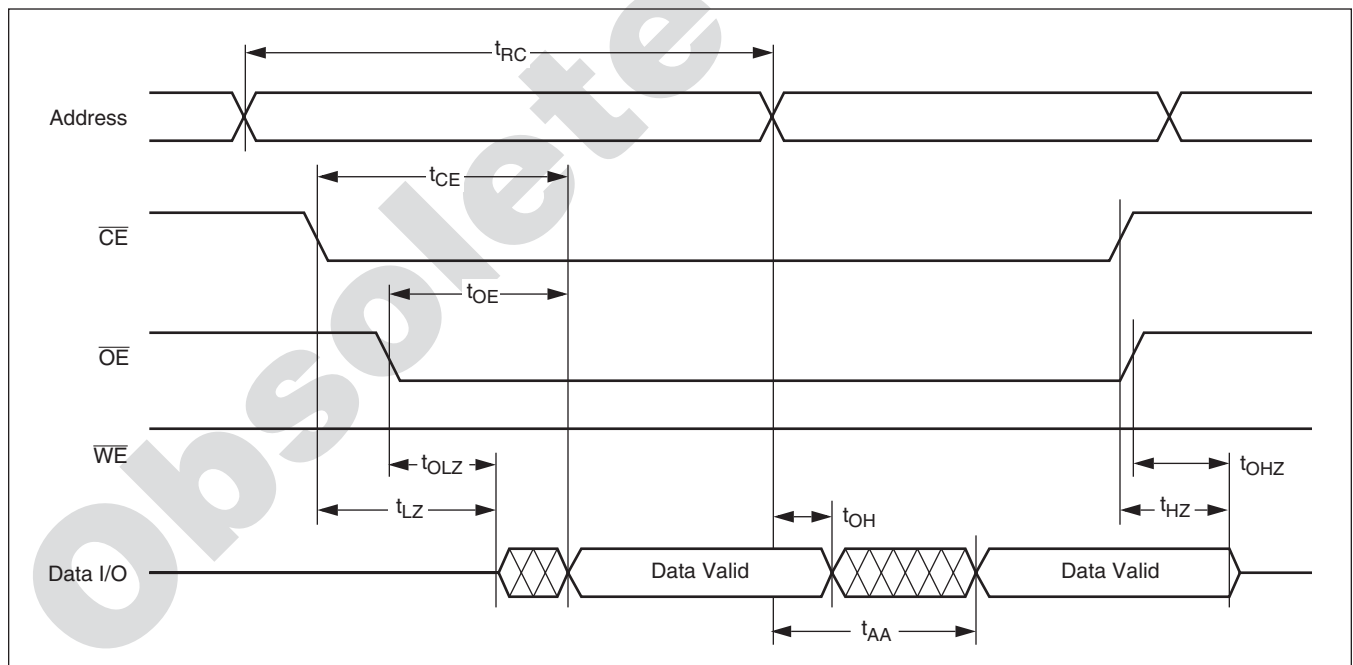
### A.C. CHARACTERISTICS (Over the recommended operating conditions unless otherwise specified)

#### Read Cycle Limits

Symbol	Parameter	X20CZ16-35 -40 to +85°C		Unit
		Min.	Max.	
$t_{RC}^{(3)}$	Read cycle time	35		ns
$t_{CE}$	Chip enable access time		35	ns
$t_{AA}$	Address access time		35	ns
$t_{OE}$	Output enable access time		20	ns
$t_{LZ}^{(3)}$	Chip enable to output in low Z	5		ns
$t_{OLZ}^{(3)}$	Output enable to output in low Z	0		ns
$t_{HZ}^{(3)}$	Chip disable to output in high Z	0	15	ns
$t_{OHZ}^{(3)}$	Output disable to output in high Z	0	15	ns
$t_{OH}^{(3)}$	Output hold from address change	3		ns

**Note:** (3) These parameters are periodically sampled and not 100% tested.  $t_{HZ}$  max. and  $t_{OHZ}$  max. are measured, with  $C_L = 5pF$ , from the point when  $\overline{CE}$  or  $\overline{OE}$  return HIGH (whichever occurs first) to the time when the outputs are no longer driven.

