

**Description**

The NEC μPD416 is a 16,384-word by 1-bit dynamic MOS Random-access Memory. It is designed for memory applications where very low cost and large bit storage are important design objectives.

The μPD416 is fabricated using a double-poly-layer, N-channel, silicon-gate process which affords high storage cell density and high performance. The use of dynamic circuitry throughout, including the sense amplifiers, assures minimal power dissipation.

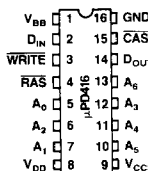
Multiplexed address inputs permit the μPD416 to be packaged in the standard 16-pin dual-in-line package. The 16-pin package provides the highest system bit densities and is available in either ceramic or plastic. Noncritical clock timing requirements allow use of the multiplexing technique while maintaining high performance.

**Features**

- 16,384-word x 1-bit organization
- High memory density: 16-pin ceramic or plastic packages
- Multiplexed address inputs
- Standard power supplies: +12V, -5V, +5V
- Low power dissipation: 462mw active (max), 20mw standby (max)
- Output data controlled by  $\overline{\text{CAS}}$  and unlatched at end of cycle
- Read-modify-write,  $\overline{\text{RAS}}$ -only refresh, and page mode capability
- All inputs TTL-compatible and low capacitance
- 128 refresh cycles
- 3 performance ranges:

Device	Access Time	R/W Cycle	RMW Cycle
μPD416-2	200ns	375ns	375ns
μPD416-3	150ns	320ns	320ns
μPD416-5	120ns	320ns	320ns

**Pin Configuration**



**Pin Identification**

Pin		
No.	Symbol	Function
1	V <sub>BB</sub>	-5V power supply
2	D <sub>IN</sub>	Data-in
3	WRITE	Read/write
4	RAS	Row address strobe
5-7, 10-13	A <sub>0</sub> -A <sub>8</sub>	Address inputs
8	V <sub>DD</sub>	+12V power supply
9	V <sub>CC</sub>	+5V power supply
14	D <sub>OUT</sub>	Data-out
15	CAS	Column address strobe
16	GND	Ground

**Absolute Maximum Ratings\***

Operating Temperature, T <sub>OPR</sub>	0°C to +70°C
Storage Temperature, T <sub>STG</sub>	-55°C to +150°C
All Output Voltages, V <sub>O</sub> ①	-0.5V to +20V
All Input Voltages, V <sub>I</sub> ①	-0.5V to +20V
Supply Voltages V <sub>DD</sub> , V <sub>CC</sub> , GND ①	-0.5V to +20V
Supply Voltages V <sub>DD</sub> , V <sub>CC</sub> ②	-1.0V to +15V
Short-circuit Output Current	50mA
Power Dissipation, P <sub>D</sub>	1w

Notes: ① Relative to V<sub>BB</sub>.  
 ② Relative to GND.

\* COMMENT: Exposing the device to stresses above those listed in Absolute Maximum Ratings could cause permanent damage. The device is not meant to be operated under conditions outside the limits described in the operational sections of this specification. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Capacitance**

T<sub>A</sub> = 0°C to +70°C; V<sub>DD</sub> = +12V ± 10%;  
 V<sub>BB</sub> = -5V ± 10%; V<sub>CC</sub> = +5V ± 10%; GND = 0V

Parameter	Symbol	Limits			Unit	Test Conditions
		Min	Typ	Max		
Input Capacitance (A <sub>0</sub> -A <sub>8</sub> ), D <sub>IN</sub>	C <sub>I1</sub>		4	5	pF	
Input Capacitance RAS, CAS, WRITE	C <sub>I2</sub>		8	10	pF	
Output Capacitance (D <sub>OUT</sub> )	C <sub>O</sub>		5	7	pF	



**Operational Description**

**Addressing**

The 14 address bits required to decode 1 of 16,384-bit locations are multiplexed on to the 7 address pins and then latched on the chip with the use of the row address strobe ( $\overline{RAS}$ ), and the column address strobe ( $\overline{CAS}$ ). The 7-bit row address is first applied and  $\overline{RAS}$  is then brought low. After the  $\overline{RAS}$  hold time has elapsed, the 7-bit column address is applied and  $\overline{CAS}$  is brought low. Since the column address is not needed internally until a time of  $t_{CRD}$  max after the row address, this multiplexing operation imposes no penalty on access time as long as  $\overline{CAS}$  is applied no later than  $t_{CRD}$  max. If this time is exceeded, access time will be defined from  $\overline{CAS}$  instead of  $\overline{RAS}$ .

