

# MOTOROLA

## SEMICONDUCTOR TECHNICAL DATA

### 3-Digit BCD Counter

The MC14553B 3-digit BCD counter consists of 3 negative edge triggered BCD counters that are cascaded synchronously. A quad latch at the output of each counter permits storage of any given count. The information is then time division multiplexed, providing one BCD number or digit at a time. Digit select outputs provide display control. All outputs are TTL compatible.

An on-chip oscillator provides the low-frequency scanning clock which drives the multiplexer output selector.

This device is used in instrumentation counters, clock displays, digital panel meters, and as a building block for general logic applications.

- TTL Compatible Outputs
- On-Chip Oscillator
- Cascadable
- Clock Disable Input
- Pulse Shaping Permits Very Slow Rise Times on Input Clock
- Output Latches
- Master Reset

#### 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
$I_{in}$	Input Current (DC or Transient), per Pin	$\pm 10$	mA
$I_{out}$	Output Current (DC or Transient), per Pin	+ 20	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

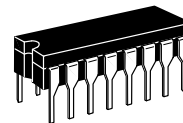
Ceramic "L" Packages: - 12 mW/°C From 100°C To 125°C

#### TRUTH TABLE

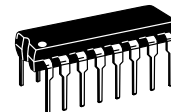
Inputs				Outputs
Master Reset	Clock	Disable	LE	
0	$\nearrow$	0	0	No Change
0	$\searrow$	0	0	Advance
0	X	1	X	No Change
0	1	$\nearrow$	0	Advance
0	1	$\searrow$	0	No Change
0	0	X	X	No Change
0	X	X	$\nearrow$	Latched
0	X	X	1	Latched
1	X	X	0	$Q_0 = Q_1 = Q_2 = Q_3 = 0$

X = Don't Care

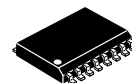
## MC14553B



**L SUFFIX**  
CERAMIC  
CASE 620



**P SUFFIX**  
PLASTIC  
CASE 648



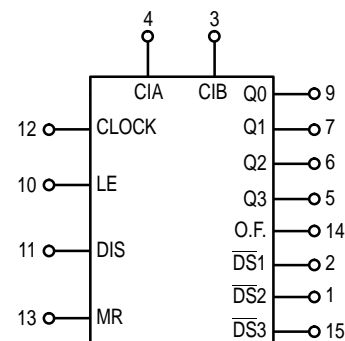
**DW SUFFIX**  
SOIC  
CASE 751G

#### ORDERING INFORMATION

MC14XXXBCP Plastic  
MC14XXXBCL Ceramic  
MC14XXXBDW SOIC

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

#### BLOCK DIAGRAM



$V_{DD} = \text{PIN } 16$   
 $V_{SS} = \text{PIN } 8$

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  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

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 ("0" Level $V_{OL} = 4.5$ or $0.5$ Vdc) $V_{OH} = 9.0$ or $1.0$ Vdc) $V_{OL} = 13.5$ or $1.5$ Vdc)	$V_{IL}$	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 $V_{OH} = 0.5$ or $4.5$ Vdc) $V_{OL} = 1.0$ or $9.0$ Vdc) $V_{OH} = 1.5$ or $13.5$ Vdc)	$V_{IH}$	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	—	
Output Drive Current $V_{OH} = 4.6$ Vdc) Source — $V_{OH} = 9.5$ Vdc) Pin 3 $V_{OH} = 13.5$ Vdc)	$I_{OH}$	5.0	-0.25	—	-0.2	-0.36	—	0.14	—	mAdc	
		10	-0.62	—	-0.5	-0.9	—	0.35	—		
		15	-1.8	—	-1.5	-3.5	—	1.1	—		
	$V_{OH} = 4.6$ Vdc) Source — $V_{OH} = 9.5$ Vdc) Other $V_{OH} = 13.5$ Vdc) Outputs	$I_{OL}$	5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	mAdc
			10	-1.6	—	-1.3	-2.25	—	-0.9	—	
			15	-4.2	—	-3.4	-8.8	—	-2.4	—	
$V_{OL} = 0.4$ Vdc) Sink — $V_{OL} = 0.5$ Vdc) Pin 3 $V_{OL} = 1.5$ Vdc)	$I_{OL}$	5.0	0.5	—	0.4	0.88	—	0.28	—	mAdc	
		10	1.1	—	0.9	2.25	—	0.65	—		
		15	1.8	—	1.5	8.8	—	1.20	—		
$V_{OL} = 0.4$ Vdc) Sink — Other $V_{OL} = 0.5$ Vdc) Outputs $V_{OL} = 1.5$ Vdc)	$I_{OL}$	5.0	3.0	—	2.5	4.0	—	1.6	—	mAdc	
		10	6.0	—	5.0	8.0	—	3.5	—		
		15	18	—	15	20	—	10	—		
Input Current	$I_{in}$	15	—	$\pm 0.1$	—	$\pm 0.00001$	$\pm 0.1$	—	$\pm 1.0$	$\mu$ Adc	
Input Capacitance $V_{in} = 0$ )	$C_{in}$	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (Per Package) MR = $V_{DD}$	$I_{DD}$	5.0	—	5.0	—	0.010	5.0	—	150	$\mu$ Adc	
		10	—	10	—	0.020	10	—	300		
		15	—	20	—	0.030	20	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) $C_L = 50$ pF on all outputs, all buffers switching)	$I_T$	5.0	$I_T = (0.35 \mu A/kHz) f + I_{DD}$							$\mu$ Adc	
10	$I_T = (0.85 \mu A/kHz) f + I_{DD}$										
15	$I_T = (1.50 \mu A/kHz) f + I_{DD}$										

