1M x 1 Bit Dynamic RAM with Fast Page Mode

FEATURES

- **Performance range:**

	t_{RAC}	t_{CAC}	t_{RC}
KM41C1000-10	100ns	25ns	190ns
KM41C1000-12	120ns	30ns	220ns

- **Fast Page Mode operation**
- **$\overline{CAS}$-before-$\overline{RAS}$ refresh**
- **$\overline{RAS}$-only and Hidden Refresh**
- **TTL compatible inputs and output**
- **Common I/O using early write**
- **Single +5V ± 10% power supply**
- **512 cycle/8ms refresh**
- **256K x 4 fast test mode**
- **JEDEC standard pinout available in Plastic DIP, SOJ, ZIP packages.**

GENERAL DESCRIPTION

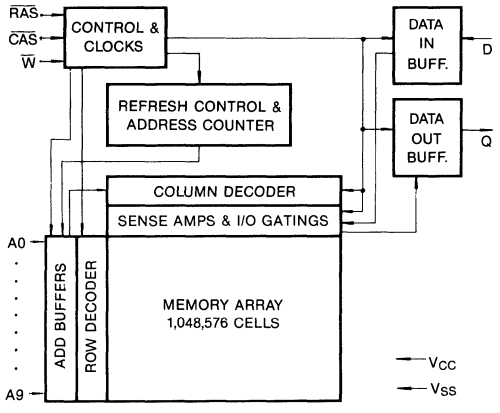
The Samsung KM41C1000 is a CMOS high speed 1,048,576 x 1 Dynamic Random Access Memory. Its design is optimized for high performance applications such as mainframes and mini computers, graphics and high performance microprocessor systems.

The KM41C1000 features Fast Page Mode operation which allows high speed random access of memory cells within the same row.

$\overline{CAS}$-before-$\overline{RAS}$ Refresh capability provides on-chip auto refresh as an alternative to $\overline{RAS}$-only Refresh. All inputs and output are fully TTL compatible.

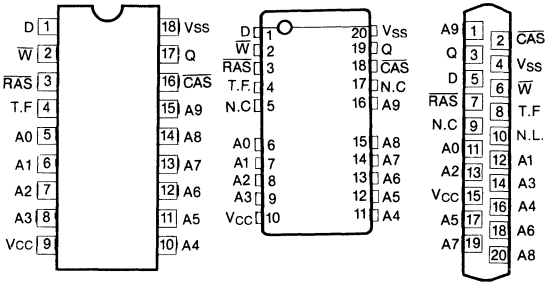
The KM41C1000 is fabricated using Samsung's advanced CMOS process.

FUNCTIONAL BLOCK DIAGRAM



PIN CONFIGURATION

- **KM41C1000P** - **KM41C1000J** - **KM41C1000Z**



Pin Name	Pin Function
A_0-A_9	Address Inputs
$\overline{RAS}$	Row Address Strobe
D	Data In
Q	Data Out
$\overline{CAS}$	Column Address Strobe
$\overline{W}$	Read/Write Input
V_{CC}	Power (+5V)
V_{SS}	Ground
T.F.	Test Function
N.C.	No Connection
N.L.	No Lead

ABSOLUTE MAXIMUM RATINGS*

Parameter	Symbol	Rating	Units
Voltage on any pin relative to V_{SS}	V_{IN}, V_{OUT}	−1 to +7.0	V
Voltage on V_{CC} supply relative to V_{SS}	V_{CC}	−1 to +7.0	V
Storage Temperature	T_{stg}	−55 to +150	°C
Power Dissipation	P_D	0.6	W
Short Circuit Output Current	I_{OS}	50	mA

*Note: Permanent device damage may occur of ABSOLUTE MAXIMUM RATINGS are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS (Voltages referenced to V_{SS}, T_A = 0 to 70°C)

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Ground	V_{SS}	0	0	0	V
Input High Voltage	V_{IH}	2.4	—	6.5	V
Input Low Voltage	V_{IL}	−1.0	—	0.8	V

DC AND OPERATING CHARACTERISTICS

(Recommended operating conditions unless otherwise noted.)

Parameter		Symbol	Min	Max	Units
OPERATING CURRENT* ($\overline{RAS}$ and $\overline{CAS}$ cycling; @t_{RC} = min.)	KM41C1000-10	I_{CC1}	—	60	mA
	KM41C1000-12		—	50	mA
STANDBY CURRENT ($\overline{RAS}$ = $\overline{CAS}$ = V_{IH})		I_{CC2}	—	2	mA
$\overline{RAS}$-ONLY REFRESH CURRENT* ($\overline{CAS}$ = V_{IH}, $\overline{RAS}$ cycling; @t_{RC} = min.)	KM41C1000-10	I_{CC3}	—	60	mA
	KM41C1000-12		—	50	mA
FAST PAGE MODE CURRENT* ($\overline{RAS}$ = V_{IL}, $\overline{CAS}$ cycling; @t_{PC} = min.)	KM41C1000-10	I_{CC4}	—	40	mA
	KM41C1000-12		—	30	mA
STANDBY CURRENT ($\overline{RAS}$ = $\overline{CAS}$ = V_{CC}-0.2V)		I_{CC5}	—	1	mA
$\overline{CAS}$-BEFORE-$\overline{RAS}$ REFRESH CURRENT* ($\overline{RAS}$ and $\overline{CAS}$ cycling @t_{RC} = min.)	KM41C1000-10	I_{CC6}	—	60	mA
	KM41C1000-12		—	50	mA
INPUT LEAKAGE CURRENT (Any input, 0≤V_{IN}≤6.5V, all other pins not under test = 0 volts.)		I_{IL}	−10	10	μA
OUTPUT LEAKAGE CURRENT (Data out is disabled, 0V≤V_{OUT}≤5.5V, Vcc = 5.5V, Vss = 0V,)		I_{OL}	−10	10	μA
OUTPUT HIGH VOLTAGE LEVEL (I_{OH} = −5mA)		V_{OH}	2.4	—	V
OUTPUT LOW VOLTAGE LEVEL (I_{OL} = 4.2mA)		V_{OL}	—	0.4	V

*NOTE: I_{CC1}, I_{CC3}, I_{CC4}, and I_{CC6} are dependent on output loading and cycle rates. Specified values are obtained with the output open. I_{CC} is specified as average current.