**Data I/O**

For a write operation, the input data is latched on the chip by the negative going edge of  $\overline{WRITE}$  or  $\overline{CAS}$ , whichever occurs later. If  $\overline{WRITE}$  is active before  $\overline{CAS}$ , this is an "early-write" cycle and data-out will remain in the high impedance state throughout the cycle. For a read, write, or read-modify-write cycle, the data output will contain the data in the selected cell after the access time. Data-out will assume the high impedance state anytime that  $\overline{CAS}$  goes high.

**Page Mode**

The page mode feature allows the  $\mu$ PD416 to be read or written at multiple column addresses for the same row address. This is accomplished by maintaining a low on  $\overline{RAS}$  and strobing the new column address with  $\overline{CAS}$ . This eliminates the set-up and hold times for the row address resulting in faster operation.

**Refresh**

Refresh of the memory matrix is accomplished by performing a memory cycle at each of the 128-row addresses every 2 milliseconds or less. Because data-out is not latched,  $\overline{RAS}$ -only cycles can be used for a simple refresh operation.

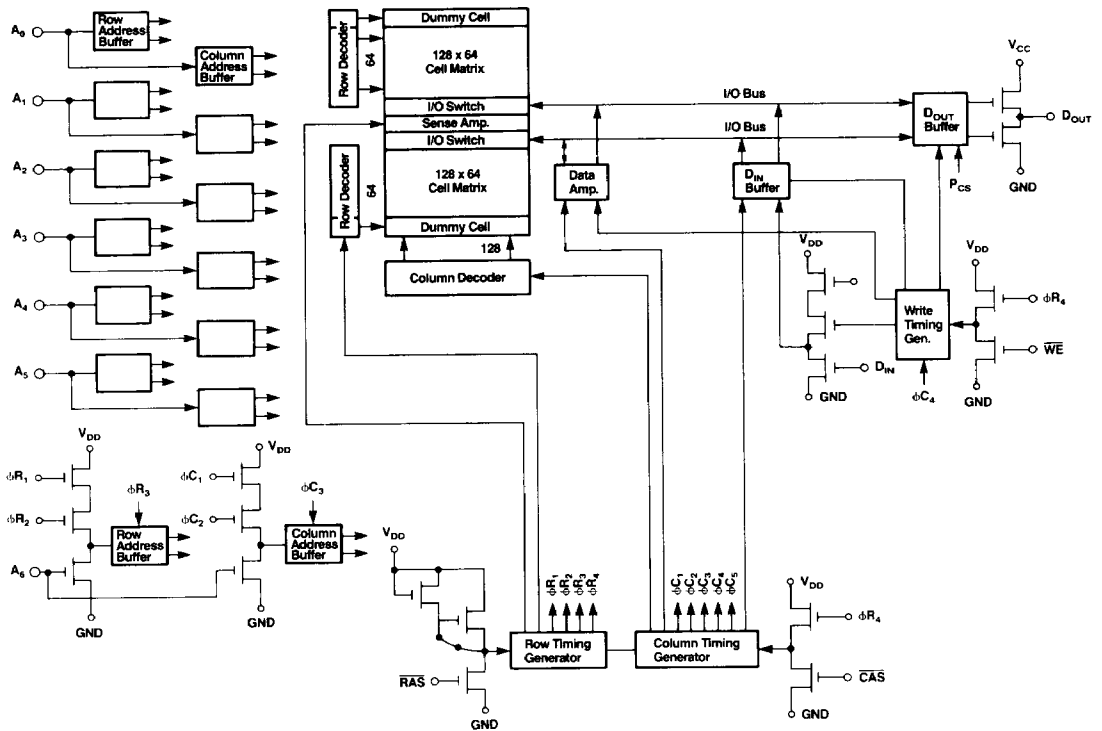
**Chip Selection**

Either  $\overline{RAS}$  and/or  $\overline{CAS}$  can be decoded for chip-select function. Unselected chip outputs will remain in the high impedance state.

**Power Sequencing**

In order to assure long-term reliability,  $V_{BB}$  should be applied first during power-up and removed last during power-down.