#### Read Cycle



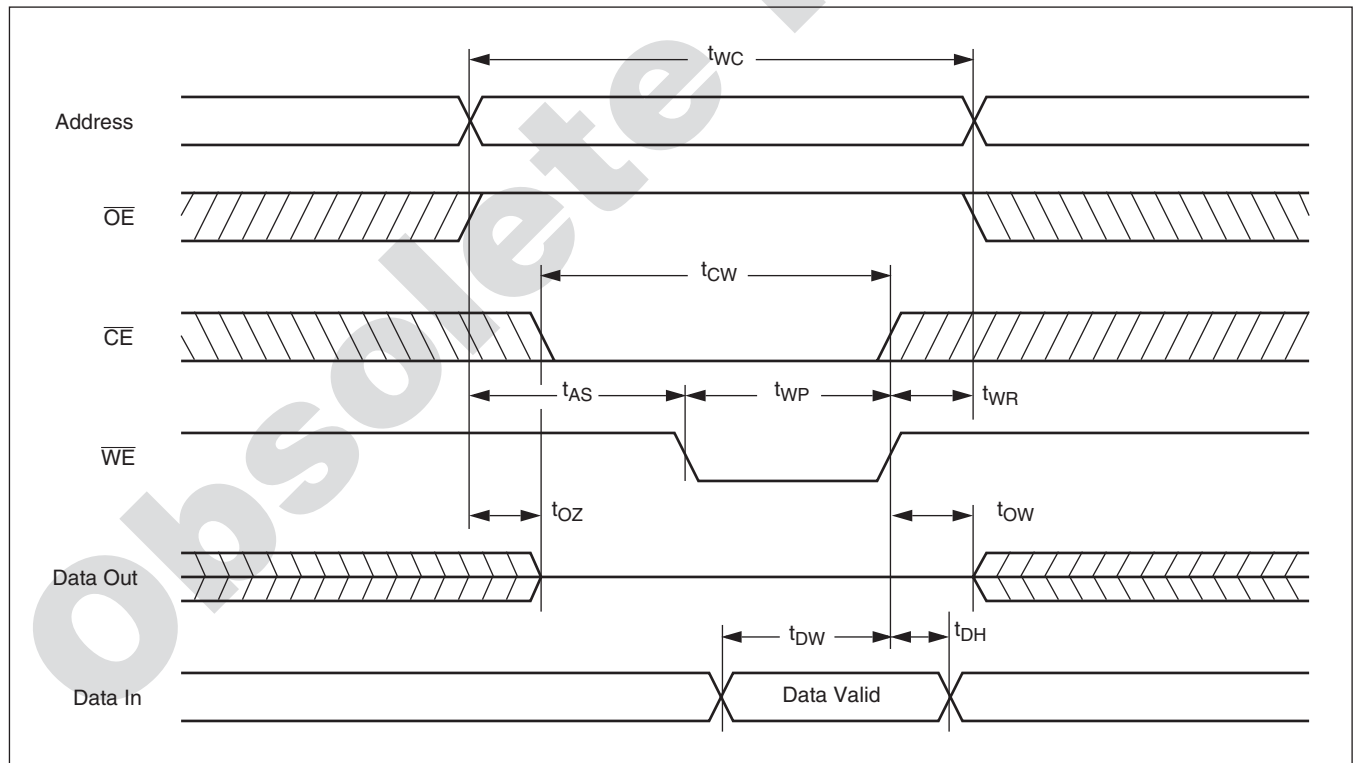
## X20CZ16

### Write Cycle Limits

Symbol	Parameter	X20CZ16-35		Unit
		Min.	Max.	
$t_{WC}^{(4)}$	Write cycle time	35		ns
$t_{CW}$	Chip enable to end of write input	30		ns
$t_{AS}$	Address setup time	0		ns
$t_{WP}$	Write pulse width	30		ns
$t_{WR}$	Write recovery time	0		ns
$t_{DW}$	Data setup to end of write	30		ns
$t_{DH}$	Data hold time	0		ns
$t_{WZ}^{(4)}$	Write enable to output in high Z		15	ns
$t_{OW}^{(4)}$	Output active from end of write	5		ns
$t_{OZ}^{(4)}$	Output enable to output in high Z		20	ns