CAPACITANCE ($T_A = 25°C$)

Parameter	Symbol	Min	Max	Unit
Input Capacitance (D)	C_{IN1}	—	5	pF
Input Capacitance ($A_0 - A_9$)	C_{IN2}	—	6	pF
Input Capacitance ($\overline{RAS}$, $\overline{CAS}$, $\overline{W}$)	C_{IN3}	—	7	pF
Output Capacitance (Q)	C_{OUT}	—	7	pF

AC CHARACTERISTICS ($0°C \leq T_A \leq 70°C$, $V_{CC} = 5.0V \pm 10\%$. See notes 1,2)

STANDARD OPERATION

Parameter	Symbol	KM41C1000-10		KM41C1000-12		Unit	Notes
		Min	Max	Min	Max		
Random read or write cycle time	t_{RC}	190		220		ns	
Read-modify-write cycle time	t_{RWC}	220		255		ns	
Access time from $\overline{RAS}$	t_{RAC}		100		120	ns	3, 4, 10
Access time from $\overline{CAS}$	t_{CAC}		25		30	ns	3, 4, 5
Access time from column address	t_{AA}		50		60	ns	3, 10
Access time from $\overline{CAS}$ precharge	t_{CPA}		55		65	ns	3
$\overline{CAS}$ to output in Low-Z	t_{CLZ}	5		5		ns	3
Output buffer turn-off delay time	t_{OFF}	0	30	0	35	ns	6
Transition time (rise and fall)	t_T	3	50	3	50	ns	2
$\overline{RAS}$ precharge time	t_{RP}	80		90		ns	
$\overline{RAS}$ pulse width	t_{RAS}	100	10,000	120	10,000	ns	
$\overline{RAS}$ hold time	t_{RSH}	25		30		ns	
$\overline{CAS}$ precharge time (except fast page mode cycle)	t_{CPN}	15		20		ns	
$\overline{CAS}$ pulse width	t_{CAS}	25	10,000	30	10,000	ns	
$\overline{CAS}$ hold time	t_{CSH}	100		120		ns	
$\overline{RAS}$ to $\overline{CAS}$ delay time	t_{RCD}	25	75	25	90	ns	4
$\overline{CAS}$ to $\overline{RAS}$ precharge time	t_{CRP}	10		10		ns	
Row address set-up time	t_{ASR}	0		0		ns	
Row address hold time	t_{RAH}	15		15		ns	
Column address set-up time	t_{ASC}	0		0		ns	
Column address hold time	t_{CAH}	20		25		ns	
Column address hold time referenced to $\overline{RAS}$	t_{AR}	95		115		ns	
Column Address to $\overline{RAS}$ lead time	t_{RAL}	50		60		ns	
$\overline{RAS}$ to column address delay time	t_{RAD}	20	50	20	60	ns	10
Read command set-up time	t_{RCS}	0		0		ns	
Read command hold time referenced to $\overline{CAS}$	t_{RCH}	0		0		ns	8

STANDARD OPERATION (Continued)

Parameter	Symbol	KM41C1000-10		KM41C1000-12		Unit	Notes
		Min	Max	Min	Max		
Read command hold time referenced to $\overline{RAS}$	t_{RRH}	0		0		ns	8
Write command set-up time	t_{WCS}	0		0		ns	7
Write command hold time	t_{WCH}	20		25		ns	
Write command pulse width	t_{WP}	20		25		ns	
Write command to $\overline{RAS}$ lead time	t_{RWL}	25		30		ns	
Write command to $\overline{CAS}$ lead time	t_{CWL}	25		30		ns	
Data-in set-up time	t_{DS}	0		0		ns	9
Data-in hold time	t_{DH}	20		25		ns	9
$\overline{CAS}$ to write enable delay time	t_{CWD}	25		30		ns	7
$\overline{RAS}$ to write enable delay time	t_{RWD}	100		120		ns	7
Column address to $\overline{W}$ delay time	t_{AWD}	50		60		ns	7
Write command hold time referenced to $\overline{RAS}$	t_{WCR}	95		115		ns	
Data-in hold time referenced to $\overline{RAS}$	t_{DHR}	95		115		ns	
Refresh period (512 cycles)	t_{REF}		8		8	ms	

FAST PAGE MODE

Page mode cycle time	t_{PC}	60		70		ns	
$\overline{CAS}$ precharge time (fast page mode)	t_{CP}	10		15		ns	
Fast page mode read-modify-write	t_{PRWC}	90		105		ns	
$\overline{RAS}$ pulse width (Fast page mode)	t_{RASP}	100	100,000	120	100,000	ns	

$\overline{CAS}$-BEFORE-$\overline{RAS}$ REFRESH

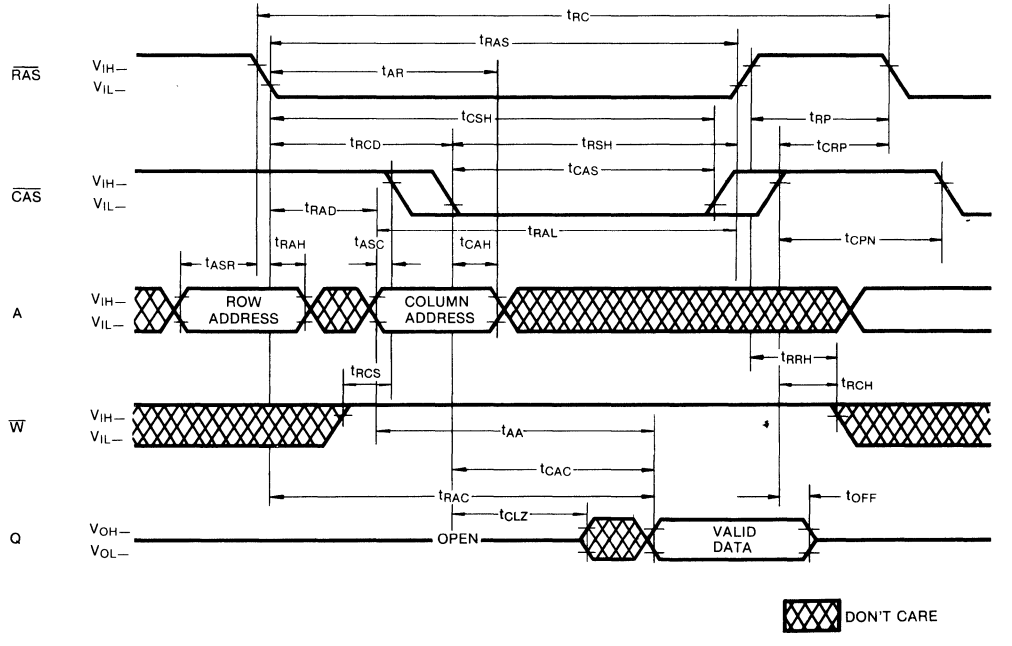
$\overline{CAS}$ setup time ($\overline{CAS}$-before-$\overline{RAS}$ refresh)	t_{CSR}	10		10		ns	
$\overline{CAS}$ hold time ($\overline{CAS}$-before-$\overline{RAS}$ refresh)	t_{CHR}	30		30		ns	
$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	t_{RPC}	10		10		ns	
Refresh counter test $\overline{CAS}$ precharge time	t_{CPT}	50		60		ns	

