

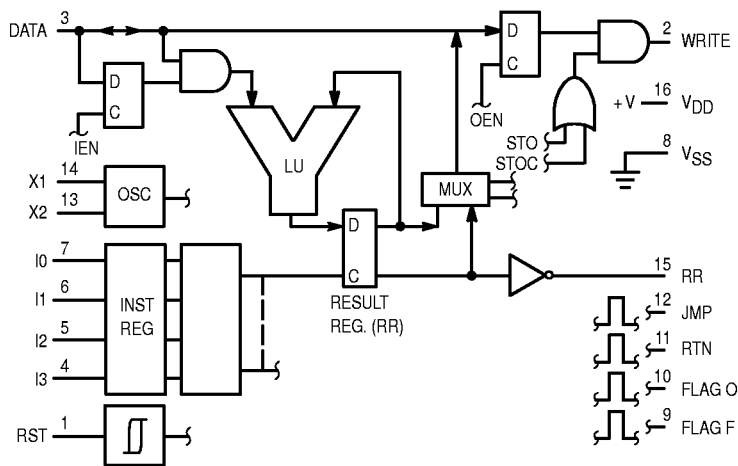
MC14500B

Industrial Control Unit

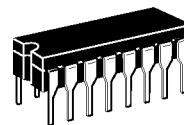
The MC14500B Industrial Control Unit (ICU) is a single-bit CMOS processor. The ICU is designed for use in systems requiring decisions based on successive single-bit information. An external ROM stores the control program. With a program counter (and output latches and input multiplexers, if required) the ICU in a system forms a stored-program controller that replaces combinatorial logic. Applications include relay logic processing, serial data manipulation and control. The ICU also may control an MPU or be controlled by an MPU.

- 16 Instructions
- DC to 1.0 MHz Operation at $V_{DD} = 5\text{ V}$
- On-Chip Clock (Oscillator)
- Executes One Instruction per Clock Cycle
- 3 to 18 V Operation
- Low Quiescent Current Characteristic of CMOS Devices
- Capable of Driving One Low-Power Schottky Load or Two Low-Power TTL Loads over Full Temperature Range

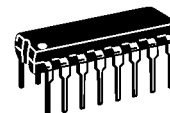
BLOCK DIAGRAM



X1 — OSCILLATOR OUTPUT
X2 — OSCILLATOR INPUT



L SUFFIX
CERAMIC
CASE 620



P SUFFIX
PLASTIC
CASE 648



DW SUFFIX
SOIC
CASE 751G

ORDERING INFORMATION

MC14XXXBCP	Plastic
MC14XXXBCL	Ceramic
MC14XXXBDW	SOIC

$T_A = -55^\circ\text{C}$ to 125°C for all packages.

PIN ASSIGNMENT

RST	1	16	V_{DD}
WRITE	2	15	RR
DATA	3	14	X1
I3	4	13	X2
I2	5	12	JMP
I1	6	11	RTN
I0	7	10	FLAG O
V_{SS}	8	9	FLAG F



MAXIMUM RATINGS* (Voltages Referenced to V_{SS})

Symbol	Parameter	Value	Unit
V _{DD}	DC Supply Voltage	- 0.5 to + 18.0	V
V _{in} , V _{out}	Input or Output Voltage (DC or Transient)	- 0.5 to V _{DD} + 0.5	V
I _{in} , I _{out}	Input or Output Current (DC or Transient), per Pin	± 10	mA
P _D	Power Dissipation, per Package†	500	mW
T _{stg}	Storage Temperature	- 65 to + 150	°C
T _L	Lead Temperature (8-Second Soldering)	260	°C

* Maximum Ratings are those values beyond which damage to the device may occur.

† Temperature Derating:

Plastic "P and D/DW" Packages: - 7.0 mW/°C From 65°C To 125°C

Ceramic "L" Packages: - 12 mW/°C From 100°C To 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V_{in} and V_{out} should be constrained to the range V_{SS} ≤ (V_{in} or V_{out}) ≤ V_{DD}.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}). Unused outputs must be left open.