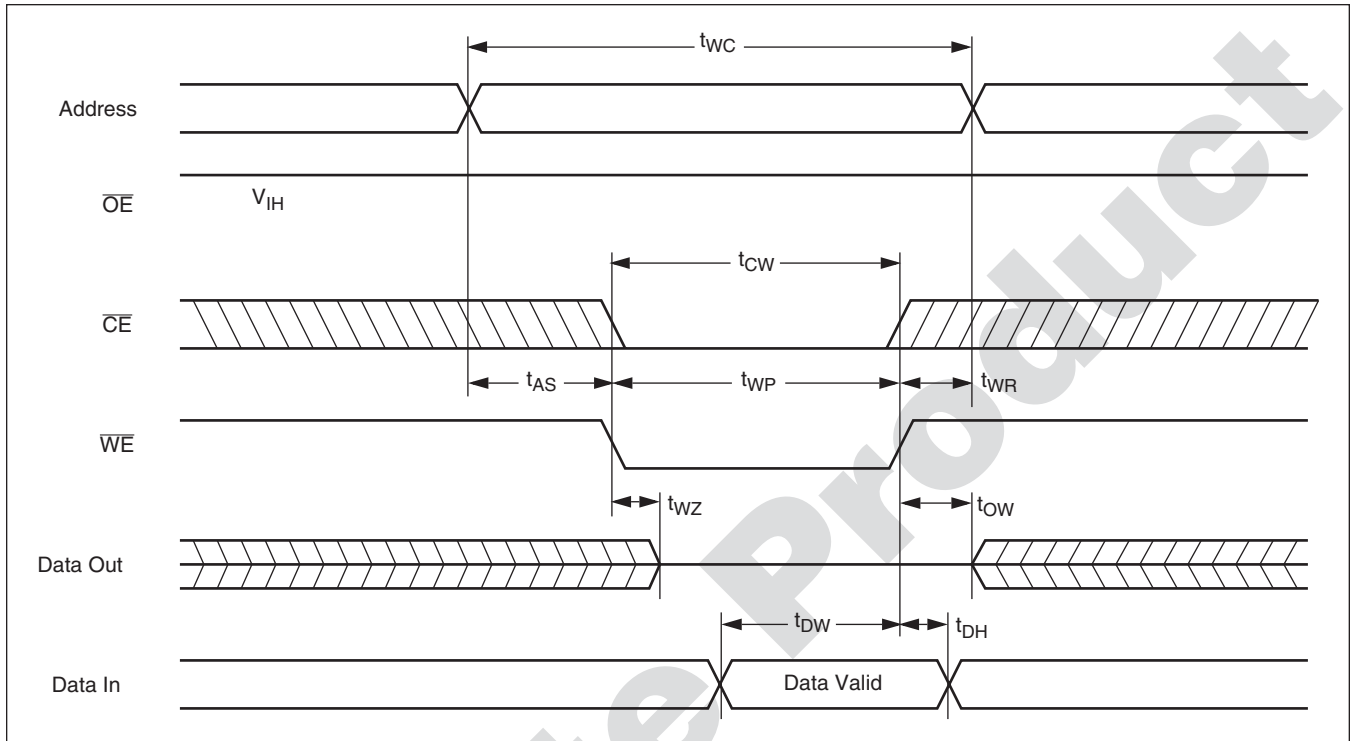
**Note:** (4) These parameters are periodically sampled and not 100% tested.

### $\overline{WE}$ Controlled Write Cycle



# X20CZ16

## $\overline{CE}$ Controlled Write Cycle



## X20CZ16

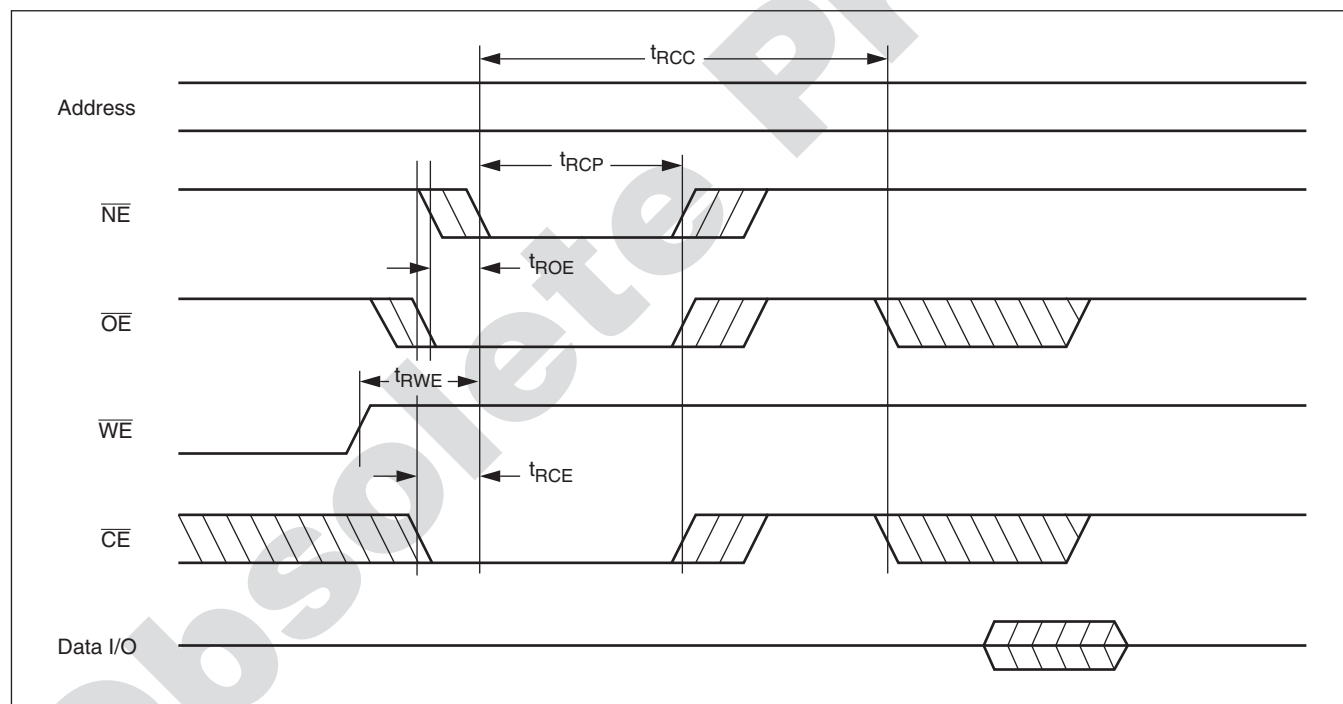
### ARRAY RECALL CYCLE LIMITS<sup>(6)</sup>