NOTES

1. An initial pause of 200μs is required after power up followed by any 8 $\overline{RAS}$ cycles before proper device operation is achieved.
2. V_{IH}(min) and V_{IL}(max) are reference levels for measuring timing of input signals. Transition times are measured between V_{IH}(min) and V_{IL}(max), and are assumed to be 5ns for all inputs.
3. Measured with a load equivalent to 2 TTL loads and 100pF.
4. Operation within the t_{RCD}(max) limit insures 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_{RCD}(max) limit, then access time is controlled exclusively by t_{CAC}.
5. Assumes that $t_{RCD} \geq t_{RCD}$(max).
6. This parameter defines the time at which the output achieves the open circuit condition and is not referenced to V_{OH} or V_{OL}.
7. t_{WCS}, t_{RWD}, t_{CWD} and t_{AWD} are non 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 output will remain open circuit throughout the entire cycle. If $t_{CWD} \geq t_{CWD}$(min) and $t_{RWD} \geq t_{RWD}$(min) and $t_{AWD} \geq t_{AWD}$ (min), then the cycle is a read-write cycle and the data output will contain data read from the selected cell. If neither of the above conditions are satisfied, the condition of the data out is indeterminate.
8. Either t_{RCH} or t_{RRH} must be satisfied a read cycle.
9. These parameters are referenced to the $\overline{CAS}$ leading edge in early write cycles and to the $\overline{W}$ leading edge in read-write cycles.
10. Operation within the t_{RAD} (max) limit insures that t_{RAC} (max) can be met. t_{RAD} (max) is specified as a reference point only. If t_{RAD} is greater than the specified t_{RAD} (max) limit, then access time is controlled by t_{AA}.
11. Normal operation requires the "T.F" pin to be connected to V_{SS} or TTL logic low level or left unconnected on the printed wiring board.
12. When the "T.F" pin is connected to a defined positive voltage, the internal test function may be activated. Contact Samsung Semiconductor for specific operational details of the "test function".