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

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

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) Vfk$$

where:  $I_T$  is in  $\mu A$  (per package),  $C_L$  in pF,  $V = (V_{DD} - V_{SS})$  in volts,  $f$  in kHz is input frequency, and  $k = 0.004$ .

**SWITCHING CHARACTERISTICS** ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Figure	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	2a	$t_{TLH}$ , $t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Clock to BCD Out	2a	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	900 500 200	1800 1000 400	ns
Clock to Overflow	2a	$t_{PHL}$	5.0 10 15	— — —	600 400 200	1200 800 400	ns
Reset to BCD Out	2b	$t_{PHL}$	5.0 10 15	— — —	900 500 300	1800 1000 600	ns
Clock to Latch Enable Setup Time Master Reset to Latch Enable Setup Time	2b	$t_{su}$	5.0 10 15	600 400 200	300 200 100	— — —	ns
Removal Time Latch Enable to Clock	2b	$t_{rem}$	5.0 10 15	- 80 - 10 0	- 200 - 70 - 50	— — —	ns
Clock Pulse Width	2a	$t_{WH}(cl)$	5.0 10 15	550 200 150	275 100 75	— — —	ns
Reset Pulse Width	2b	$t_{WH}(R)$	5.0 10 15	1200 600 450	600 300 225	— — —	ns
Reset Removal Time	—	$t_{rem}$	5.0 10 15	- 80 0 20	- 180 - 50 - 30	— — —	ns
Input Clock Frequency	2a	$f_{cl}$	5.0 10 15	— — —	1.5 5.0 7.0	0.9 2.5 3.5	MHz
Input Clock Rise Time	2b	$t_{TLH}$	5.0 10 15	No Limit			ns
Disable, MR, Latch Enable Rise and Fall Times	—	$t_{TLH}$ , $t_{THL}$	5.0 10 15	— — —	— — —	15 5.0 4.0	$\mu\text{s}$
Scan Oscillator Frequency (C1 measured in $\mu\text{F}$ )	1	$f_{osc}$	5.0 10 15	— — —	1.5/C1 4.2/C1 7.0/C1	— — —	Hz

\* 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.