**Block Diagram**



## AC Characteristics

$T_A = 0^\circ\text{C to } +70^\circ\text{C}; V_{DD} = +12\text{V} \pm 10\%;$   
 $V_{CC} = +5\text{V} \pm 10\%; V_{BB} = -5\text{V} \pm 10\%; \text{GND} = 0\text{V}$

Parameter	Symbol	Limits						Unit	Test Conditions
		μPD416-2		μPD416-3		μPD416-5			
		Min	Max	Min	Max	Min	Max		
Random Read or Write Cycle Time	$t_{RC}$	375	320		320		ns	②	
Read-Write Cycle Time	$t_{RWC}$	375	375		320		ns	②	
Page Mode Cycle Time	$t_{PC}$	225	170		160		ns		
Access Time from RAS	$t_{RAC}$		200		150		120	ns	③ ④
Access Time from CAS	$t_{CAC}$		135		100		80	ns	④ ⑤
Output Buffer Turn-off Delay	$t_{OFF}$	0	50	0	40	0	35	ns	⑥
Transition Times (rise and fall)	$t_T$	3	50	3	35	3	35	ns	⑦
RAS Precharge Time	$t_{RP}$	120		100		100		ns	
RAS Pulse Width	$t_{RAS}$	200	32,000	150	32,000	120	10,000	ns	
RAS Hold Time	$t_{RSH}$	135		100		80		ns	
CAS Pulse Width	$t_{CAS}$	135	10,000	100	10,000	80	10,000	ns	
RAS to CAS Delay Time	$t_{RCD}$	25	65	20	50	15	40	ns	⑧
CAS to RAS Precharge Time	$t_{CRP}$	-20		-20		0		ns	
Row Address Set-up Time	$t_{ASR}$	0		0		0		ns	
Row Address Hold Time	$t_{RAH}$	25		20		15		ns	
Column Address Set-up Time	$t_{ASC}$	-10		-10		-10		ns	
Column Address Hold Time	$t_{CAH}$	55		45		40		ns	
Column Address Hold Time Referenced to RAS	$t_{AR}$	120		95		80		ns	
Read Command Set-up Time	$t_{RCS}$	0		0		0		ns	
Read Command Hold Time	$t_{RCH}$	0		0		0		ns	
Write Command Hold Time	$t_{WCH}$	55		45		40		ns	
Write Command Hold Time Referenced to RAS	$t_{WCR}$	120		95		80		ns	
Write Command Pulse Width	$t_{WP}$	55		45		40		ns	
Write Command to RAS Lead Time	$t_{RWL}$	70		50		50		ns	
Write Command to CAS Lead Time	$t_{CWL}$	70		50		50		ns	
Data-in Set-up Time	$t_{DS}$	0		0		0		ns	⑨
Data-in Hold Time	$t_{DH}$	55		45		40		ns	⑨
Data-in Hold Time Referenced to RAS	$t_{DHR}$	120		95		80		ns	
CAS Precharge Time (for page mode cycle only)	$t_{CP}$	80		60		60		ns	
Refresh Period	$t_{REF}$		2		2		2	ms	
Write Command Set-up Time	$t_{WCS}$	-20		-20		0		ns	⑩
CAS to WRITE Delay	$t_{CWD}$	95		70		80		ns	⑩
RAS to WRITE Delay	$t_{RWD}$	160		120		120		ns	⑩

- Notes:**
- ① AC measurements assume  $t_T = 5\text{ns}$ .
  - ② The specifications for  $t_{RC}$  (min) and  $t_{RWC}$  (min) are used only to indicate cycle time at which proper operation over the full temperature range ( $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$ ) is assured.
  - ③ Assumes that  $t_{RCD} \leq t_{ACD}$  (max). If  $t_{RCD}$  is greater than the maximum recommended value shown in this table,  $t_{RAC}$  will increase by the amount that  $t_{RCD}$  exceeds the values shown.
  - ④ Measured with a load equivalent to 2 TTL loads and 100pF.