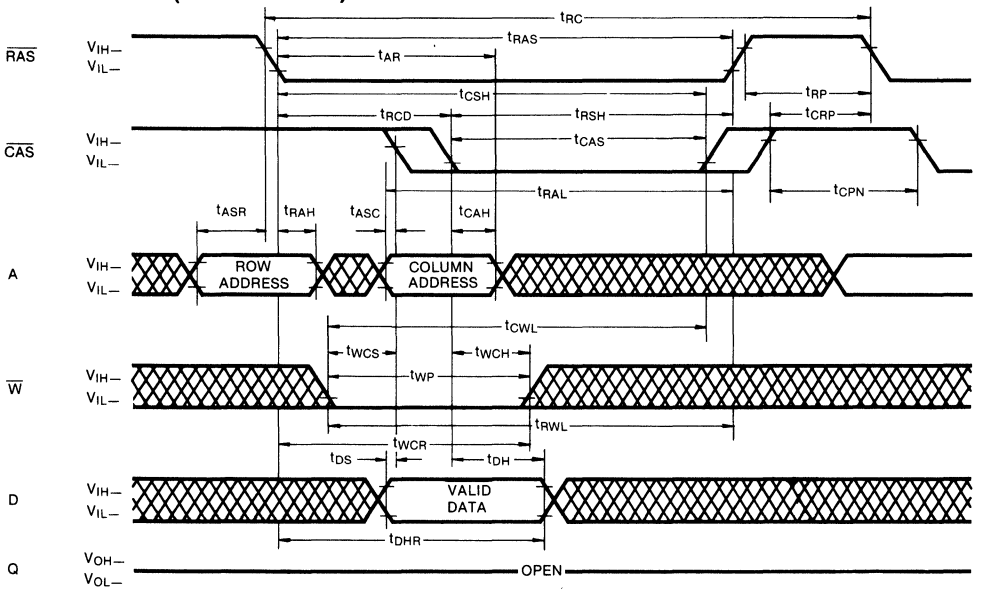
TIMING DIAGRAMS

READ CYCLE

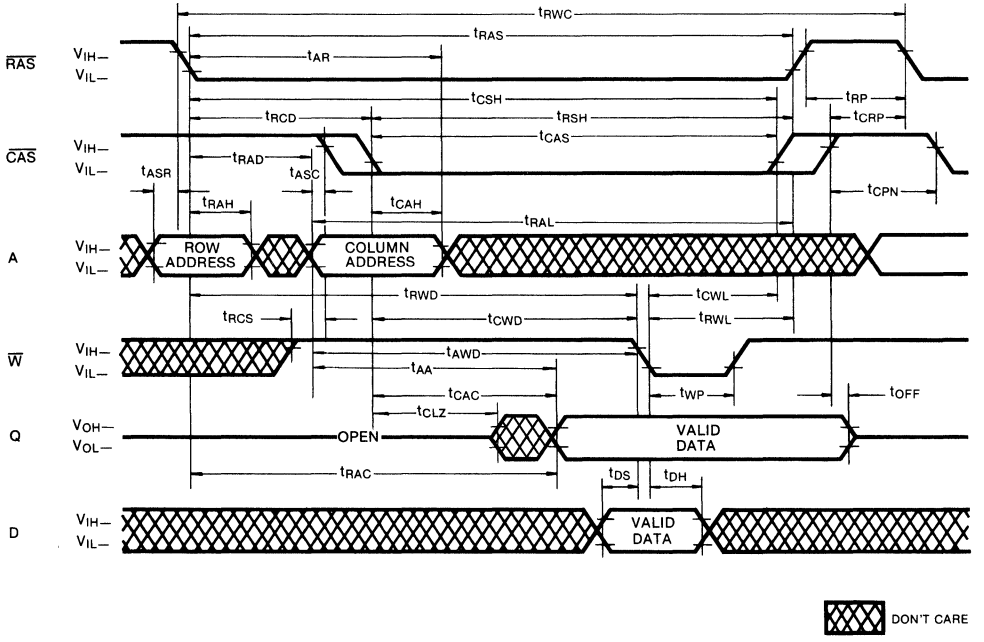


TIMING DIAGRAMS (Continued)

WRITE CYCLE (EARLY WRITE)