ELECTRICAL CHARACTERISTICS (Voltages Referenced to V_{SS})

Characteristic	Symbol	V _{DD} Vdc	- 55°C		25°C			125°C		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V _{in} = V _{DD} or 0	"0" Level V _{OL}	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	V _{in} = 0 or V _{DD} "1" Level V _{OH}	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage RST, D, X2 (V _O = 4.5 or 0.5 Vdc) (V _O = 9.0 or 1.0 Vdc) (V _O = 13.5 or 1.5 Vdc)	"0" Level V _{IL}	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V _{IH}	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11	—	11	8.25	—	11	—	
Input Voltage # I0, I1, I2, I3 (V _O = 4.5 or 0.5 Vdc) (V _O = 9.0 or 1.0 Vdc) (V _O = 13.5 or 1.5 Vdc)	"0" Level V _{IL}	5.0	—	0.8	—	1.1	0.8	—	0.8	Vdc
		10	—	1.6	—	2.2	1.6	—	1.6	
		15	—	2.4	—	3.4	2.4	—	2.4	
	"1" Level V _{IH}	5.0	2.0	—	2.0	1.9	—	2.0	—	Vdc
		10	6.0	—	6.0	3.1	—	6.0	—	
		15	10	—	10	4.3	—	10	—	
Output Drive Current Data, Write (V _{OH} = 4.6 Vdc) (V _{OH} = 9.5 Vdc) (V _{OH} = 13.5 Vdc)	Source I _{OH}	5.0	- 1.2	—	- 1.0	- 2.0	—	- 0.7	—	mA _{dc}
		10	- 3.6	—	- 3.0	- 6.0	—	- 2.1	—	
		15	- 7.2	—	- 6.0	- 12	—	- 4.2	—	
	Sink I _{OL}	5.0	1.9	—	1.6	3.2	—	1.1	—	mA _{dc}
		10	3.6	—	3.0	6.0	—	2.1	—	
		15	7.2	—	6.0	12	—	4.2	—	
Output Drive Current Other Outputs (V _{OH} = 2.5 Vdc) (V _{OH} = 4.6 Vdc) (V _{OH} = 9.5 Vdc) (V _{OH} = 13.5 Vdc)	Source I _{OH}	5.0	- 3.0	—	- 2.4	- 4.2	—	- 1.7	—	mA _{dc}
		5.0	- 0.64	—	- 0.51	- 0.88	—	- 0.36	—	
		10	- 1.6	—	- 1.3	- 2.25	—	- 0.9	—	
	Sink I _{OL}	15	- 4.2	—	- 3.4	- 8.8	—	- 2.4	—	
		5.0	0.64	—	0.51	0.88	—	0.36	—	mA _{dc}
		10	1.6	—	1.3	2.25	—	0.9	—	
15	4.2	—	3.4	8.8	—	2.4	—			

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

ELECTRICAL CHARACTERISTICS — continued (Voltages Referenced to V_{SS})

Characteristic	Symbol	V _{DD} Vdc	-55°C		25°C			125°C		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Input Current, RST	I _{in}	15	25	—	—	150	—	—	250	μAdc
Input Current	I _{in}	15	—	± 0.1	—	±0.00001	± 0.1	—	± 1.0	μAdc
Input Capacitance (Data)	C _{in}	—	—	—	—	15	—	—	—	pF
Input Capacitance (All Other Inputs)	C _{in}	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (Per Package) I _{out} = 0 μA, V _{in} = 0 or V _{DD}	I _{DD}	5.0 10 15	— — —	5.0 10 20	— — —	0.005 0.010 0.015	5.0 10 20	— — —	150 300 600	μAdc
**Total Supply Current at an External Load Capacitance (C _L) on All Outputs	I _T	—	I _T = (1.5 μA/kHz) f + I _{DD} I _T = (3.0 μA/kHz) f + I _{DD} I _T = (4.5 μA/kHz) f + I _{DD}						μAdc	

**The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

SWITCHING CHARACTERISTICS* (T_A = 25°C; t_r = t_f = 20 ns for X and I inputs; C_L = 50 pF for JMP, X1, RR, Flag O, Flag F; C_L = 130 pF + 1 TTL load for Data and Write.)