Symbol	Parameter	X20CZ16-35		Unit
		Min.	Max.	
$t_{RCC}$	Array recall cycle time		20	$\mu\text{s}$
$t_{RCP}^{(5)}$	Recall pulse width to initiate recall	30		ns
$t_{RWE}$	$\overline{WE}$ setup time to $\overline{NE}$	5		ns
$t_{ROE}$	$\overline{OE}$ setup time to $\overline{NE}$	5		ns
$t_{RCE}$	$\overline{CE}$ setup time to $\overline{NE}$	5		ns

**Notes:** (5) The Recall Pulse Width ( $t_{RCP}$ ) is a minimum time that  $\overline{NE}$ ,  $\overline{OE}$  and  $\overline{CE}$  must be LOW simultaneously to insure data integrity,  $\overline{NE}$  and  $\overline{CE}$ .

(6) The limits shown are for  $\overline{NE}$  initiated recall. The setup times and pulse width requirements for the active signals in  $\overline{CE}$  initiated and  $\overline{OE}$  initiated recalls are identical.

### Array Recall Cycle



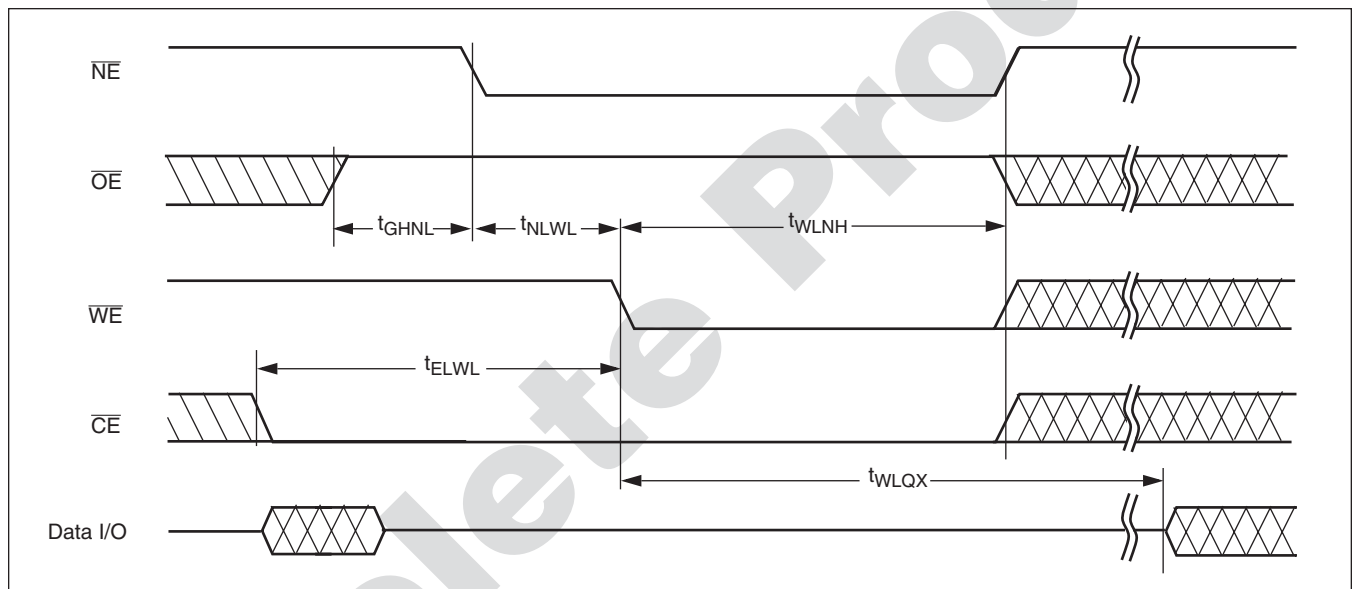


# X20CZ16

## STORE CYCLES

Symbol	Store Cycle $\overline{WE}$ -controlled	X20CZ16-35		Unit
		Min.	Max.	
$t_{WLQX}$	STORE cycle time		10	ms
$t_{WLNH}$	STORE initiation cycle time	30		ns
$t_{GHNL}$	Output disable setup to $\overline{NE}$ fall	5		ns
$t_{NLWL}$	$\overline{NE}$ setup	5		ns
$t_{ELWL}$	Chip enable setup	5		ns

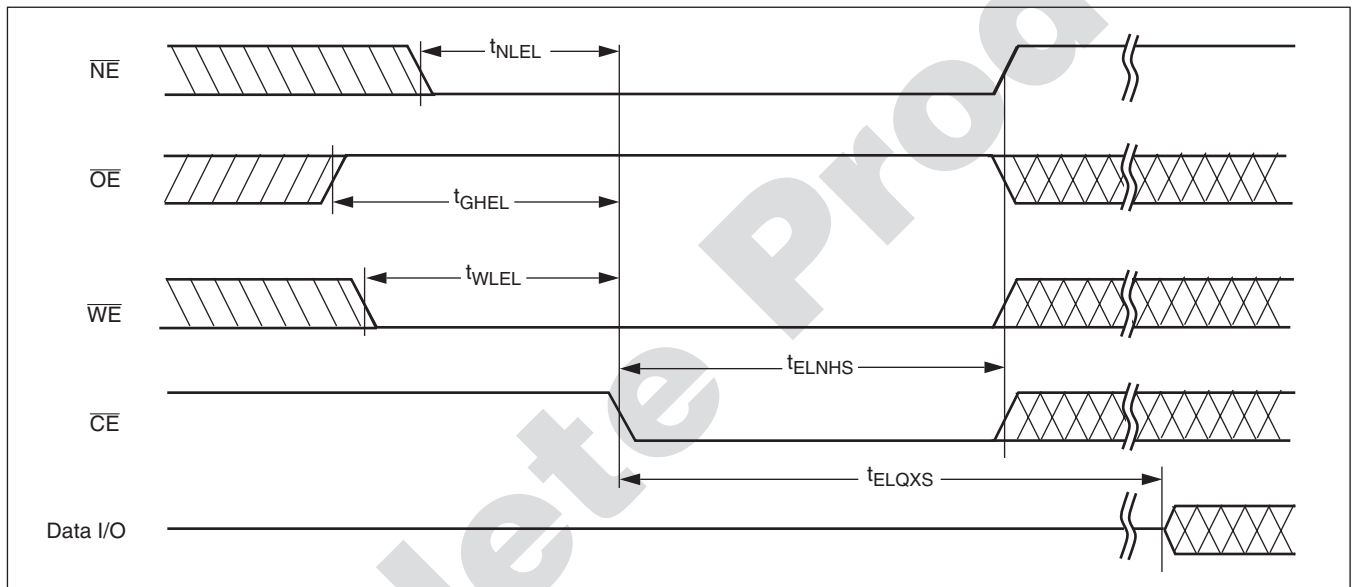
### Store Cycle: $\overline{WE}$ Controlled



# X20CZ16

Symbol	Store Cycle $\overline{CE}$ -controlled	X20CZ16-35		Unit
		Min.	Max.	
$t_{ELQXS}$	STORE cycle time		10	ms
$t_{ELNHS}$	STORE initiation cycle time	30		ns
$t_{GHLEL}$	Output disable setup to $\overline{CE}$ fall	5		ns
$t_{NLEL}$	$\overline{NE}$ setup	5		ns
$t_{WLEL}$	Write enable setup	5		ns