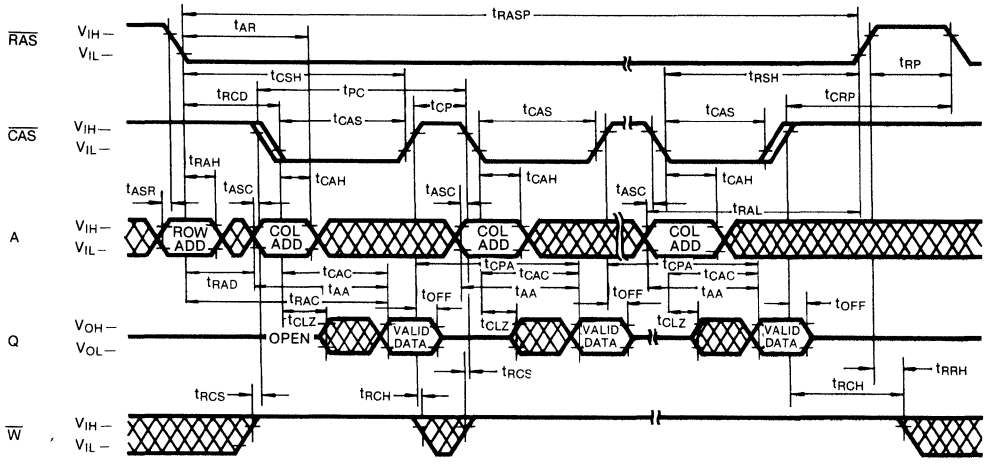


READ-WRITE/READ-MODIFY-WRITE CYCLE

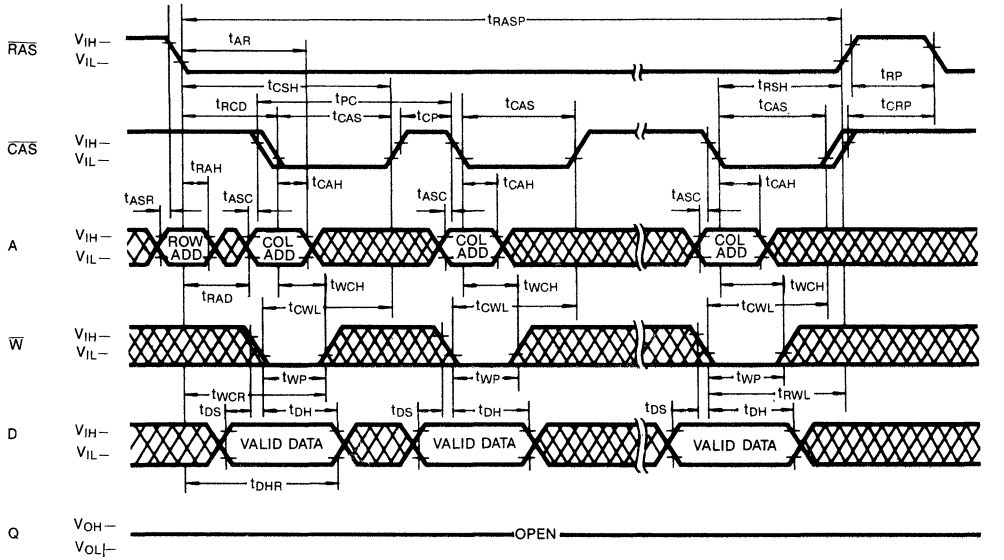


TIMING DIAGRAMS

FAST PAGE MODE READ CYCLE



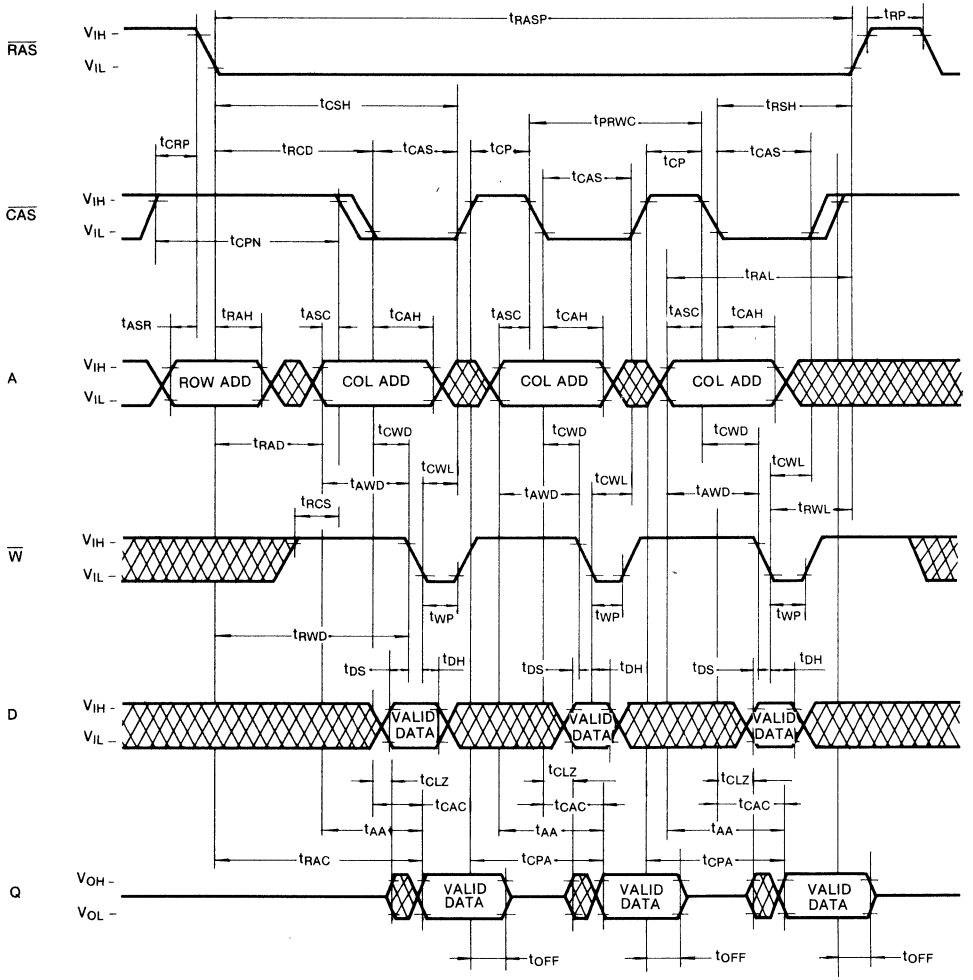
FAST PAGE MODE WRITE CYCLE



DON'T CARE

TIMING DIAGRAMS (Continued)

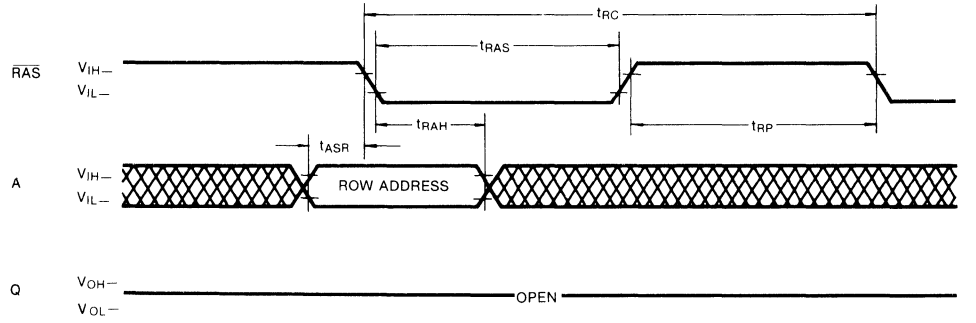
FAST PAGE MODE READ-WRITE CYCLE



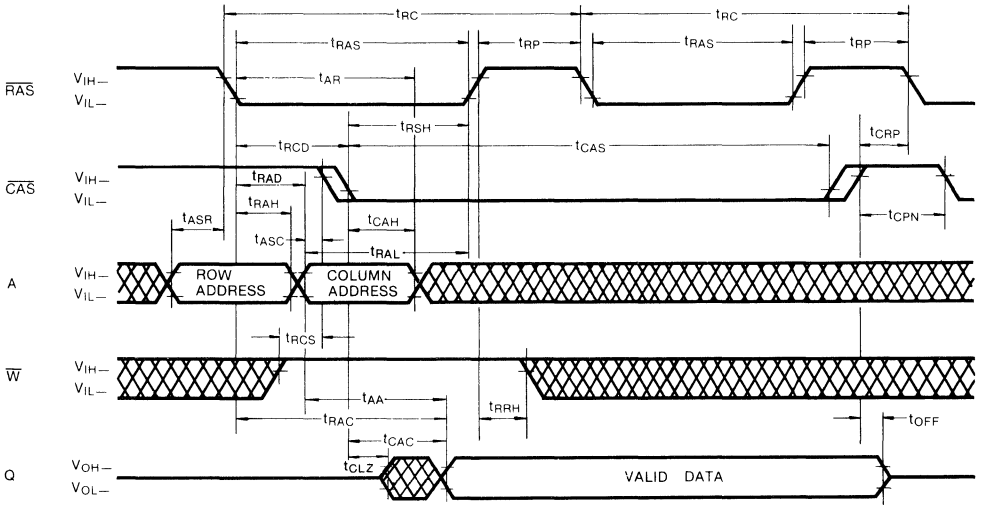
TIMING DIAGRAMS (Continued)

$\overline{RAS}$-ONLY REFRESH CYCLE

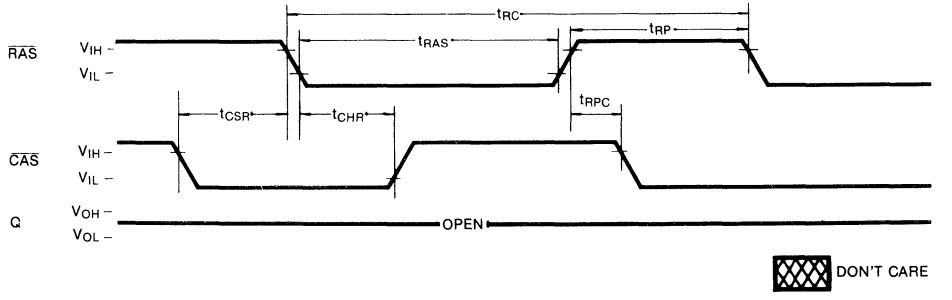
Note: $\overline{CAS}$ = V_{IH}, $\overline{W}$,D, A_9 = Don't Care