Characteristic	Symbol	V _{DD} Vdc	All Types			Unit		
			Min	Typ #	Max			
Propagation Delay Time, X1 to RR X1 to Flag F, Flag O, RTN, JMP X1 to Write X1 to Data RST to RR RST to X1 RST to Flag F, Flag O, RTN, JMP RST to Write, Data	t _{PLH} , t _{PHL}	5.0	—	250	500	ns		
		10	—	125	250			
		15	—	100	200			
		5.0	—	200	400			
		10	—	100	200			
		15	—	85	170			
		5.0	—	225	450			
		10	—	125	250			
		15	—	100	200			
		5.0	—	250	500			
		10	—	120	240			
		15	—	100	200			
		5.0	—	250	500			
		10	—	125	250			
		15	—	100	200			
		5.0	—	450	Note 1			
		10	—	200				
		15	—	150				
		5.0	—	400	800			
		10	—	200	400			
		15	—	150	300			
		5.0	—	450	900			
		10	—	225	450			
		15	—	175	350			
Clock Pulse Width, X1	t _{W(cl)}	5.0 10 15	400 200 180	200 100 90	— — —	ns		
Reset Pulse Width, RST	t _{W(R)}	5.0 10 15	500 250 200	250 125 100	— — —	ns		
Setup Time — Instruction	t _{su(I)}	5.0	400	200	—	ns		
		10	250	125	—			
		15	180	90	—			
		Data	t _{su(D)}	5.0	200		100	—
				10	100		50	—
				15	80		40	—
Hold Time — Instruction	t _{h(I)}	5.0	100	0	—	ns		
		10	50	0	—			
		15	50	0	—			
		Data	t _{h(D)}	5.0	200		100	—
				10	100		50	—
				15	100		50	—

NOTE 1. Maximum Reset Delay may extend to one-half clock period.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

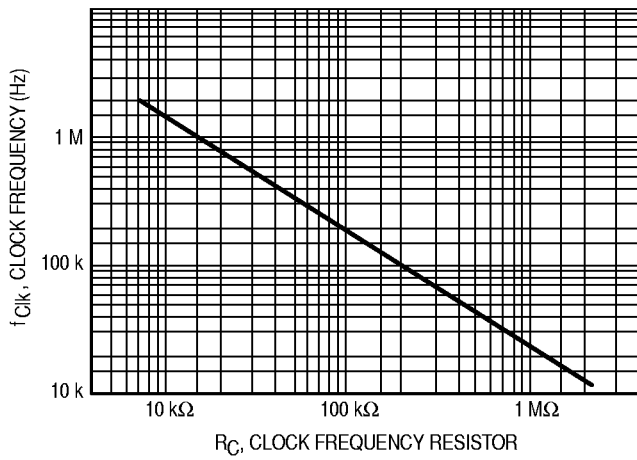


Figure 1. Typical Clock Frequency versus Resistor (R_C)

Pin No.	Function	Symbols
1	Chip Reset	RST
2	Write Pulse	Write
3	Data In/Out	Data
4	MSB Instruction Word	I_3
5	Bit 2 Instruction Word	I_2
6	Bit 1 Instruction Word	I_1
7	LSB Instruction Word	I_0
8	Negative Supply (Ground)	VSS
9	Flag on NOP F	Flag F
10	Flag on NOP O	Flag O
11	Subroutine Return Flag	RTN
12	Jump Instruction Flag	JMP
13	Oscillator Input	X2
14	Oscillator Output	X1
15	Result Register	RR
16	Positive Supply	VDD

Table 1. MC14500B Instruction Set

Instruction Code	Mnemonic	Action
0 0000	NOPO	No change in registers. $RR \rightarrow RR$, Flag O \rightarrow
1 0001	LD	Load result register. Data \rightarrow RR
2 0010	LDC	Load complement. $\overline{\text{Data}} \rightarrow$ RR
3 0011	AND	Logical AND. $RR \bullet \text{Data} \rightarrow$ RR
4 0100	ANDC	Logical AND complement. $RR \bullet \overline{\text{Data}} \rightarrow$ RR
5 0101	OR	Logical OR. $RR + \text{Data} \rightarrow$ RR
6 0110	ORC	Logical OR complement. $RR + \overline{\text{Data}} \rightarrow$ RR
7 0111	XNOR	Exclusive NOR. If $RR = \text{Data}$, $RR \rightarrow 1$
8 1000	STO	Store. $RR \rightarrow$ Data Pin, Write \rightarrow
9 1001	STOC	Store complement. $\overline{RR} \rightarrow$ Data Pin, Write \rightarrow
A 1010	IEN	Input enable. Data \rightarrow IEN Register
B 1011	OEN	Output enable. Data \rightarrow OEN Register
C 1100	JMP	Jump. JMP Flag \rightarrow
D 1101	RTN	Return. RTN Flag \rightarrow and skip next instruction
E 1110	SKZ	Skip next instruction if $RR = 0$
F 1111	NOFP	No change in registers. $RR \rightarrow RR$, Flag F \rightarrow