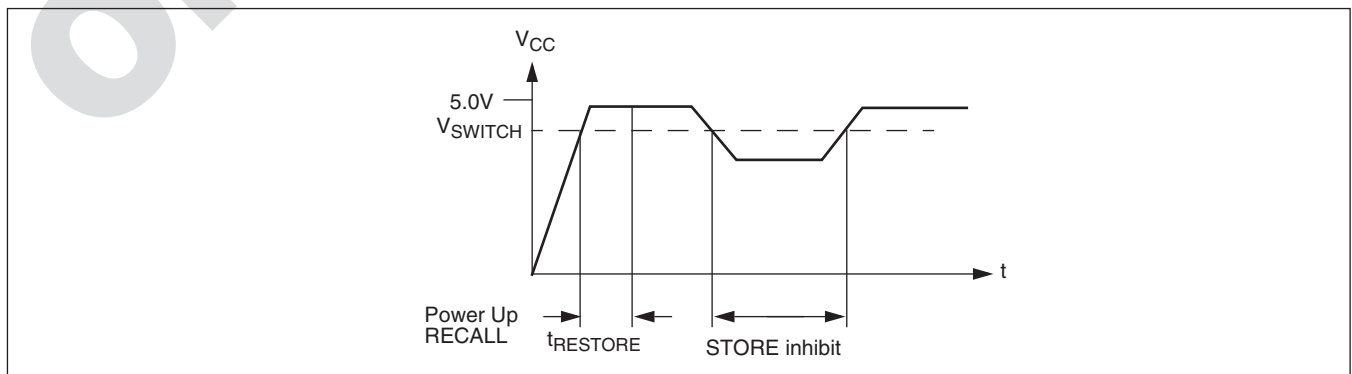
## Store Cycle: $\overline{CE}$ Controlled



## STORE CYCLE INHIBIT AND AUTOMATIC POWER UP RECALL

Symbol	Store Cycle Inhibit and Automatic Power Up RECALL	Min.	Max.	Unit
$t_{RESTORE}$	Power up RECALL duration <sup>(7)(2)</sup>		650	$\mu$ s
$V_{SWITCH}$	Low voltage trigger level	4.0	4.5	V

**Note:** (7)  $t_{RESTORE}$  starts from the time  $V_{CC}$  rises above  $V_{SWITCH}$ .



## X20CZ16

### DETAILED PIN DESCRIPTIONS

#### Addresses (A<sub>0</sub>–A<sub>10</sub>)

The Address inputs select an 8-bit memory location during a read or write operation.

#### Chip Enable ( $\overline{CE}$ )

The Chip Enable input must be LOW to enable all read/write operations. When  $\overline{CE}$  is HIGH, power consumption is reduced.

#### Output Enable ( $\overline{OE}$ )

The Output Enable input controls the data output buffers and is used to initiate read and recall operations. Output Enable LOW disables a store operation regardless of the state of  $\overline{CE}$ ,  $\overline{WE}$ , or  $\overline{NE}$ .

#### Data In/Data Out (I/O<sub>0</sub>–I/O<sub>7</sub>)

Data is written to or read from the X20CZ16 through the I/O pins. The I/O pins are placed in the high impedance state when either  $\overline{CE}$  or  $\overline{OE}$  is HIGH or when  $\overline{NE}$  is LOW.

#### Write Enable ( $\overline{WE}$ )

The Write Enable input controls the writing of data to the static RAM.

#### Nonvolatile Enable ( $\overline{NE}$ )

The Nonvolatile Enable input controls the store and recall function to the EEPROM array.

### DEVICE OPERATION

The X20CZ16 has two separate modes of operation: SRAM mode and nonvolatile mode, determined by the state of the  $\overline{NE}$  pin. In SRAM mode, the memory operates as a standard fast static RAM. In nonvolatile mode, data is transferred from SRAM to EEPROM (the STORE operation) or from EEPROM to SRAM (the RECALL operation). In this mode SRAM functions are disabled.

### SRAM Read

The X20CZ16 performs a READ cycle whenever  $\overline{CE}$  and  $\overline{OE}$  are LOW while  $\overline{WE}$  and  $\overline{NE}$  are HIGH. The address specified on pads A0–A10 determines which of the 2048 data bytes will be accessed. When the READ is initiated by an address transition, the outputs will be valid after a delay of  $t_{RC}$ . If the READ is initiated by  $\overline{CE}$  or  $\overline{OE}$ , the outputs will be valid at  $t_{CE}$  or at  $t_{OE}$ , whichever is later. The data outputs will repeatedly respond to address changes within the  $t_{RC}$  access time without the need for transition on any control input pins, and will remain valid until another address change or until  $\overline{CE}$  or  $\overline{OE}$  is brought HIGH or  $\overline{WE}$  or  $\overline{NE}$  is brought LOW.