HIDDEN REFRESH CYCLE

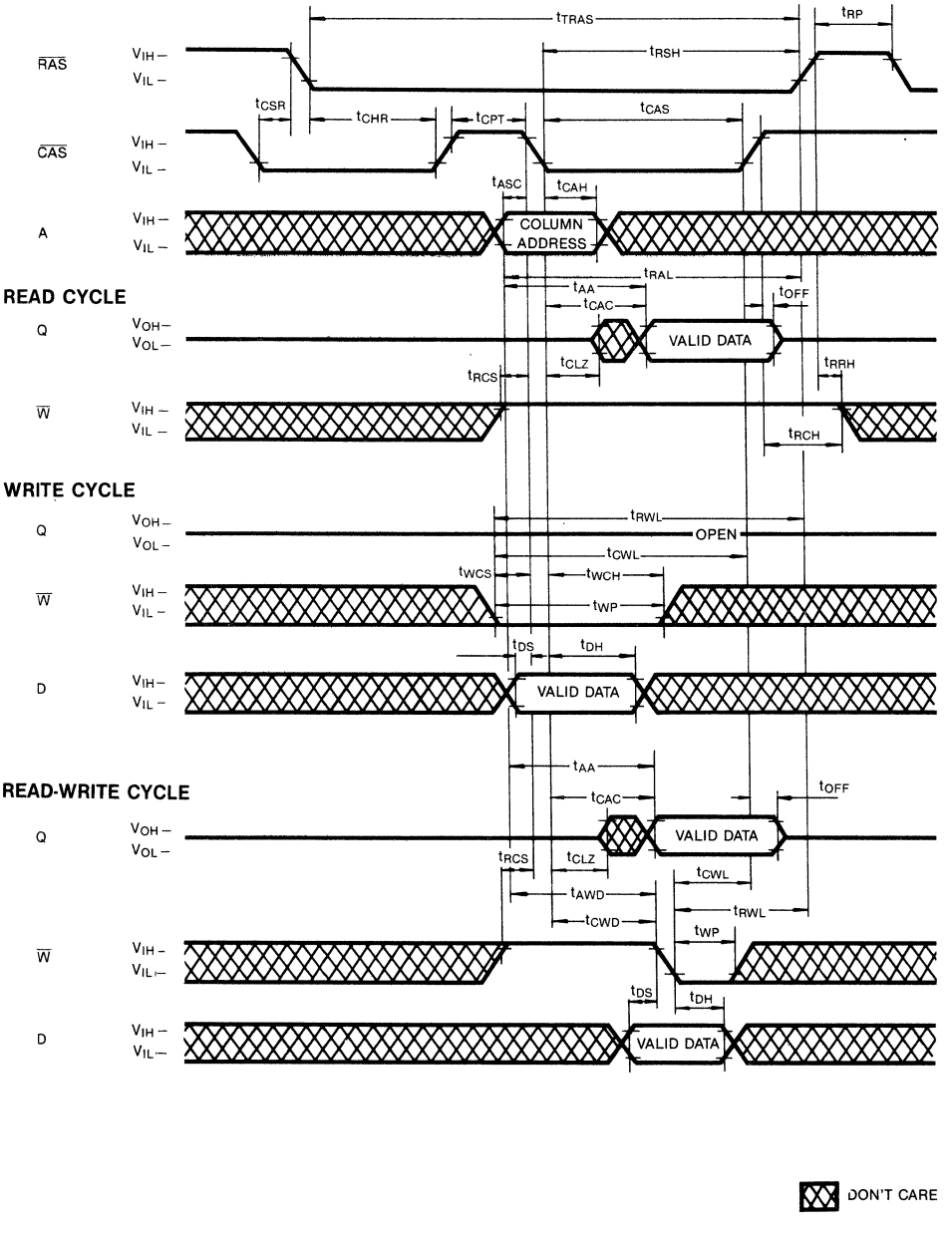


$\overline{CAS}$-BEFORE-$\overline{RAS}$ REFRESH CYCLE



TIMING DIAGRAMS (Continued)

$\overline{CAS}$-BEFORE-$\overline{RAS}$ REFRESH COUNTER TEST CYCLE



KM41C1000 OPERATION

Device Operation

The KM41C1000 contains 1,048,576 memory locations. Twenty address bits are required to address a particular memory location. Since the KM41C1000 has only 10 address input pins, time multiplexed addressing is used to input 10 row and 10 column addresses. The multiplexing is controlled by the timing relationship between the row address strobe ($\overline{RAS}$), the column address strobe ($\overline{CAS}$) and the valid row and column address inputs.

Operation of the KM41C1000 begins by strobing in a valid row address with $\overline{RAS}$ while $\overline{CAS}$ remains high. Then the address on the 10 address input pins is changed from a row address to a column address and is strobed in by $\overline{CAS}$. This is the beginning of any KM41C1000 cycle in which a memory location is accessed. The specific type of cycle is determined by the state of the write enable pin and various timing relationships. The cycle is terminated when both $\overline{RAS}$ and $\overline{CAS}$ have returned to the high state. Another cycle can be initiated after $\overline{RAS}$ remains high long enough to satisfy the $\overline{RAS}$ precharge time (tRP) requirement.

$\overline{RAS}$ and $\overline{CAS}$ Timing

The minimum $\overline{RAS}$ and $\overline{CAS}$ pulse widths are specified by tRAS(min) and tCAS(min) respectively. These minimum pulse widths must be satisfied for proper device operation and data integrity. Once a cycle is initiated by bringing $\overline{RAS}$ low, it must not be aborted prior to satisfying the minimum $\overline{RAS}$ and $\overline{CAS}$ pulse widths. In addition, a new cycle must not begin until the minimum $\overline{RAS}$ precharge time, tRP, has been satisfied. Once a cycle begins, internal clocks and other circuits within the KM41C1000 begin a complex sequence of events. If the sequence is broken by violating minimum timing requirements, loss of data integrity can occur.

Read

A read cycle is achieved by maintaining the write enable input($\overline{W}$) high during a $\overline{RAS}$/$\overline{CAS}$ cycle. The access time is normally specified with respect to the falling edge of $\overline{RAS}$. But the access time also depends on the falling edge of $\overline{CAS}$ and on the valid column address transition.

If $\overline{CAS}$ goes low before tRCD(max) and if the column address is valid before tRAD(max) then the access time to valid data is specified by tRAC(min). However, if $\overline{CAS}$ goes low after tRCD(max) or if the column address becomes valid after tRAD(max), the access time is specified by tCAC or tAA. In order to achieve the minimum access time, tRAC(min), it is necessary to meet both tRCD(max) and tRAD(max).