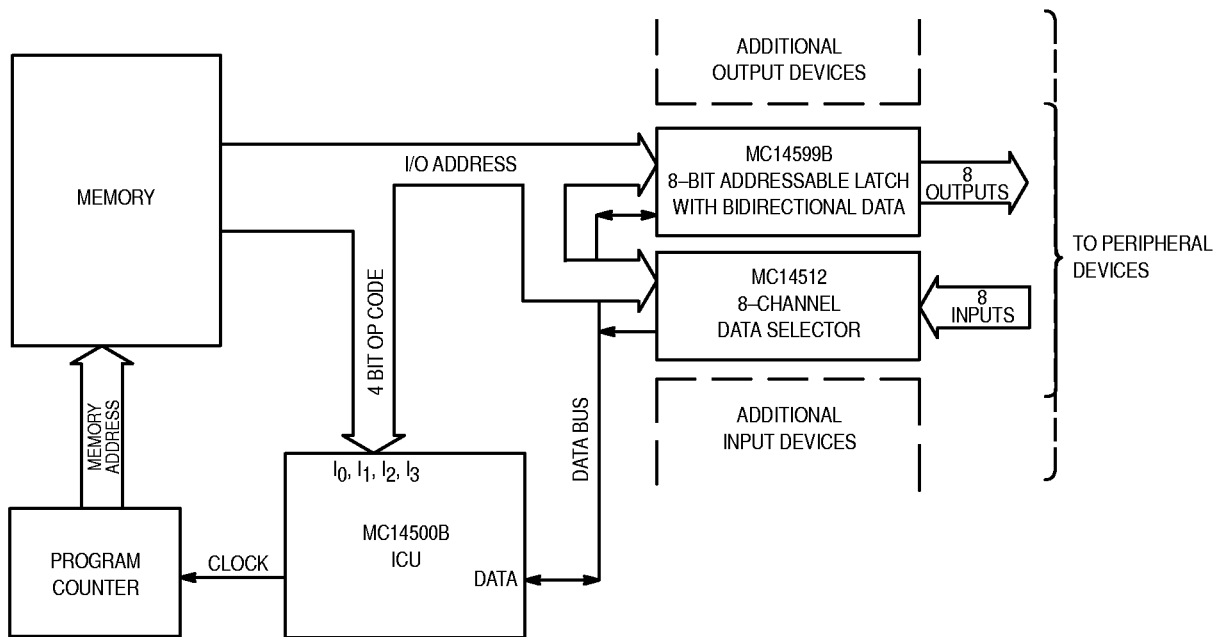
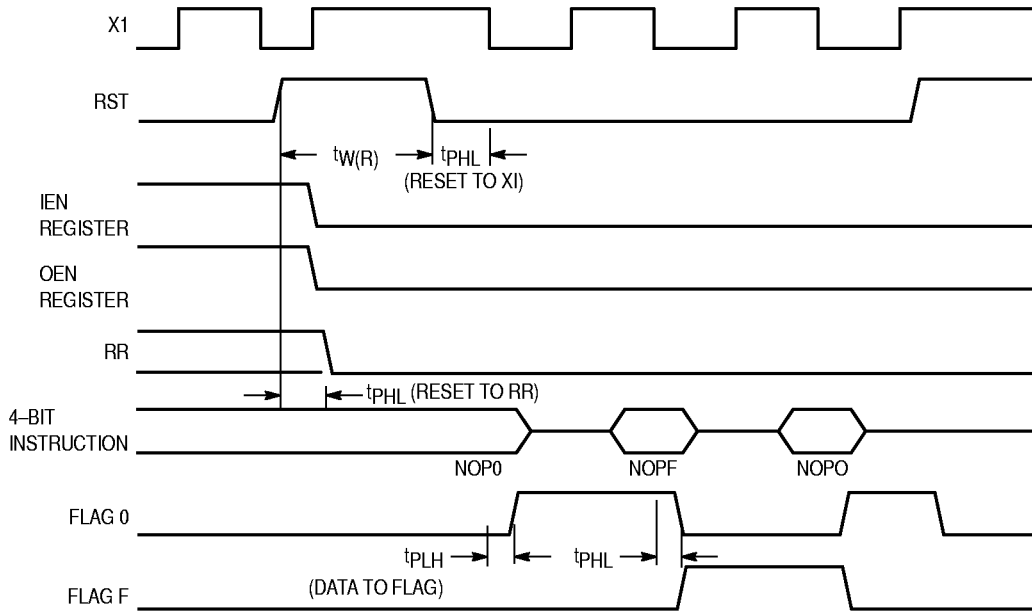