- ⑤ Assumes that  $t_{ACD} \geq t_{RCD}$  (max).
- ⑥  $t_{OFF}$  (max) defines the time at which the output achieves the open-circuit condition and is not referenced to output voltage levels.
- ⑦  $V_{IH}$  (min) or  $V_{IH}$  (min) and  $V_{IL}$  (max) are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{IH}$  or  $V_{IH}$  and  $V_{IL}$ .
- ⑧ Operation within the  $t_{ACD}$  (max) limit ensures that  $t_{RAC}$  (max) can be met.  $t_{RCD}$  (max) is specified as a reference point only. If  $t_{RCD}$  is greater than the specified  $t_{ACD}$  (max) limit, access time is controlled exclusively by  $t_{CAC}$ .
- ⑨ These parameters are referenced to CAS leading edge in early write cycles and to WRITE leading edge in delayed write or read-modify-write cycles.
- ⑩  $t_{WCS}$ ,  $t_{CWD}$  and  $t_{RWD}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If  $t_{WCS} \geq t_{WCS}$  (min), the cycle is an early write cycle and the data-out pin will remain open circuit (high impedance); if  $t_{CWD}$  (min), the cycle is a read-write cycle and the data-out will contain data read from the selected cell. If neither of the above sets of conditions is satisfied the condition of the data-out (at access time) is indeterminate.

## DC Characteristics

$T_A = 0^\circ\text{C to } +70^\circ\text{C}; ① V_{DD} = +12\text{V} \pm 10\%;$   
 $V_{CC} = +5\text{V} \pm 10\%; V_{BB} = -5\text{V} \pm 10\%; \text{GND} = 0\text{V}$

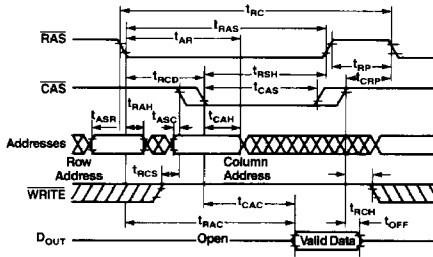
Parameter	Symbol	Limits			Unit	Test Conditions
		Min	Typ	Max		
Supply Voltage	$V_{DD}$	10.8	12.0	13.2	V	②
Supply Voltage	$V_{CC}$	4.5	5.0	5.5	V	② ③
Supply Voltage	GND	0	0	0	V	②
Supply Voltage	$V_{BB}$	-4.5	-5.0	-5.5	V	②
Input High Voltage (Logic 1), RAS, CAS, WRITE	$V_{IH}$	2.7		7.0	V	②
Input High Voltage (Logic 1), (all inputs except RAS, CAS, WRITE)	$V_{IH}$	2.4		7.0	V	②
Input Low Voltage (Logic 0), (all inputs)	$V_{IL}$	-1.0		0.8	V	②
Operating $V_{DD}$ Current	$I_{DD1}$			35	mA	RAS, CAS, cycling; $t_{RC} = t_{RC\text{ min}}$ ④
Standby $V_{DD}$ Current	$I_{DD2}$			1.5	mA	RAS = $V_{IH}$ ; $D_{OUT} = \text{high impedance}$
Refresh $V_{DD}$ Current (μPD416-5)	$I_{DD3}$			27	mA	RAS cycling; CAS = $V_{IH}$ ; $t_{RC} = 375\text{ns}$ ④
Refresh $V_{DD}$ Current (all speeds except μPD416-5)	$I_{DD3}$			25	mA	
Page Mode $V_{DD}$ Current	$I_{DD4}$			27	mA	RAS = $V_{IL}$ ; CAS cycling; $t_{PC} = 225\text{ns}$ ④
Operating $V_{CC}$ Current	$I_{CC1}$				μA	RAS, CAS cycling; $t_{RC} = 375\text{ns}$ ⑤
Standby $V_{CC}$ Current	$I_{CC2}$	-10		10	μA	RAS = $V_{IH}$ ; $D_{OUT} = \text{high impedance}$
Refresh $V_{CC}$ Current	$I_{CC3}$	-10		10	μA	RAS cycling; CAS = $V_{IH}$ ; $t_{RC} = 375\text{ns}$
Page Mode $V_{CC}$ Current	$I_{CC4}$				μA	RAS = $V_{IL}$ ; CAS cycling; $t_{PC} = 225\text{ns}$ ⑤
Operating $V_{BB}$ Current	$I_{BB1}$			200	μA	RAS, CAS cycling; $t_{RC} = 375\text{ns}$
Standby $V_{BB}$ Current	$I_{BB2}$			100	μA	RAS = $V_{IH}$ ; $D_{OUT} = \text{high impedance}$
Refresh $V_{BB}$ Current	$I_{BB3}$			200	μA	RAS cycling; CAS = $V_{IH}$ ; $t_{RC} = 375\text{ns}$
Page Mode $V_{BB}$ Current	$I_{BB4}$			200	μA	RAS = $V_{IL}$ ; CAS cycling; $t_{PC} = 225\text{ns}$
Input Leakage (any input)	$I_{IL}$	-10		10	μA	$V_{BB} = -5\text{V}; 0\text{V} \leq V_{IH} \leq +7\text{V}$ ; all other pins not under test = 0V
Output Leakage	$I_{OL}$	-10		10	μA	$D_{OUT}$ is disabled; $0\text{V} \leq V_{OUT} \leq +5.5\text{V}$
Output High Voltage (Logic 1)	$V_{OH}$	2.4			V	$I_{OUT} = -5\text{mA}$ ③
Output Low Voltage (Logic 0)	$V_{OL}$			0.4	V	$I_{OUT} = 4.2\text{mA}$