Write

The KM41C1000 can perform early write, late write and read-modify-write cycles. The differece between these cycles is in the state of data-out and is determined by the timing relationship between $\overline{W}$ and $\overline{CAS}$. In any type of write cycle, Data-in must be valid at or before the falling edge of $\overline{W}$ or $\overline{CAS}$, whichever is later.

Early Write: An early write cycle is performed by bringing $\overline{W}$ low before $\overline{CAS}$. The data at the data input pin (D) is written into the addressed memory cell. Throughout the early write cycle the output remains in the Hi-Z state. This cycle is good for common I/O applications because the data-in and data-out pins may be tied together without bus contention.

Read-Modify-Write: In this cycle, valid data from the addressed cell appears at the output before and during the time that data is being written into the same cell location. This cycle is achieved by bringing $\overline{W}$ low after $\overline{CAS}$ and meeting the data sheet read-modify-write cycle timing requirements. This cycle requires using a separate I/O to avoid bus contention.

Late Write: If $\overline{W}$ is brought low after $\overline{CAS}$, a late write cycle will occur. The late write cycle is very similar to the read-modify-write cycle except that the timing parameters, tRWD, tCWD and tAWD, are not necessarily met. The state of data-out is indeterminate since the output can be either Hi-Z or contain data depending on the timing conditions. This cycle requires a separate I/O to avoid bus contention.

Data Output

The KM41C1000 has a tri-state output buffer which is controlled by $\overline{CAS}$. Whenever $\overline{CAS}$ is high (VIH) the output is in the high impedance (Hi-Z) state. In any cycle in which valid data appears at the output the output goes into the low impedance state in a time specified by tCLZ after the falling edge of $\overline{CAS}$. Invalid data may be present at the output during the time after tCLZ and before the valid data appears at the output. The timing parameters tCAC, tRAC and tAA specify when the valid data will be present at the output. The valid data remains at the output until $\overline{CAS}$ returns high. This is true even if a new $\overline{RAS}$ cycle occurs (as in hidden refresh). Each of the KM41C1000 operating cycles is listed below after the corresponding output state produced by the cycle.

DEVICE OPERATION (Continued)

Valid Output Data: Read, Read-Modify-Write, Hidden Refresh, Fast Page Mode Read, Fast Page Mode Read-Modify-Write.

Hi-Z Output State: Early Write, $\overline{RAS}$-only Refresh, Fast Page Mode Write, $\overline{CAS}$-before-$\overline{RAS}$ Refresh, $\overline{CAS}$-only cycle.

Indeterminate Output State: Delayed Write

Refresh

The data in the KM41C1000 is stored on a tiny capacitor within each memory cell. Due to leakage the data may leak off after a period of time. To maintain data integrity it is necessary to refresh each of the rows every 8 ms. Either a burst refresh or distributed refresh may be used. There are several ways to accomplish this.

$\overline{RAS}$-Only Refresh: This is the most common method for performing refresh. It is performed by strobing in a row address with $\overline{RAS}$ while $\overline{CAS}$ remains high. This cycle must be repeated for each of the 512 row addresses, (A0-A8). The state of address A9 is ignored during refresh.

$\overline{CAS}$-before-$\overline{RAS}$ Refresh: The KM41C1000 has $\overline{CAS}$-before-$\overline{RAS}$ on-chip refresh capability that eliminates the need for external refresh addresses. If $\overline{CAS}$ is held low for the specified set up time (tCSR) before $\overline{RAS}$ goes low, the on-chip refresh circuitry is enabled. An internal refresh operation automatically occurs. The refresh address is supplied by the on-chip refresh address counter which is then internally incremented in preparation for the next $\overline{CAS}$-before-$\overline{RAS}$ refresh cycle.

Hidden Refresh: A hidden refresh cycle may be performed while maintaining the latest valid data at the output by extending the $\overline{CAS}$ active time and cycling $\overline{RAS}$. The KM41C1000 hidden refresh cycle is actually a $\overline{CAS}$-before-$\overline{RAS}$ refresh cycle within an extended read cycle. The refresh row address is provided by the on-chip refresh address counter.

Other Refresh Methods: It is also possible to refresh the KM41C1000 by using read, write or read-modify-write cycles. Whenever a row is accessed, all the cells in that row are automatically refreshed. There are certain applications in which it might be advantageous to perform refresh in this manner but in general $\overline{RAS}$-only or $\overline{CAS}$-before-$\overline{RAS}$ refresh is the preferred method.

$\overline{CAS}$-before-$\overline{RAS}$ Refresh Counter Test Cycle

A special timing sequence using the $\overline{CAS}$-before-$\overline{RAS}$ refresh counter test cycle provides a convenient method of verifying the functionality of the $\overline{CAS}$-before-$\overline{RAS}$ refresh activated circuitry. The cycle begins as a $\overline{CAS}$-before-$\overline{RAS}$ refresh operation. Then, if $\overline{CAS}$ is brought high and then low again while $\overline{RAS}$ is held low, the read and write operations are enabled. In this mode, the row address bits A0 through A8 are supplied by the on-chip refresh counter. The A9 bit is set high internally.

Fast Page Mode

The KM41C1000 has Fast Page mode capability which provides high speed read, write or read-modify-write access to all memory cells within a selected row. These cycles may be mixed in any order. A fast page mode cycle begins with a normal cycle. Then, while $\overline{RAS}$ is kept low to maintain the row address, $\overline{CAS}$ is cycled to strobe in additional column addresses. This eliminates the time required to set up and strobe sequential row addresses for the same page.

Power-up

If $\overline{RAS} = V_{SS}$ during power-up, the KM41C1000 could begin an active cycle. This condition results in higher than necessary current demands from the power supply during power-up. It is recommended that $\overline{RAS}$ and $\overline{CAS}$ track with V_{CC} during power-up or be held at a valid VIH in order to minimize the power-up current.

An initial pause of 200 μsec is required after power-up followed by 8 initialization cycles before proper device operation is assured. Eight initialization cycles are also required after any 8 msec period in which there are no $\overline{RAS}$ cycles. An initialization cycle is any cycle in which $\overline{RAS}$ is cycled.