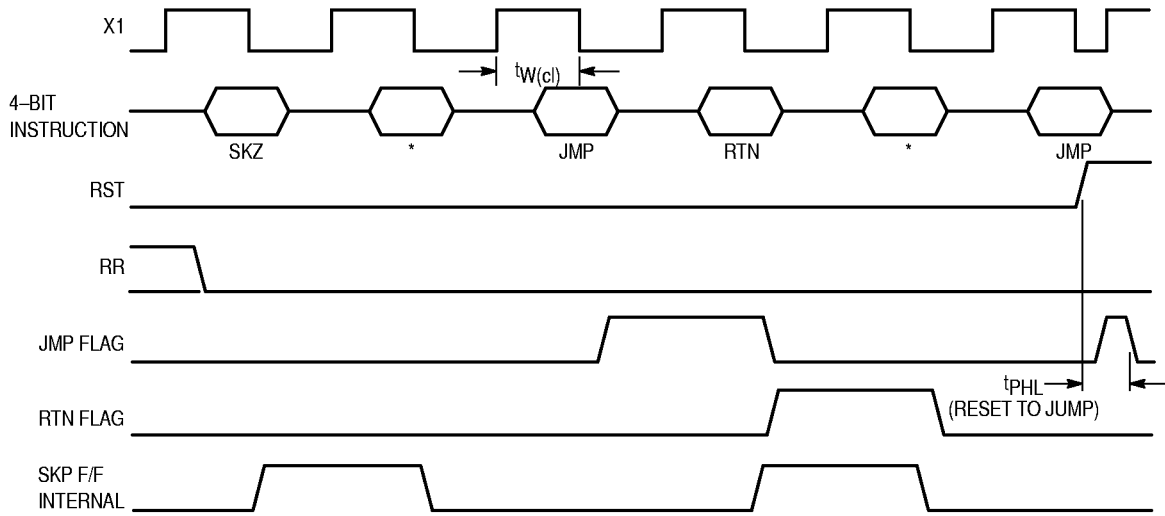
Figure 2. Outline of a Typical Organization for a MC14500B-Based System

TIMING WAVEFORMS

Instructions NOPO, NOPF
RR, IEN, OEN remain unaffected



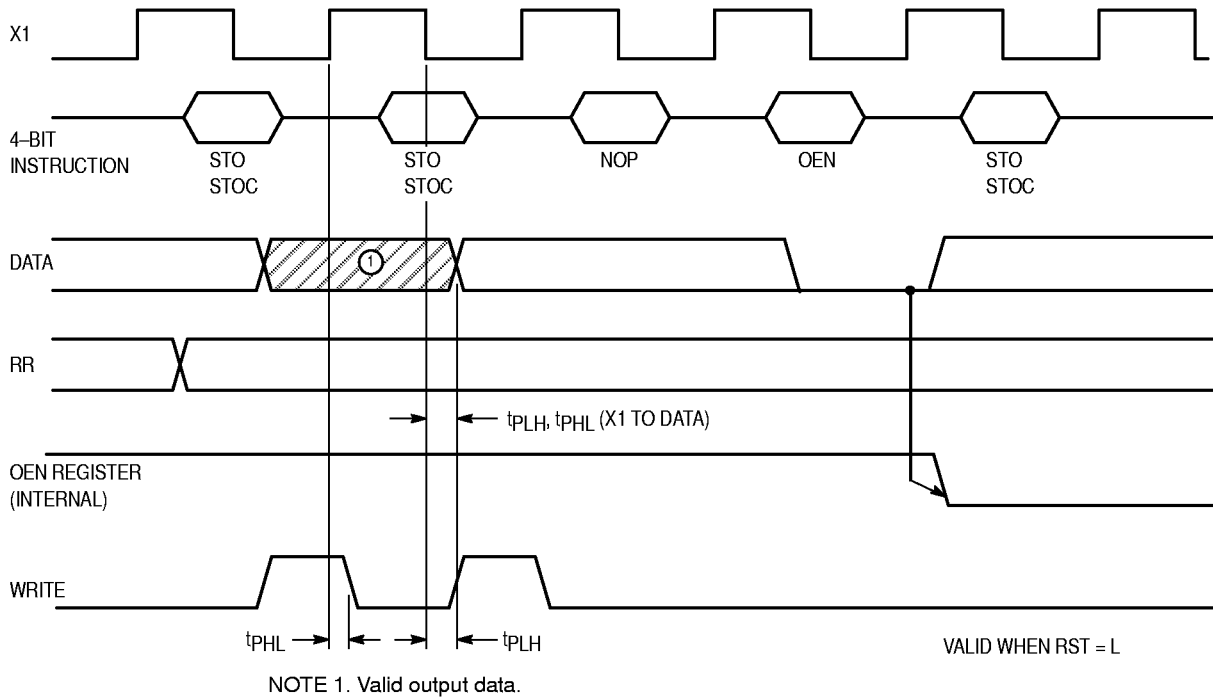
Instructions SKZ, JMP, RTN
RR, IEN, OEN remain unaffected