- Notes:**
- ①  $T_A$  is specified here for operation at frequencies to  $t_{RC} \geq t_{RC}$  (min). Operation at higher cycle rates with reduced ambient temperatures and high power dissipation is permissible, provided AC operating parameters are met. See Figure 1 for derating curve.
  - ② All voltages referenced to GND.
  - ③ Output voltage will swing from GND to  $V_{CC}$  when activated with no current loading. For purposes of maintaining data in standby mode,  $V_{CC}$  may be reduced to GND without affecting refresh operations or data retention. However, the  $V_{OH}$  (min) specification is not guaranteed in this mode.
  - ④  $I_{DD1}$ ,  $I_{DD3}$  and  $I_{DD4}$  depend on cycle rate. See Figures 2, 3 and 4 for  $I_{DD}$  limits at other cycle rates.
  - ⑤  $I_{CC1}$  and  $I_{CC4}$  depend upon output loading. During readout of high-level data  $V_{CC}$  is connected through a low impedance (135Ω typ) to data-out. At all other times  $I_{CC}$  consists of leakage currents only.

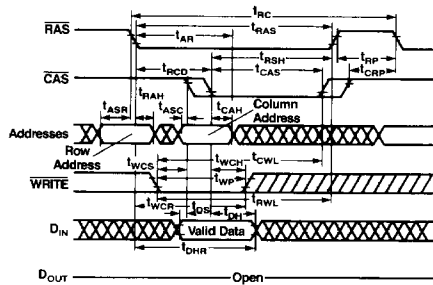
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### Timing Waveforms