Termination

The lines from the TTL driver circuits to the KM41C1000 inputs act like unterminated transmission lines resulting in significant positive and negative overshoots at the inputs. To minimize overshoot it is advisable to terminate the input lines and to keep them as short as possible. Although either series or parallel termination may be used, series termination is generally recommended since it is simple and draws no additional power. It consists of a resistor in series with the input line placed close to the KM41C1000 input pin. The optimum value depends on the board layout. It must be determined experimentally and is usually in the range of 20 to 40 ohms.

DEVICE OPERATION (Continued)

Board Layout

It is important to lay out the power and ground lines on memory boards in such a way that switching transient effects are minimized. The recommended methods are gridded power and ground lines or separate power and ground planes. The power and ground lines act like transmission lines to the high frequency transients generated by DRAMS. The impedance is minimized if all the power supply traces to all the DRAMS run both horizontally and vertically and are connected at each intersection or better yet if power and ground planes are used.

Address and control lines should be as short as possible to avoid skew. In boards with many DRAMS these lines should fan out from a central point like a fork or comb rather than being connected in a serpentine pattern. Also the control logic should be centrally located on large memory boards to facilitate the shortest possible address and control lines to all the DRAMS.

Decoupling

The importance of proper decoupling can not be over emphasized. Excessive transient noise or voltage droop on the V_{CC} line can cause loss of data integrity (soft errors). It is recommended that the total combined voltage changes over time in the VCC to VSS voltage (measured at the device pins) should not exceed 500mV.

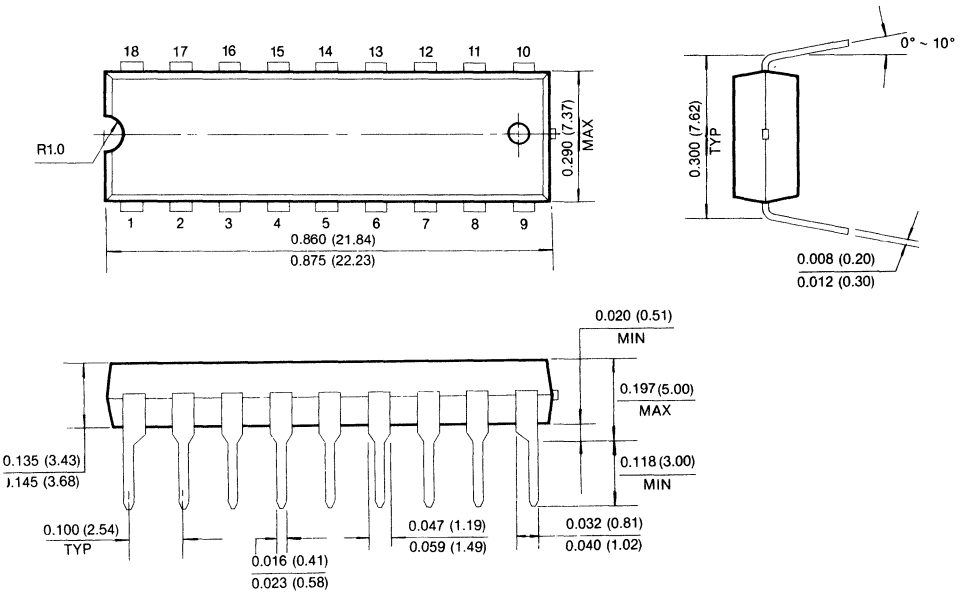
A high frequency 0.3μF ceramic decoupling capacitor should be connected between the V_{CC} and ground pins of each KM41C1000 using the shortest possible traces. These capacitors act as a low impedance shunt for the high frequency switching transients generated by the KM41C1000 and they supply much of the current used by the KM41C1000 during cycling.

In addition, a large tantalum capacitor with a value of 47μF to 100μF should be used for bulk decoupling to recharge the 0.3μF capacitors between cycles, thereby reducing power line droop. The bulk decoupling capacitor should be placed near the point where the power traces meet the power grid or power plane. Even better results may be achieved by distributing more than one tantalum capacitor around the memory array.

PACKAGE DIMENSIONS

18-LEAD PLASTIC DUAL IN-LINE PACKAGE

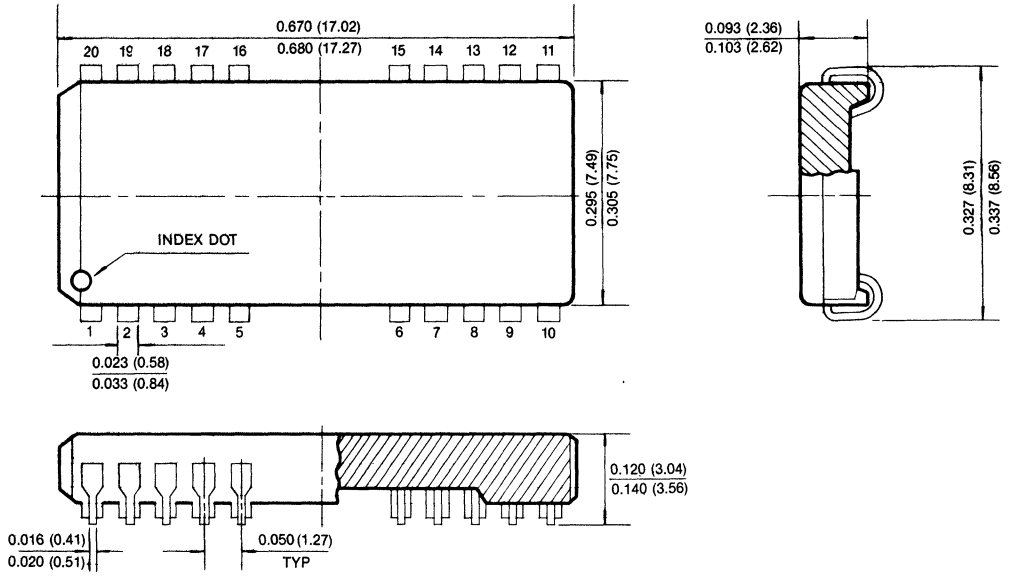
Units: Inches (millimeters)



PACKAGE DIMENSIONS

20/26-PIN PLASTIC SMALL OUT-LINE J-LEAD

Unit: Inches (millimeters)



20-LEAD PLASTIC ZIGZAG-IN-LINE PACKAGE

Units: Inches (millimeters)