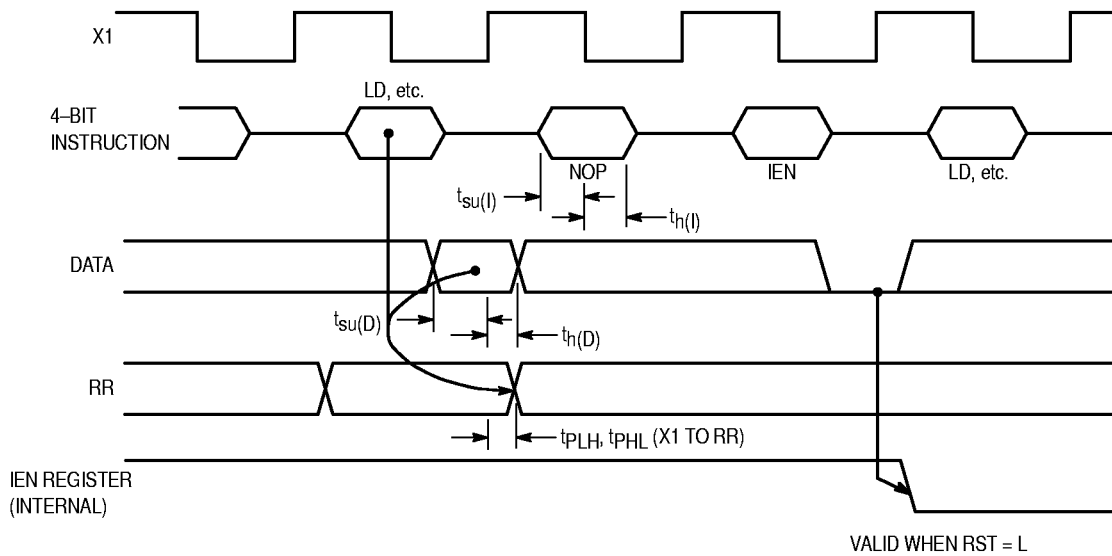
* Instructions Ignored.