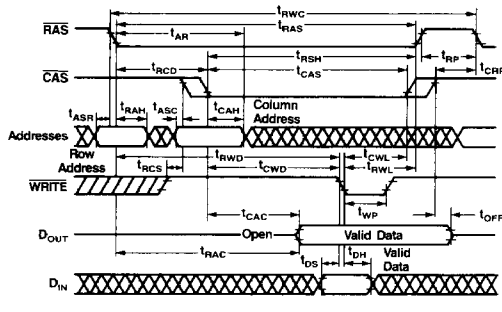
#### Read Cycle



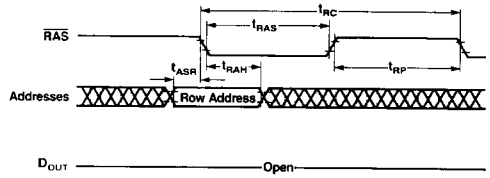
#### Write Cycle



#### Read-Write/Read-Modify-Write Cycle

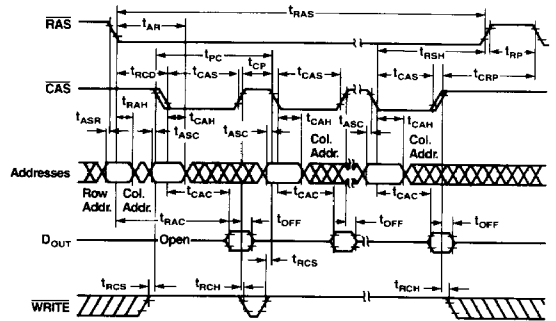


#### RAS-only Refresh Cycle

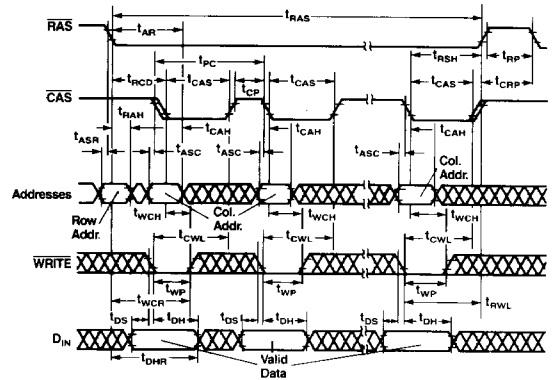


Note: CAS = V<sub>HC</sub>; WRITE = Don't care.

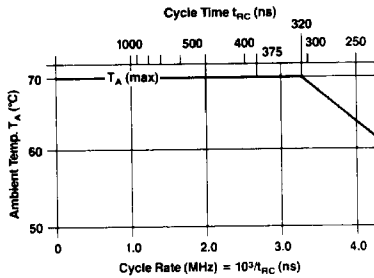
#### Page Mode Read Cycle



#### Page Mode Write Cycle

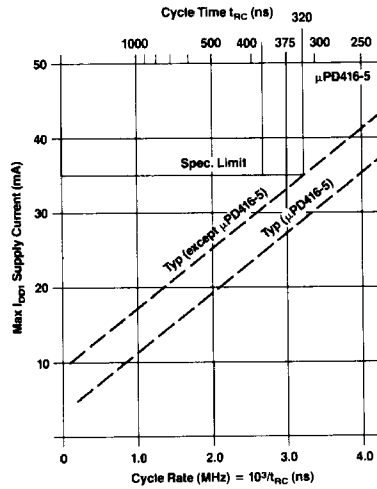


**Derating Curves**

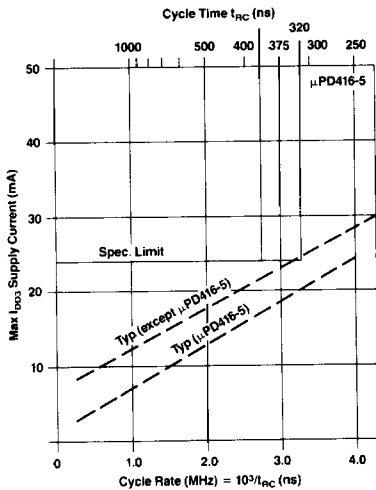


**Figure 1. Maximum Ambient Temperature versus Cycle Rate for Extended Frequency Operation**

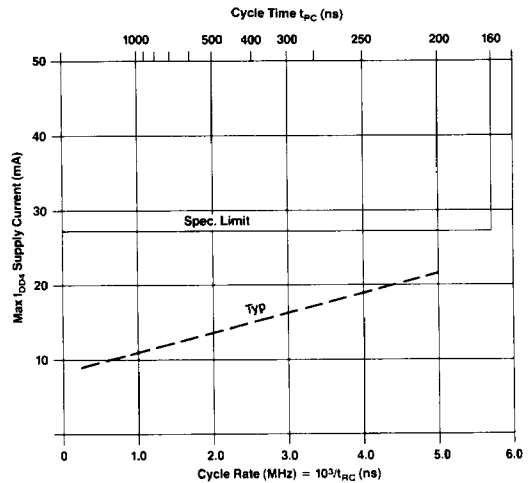
**Note:**  $T_A$  (max) for operation at cycling rates greater than 2.66MHz ( $t_{CYC} < 375ns$ ) is determined by  $T_A$  (max) [°C] = 70 - 9.0 x (cycle rate [MHz] - 2.66). For μPD416-5, it is  $T_A$  (max) [°C] = 70 - 9.0 x (cycle rate [MHz] - 3.125).



**Figure 2. Maximum  $I_{DD1}$  versus Cycle Rate for Device Operation at Extended Frequencies**



**Figure 3. Maximum  $I_{DD3}$  versus Cycle Rate for Device Operation at Extended Frequencies**



**Figure 4. Maximum  $I_{DD4}$  versus Cycle Rate for Device Operation in Page Mode**

**3**

**Package Outlines**

For information, see Section 9.

Plastic, μPD416C  
Ceramic, μPD416D