### SRAM Write

A WRITE cycle is performed whenever  $\overline{CE}$  and  $\overline{WE}$  are LOW and  $\overline{NE}$  is HIGH. The address inputs must be stable prior to entering the WRITE cycle and must remain stable until either  $\overline{CE}$  or  $\overline{WE}$  goes HIGH at the end of the cycle. The data on pins DQ0–7 will be written into the memory if it is valid  $t_{DW}$  before the end of a  $\overline{WE}$  controlled WRITE or  $t_{DW}$  before the end of a  $\overline{CE}$  controlled WRITE.

It is recommended that  $\overline{OE}$  is kept HIGH during the entire WRITE cycle to avoid data bus contention on the common I/O lines. If  $\overline{OE}$  is left LOW, internal circuitry will turn off the output buffers  $t_{WZ}$  after  $\overline{WE}$  goes LOW.

### Noise Consideration

The X20CZ16 is a high speed memory and therefore must have a high frequency bypass capacitor of approximately 0.1  $\mu$ F connected between  $V_{CC}$  and  $V_{SS}$  using leads and traces that are as short as possible. As with all high speed CMOS ICs, normal careful routing of power, ground and signals will help prevent noise problems.

### Hardware Nonvolatile STORE

A STORE cycle is performed when  $\overline{NE}$ ,  $\overline{CE}$  and  $\overline{WE}$  are LOW while  $\overline{OE}$  is HIGH. While any sequence to achieve this state will initiate a STORE, only  $\overline{WE}$  initiation and  $\overline{CE}$  initiation are practical without risking an unintentional SRAM WRITE that would disturb SRAM data. During a STORE cycle, previous nonvolatile data is erased the SRAM contents are then programmed into nonvolatile elements. Once a STORE cycle is initiated, further input and output is disabled and the DQ0–7 pins are tristated until the cycle is completed.

## X20CZ16

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If  $\overline{CE}$  and  $\overline{OE}$  are LOW and  $\overline{WE}$  and  $\overline{NE}$  are HIGH at the end of the cycle, a READ will be performed and the outputs will go active, indicating the end of the STORE.

### Hardware Nonvolatile RECALL

A RECALL cycle is performed when  $\overline{CE}$ ,  $\overline{OE}$  and  $\overline{NE}$  are LOW while  $\overline{WE}$  is HIGH. Like the STORE cycle, RECALL is initiated when the last of the three clock-signals goes to the RECALL state. Once initiated, the RECALL cycle will complete, during which all inputs are ignored. When the RECALL completes, any READ or WRITE state on the input pins will take effect.

Internally, RECALL is a two step procedure. First, the SRAM data is cleared and second, the nonvolatile information is transferred into the SRAM cells. The RECALL in no way alters the data in the nonvolatile cells. The nonvolatile data can be recalled an unlimited number of times.

Like the STORE cycle, a transition must occur on some control pins to cause a RECALL, preventing inadvertent multi-triggering.

### Automatic Power Up RECALL

On power up, once  $V_{CC}$  exceeds the sense voltage of  $V_{SWITCH}$ , a RECALL cycle is automatically initiated. The voltage on the  $V_{CC}$  pin must not drop below  $V_{SWITCH}$  once it has risen above it in order for the RECALL to operate properly. Due to this automatic RECALL, SRAM operation cannot commence until  $t_{RESTORE}$  after  $V_{CC}$  exceeds  $V_{SWITCH}$ . If the X20CZ16 is in a WRITE state at the end of power up RECALL, the SRAM data will be corrupted.

To help avoid this situation, a 10 K $\Omega$  resistor should be connected between  $\overline{WE}$  and system  $V_{CC}$ .

### Hardware Protection

The X20CZ16 offers two levels of protection to suppress inadvertent STORE cycles. If the control signals ( $\overline{CE}$ ,  $\overline{OE}$ ,  $\overline{WE}$  and  $\overline{NE}$ ) remain in the STORE condition at the end of a STORE cycle, a second STORE cycle will not be started. The STORE (or RECALL) will be initiated only after a transition on any one of these signals to the required state. In addition to multi-trigger protection, the X20CZ16 offers hardware protection through  $V_{CC}$  Sense. When  $V_{CC} < V_{SWITCH}$  the externally initiated STORE operation will be inhibited.

### Low Average Active Power

The X20CZ16 has been designed to draw significantly less power when  $\overline{WE}$  is LOW (chip enabled) but the access cycle time is longer than 55 ns.

When  $\overline{WE}$  is HIGH the chip consumes only standby current.