TIMING WAVEFORMS

Instructions STO, STOC, OEN

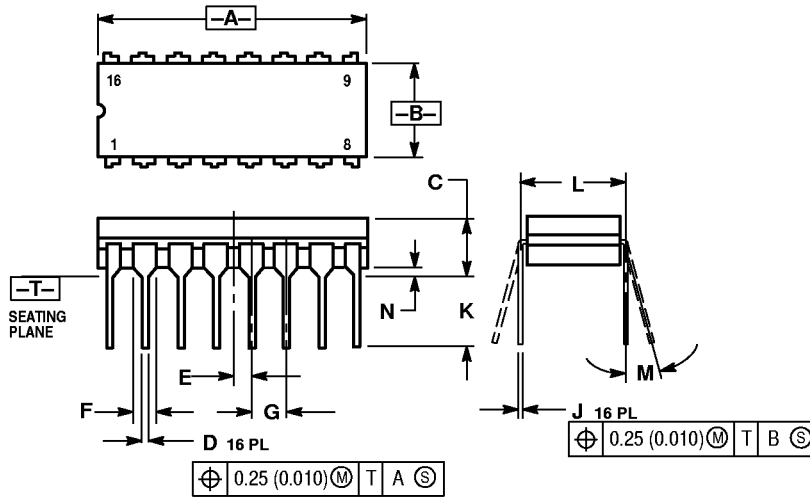


Instructions LD, LDC, AND, ANDC OR, ORC, XNOR, IEN



OUTLINE DIMENSIONS

L SUFFIX CERAMIC DIP PACKAGE CASE 620-10 ISSUE V

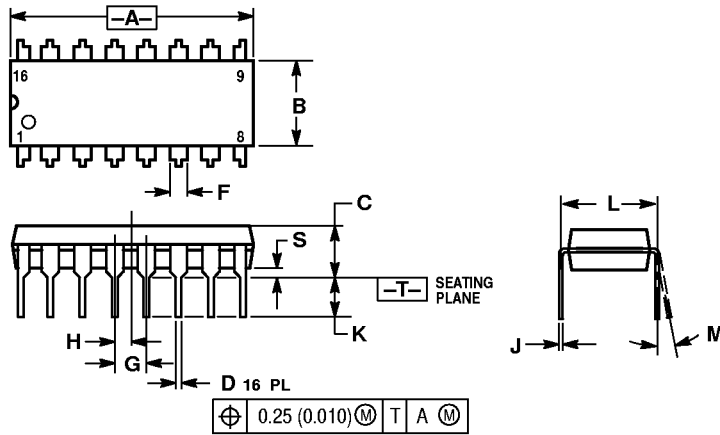


NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
4. DIMENSION F MAY NARROW TO 0.76 (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.750	0.785	19.05	19.93
B	0.240	0.295	6.10	7.49
C	—	0.200	—	5.08
D	0.015	0.020	0.39	0.50
E	0.050 BSC		1.27 BSC	
F	0.055	0.065	1.40	1.65
G	0.100 BSC		2.54 BSC	
H	0.008	0.015	0.21	0.38
K	0.125	0.170	3.18	4.31
L	0.300 BSC		7.62 BSC	
M	0° 15°		0° 15°	
N	0.020	0.040	0.51	1.01

P SUFFIX PLASTIC DIP PACKAGE CASE 648-08 ISSUE R



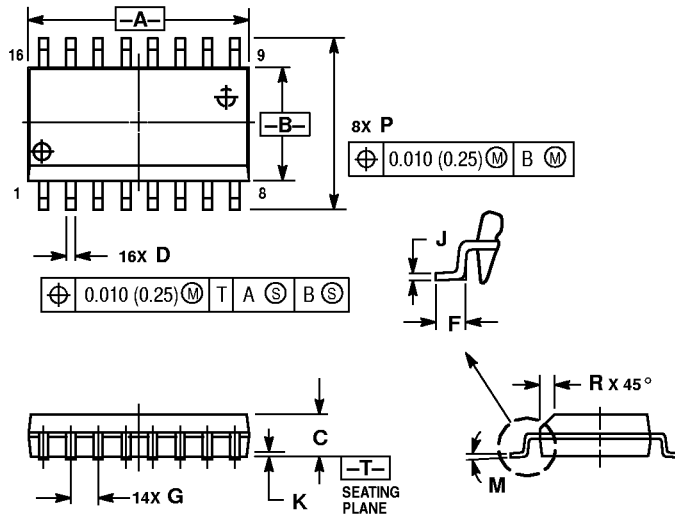
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.740	0.770	18.80	19.55
B	0.250	0.270	6.35	6.85
C	0.145	0.175	3.69	4.44
D	0.015	0.021	0.39	0.53
F	0.040	0.70	1.02	1.77
G	0.100 BSC		2.54 BSC	
H	0.050 BSC		1.27 BSC	
J	0.008	0.015	0.21	0.38
K	0.110	0.130	2.80	3.30
L	0.295	0.305	7.50	7.74
M	0° 10°		0° 10°	
S	0.020	0.040	0.51	1.01

OUTLINE DIMENSIONS


DW SUFFIX PLASTIC SOIC PACKAGE CASE 751G-02 ISSUE A



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.15	10.45	0.400	0.411
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

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MC14500B/D