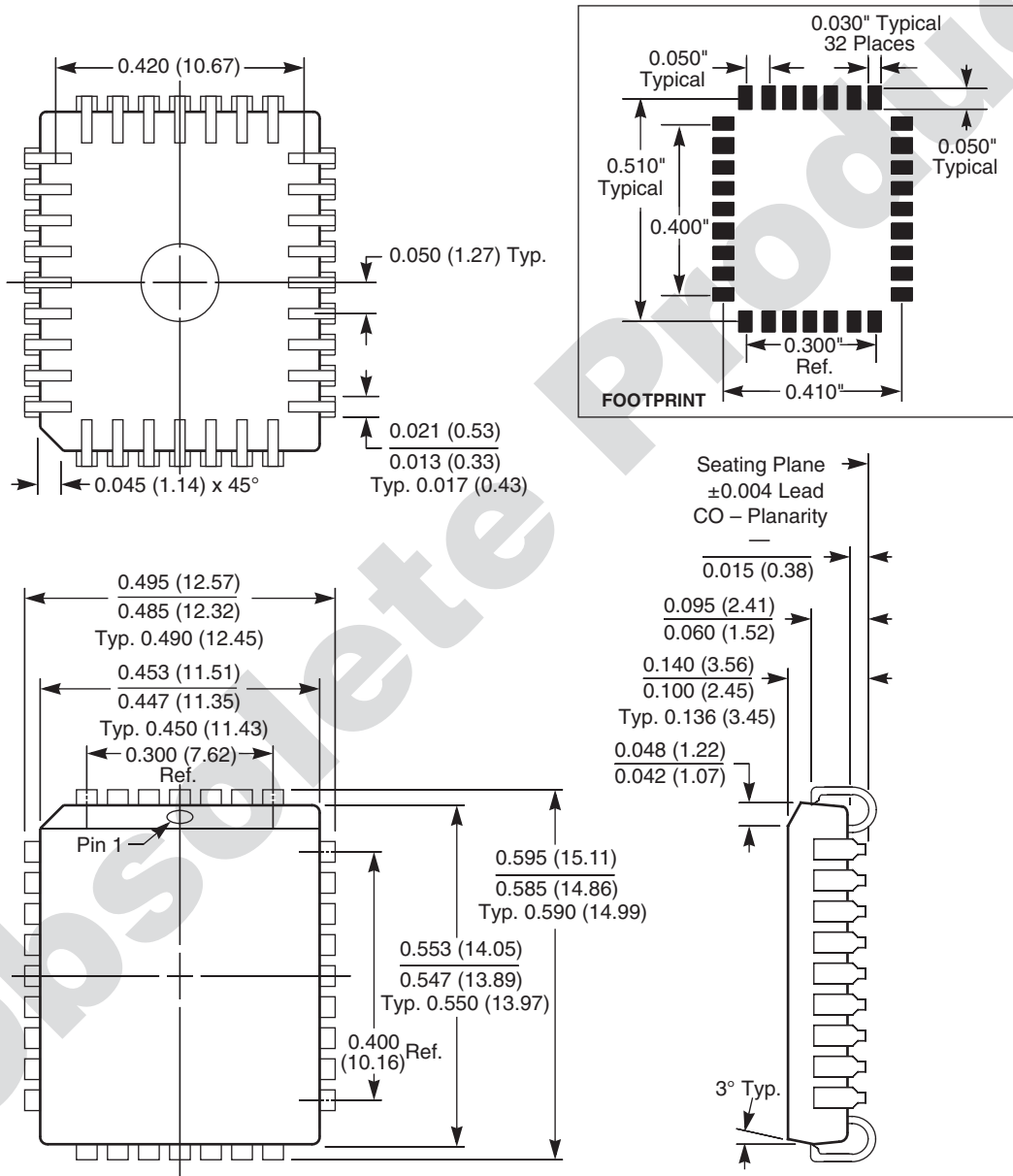
The overall average current drawn by the part depends on the following items:

1. CMOS or TTL input levels
2. The time during which the chip is disabled ( $\overline{CE}$  HIGH)
3. The cycle time for accesses ( $\overline{CE}$  LOW)
4. The ratio of READs to WRITEs
5. The operating temperature
6. The  $V_{CC}$  level

# X20CZ16

## PACKAGING INFORMATION

### 32-Lead Plastic, PLCC, Package Code J32



**NOTES:**

1. ALL DIMENSIONS IN INCHES (IN PARENTHESES IN MILLIMETERS)
2. DIMENSIONS WITH NO TOLERANCE FOR REFERENCE ONLY

## X20CZ16

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Obsolete Product

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### LIMITED WARRANTY

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In situations where semiconductor component failure may endanger life, system designers using this product should design the system with appropriate error detection and correction, redundancy and back-up features to prevent such an occurrence.

Xicor's products are not authorized for use in critical components in life support devices or systems.

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
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