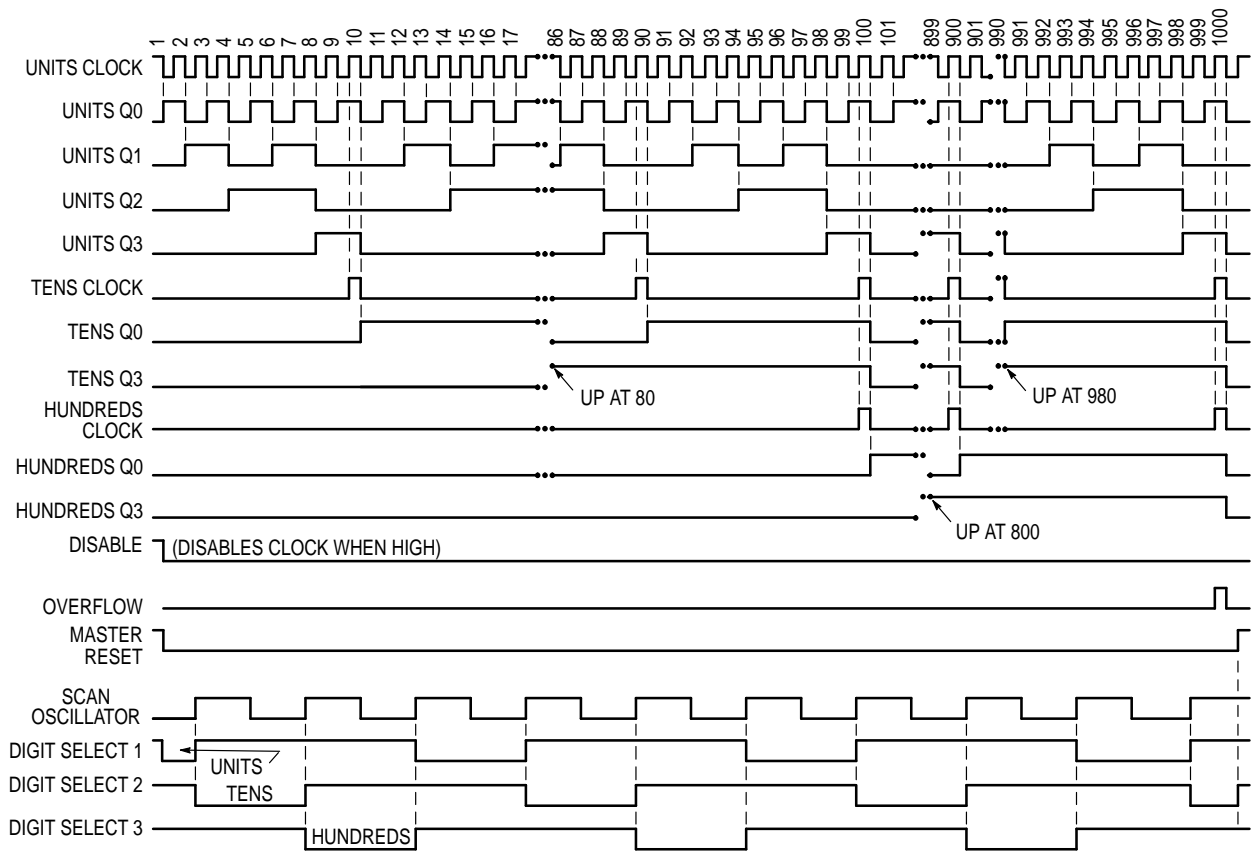


Figure 1. 3-Digit Counter Timing Diagram (Reference Figure 3)

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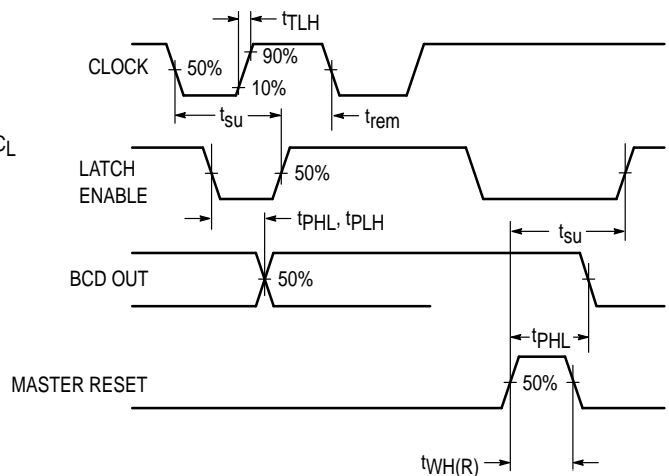
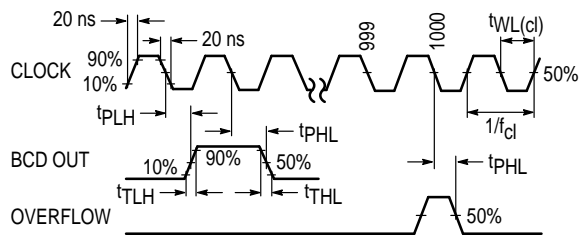
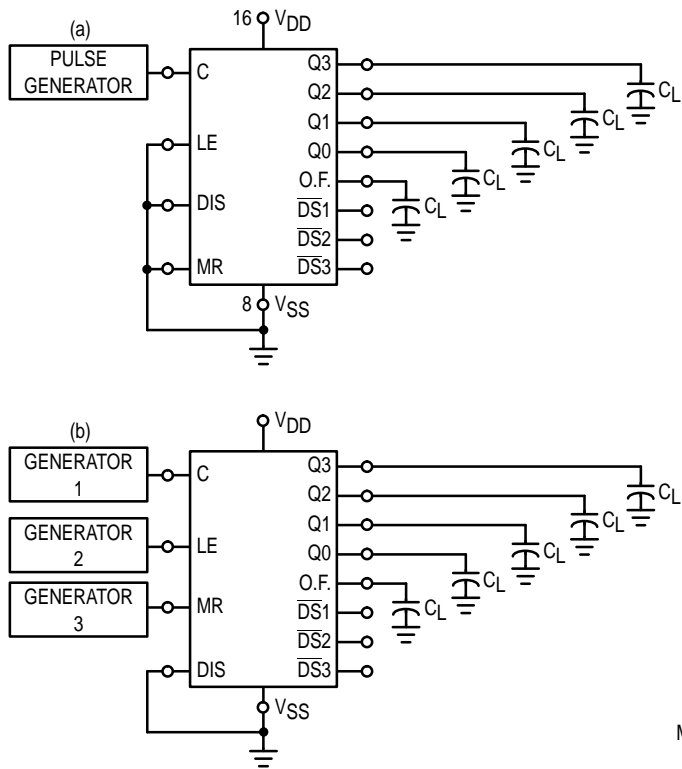


Figure 2. Switching Time Test Circuits and Waveforms

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## OPERATING CHARACTERISTICS

The MC14553B three-digit counter, shown in Figure 3, consists of three negative edge-triggered BCD counters which are cascaded in a synchronous fashion. A quad latch at the output of each of the three BCD counters permits storage of any given count. The three sets of BCD outputs (active high), after going through the latches, are time division multiplexed, providing one BCD number or digit at a time. Digit select outputs (active low) are provided for display control. All outputs are TTL compatible.

An on-chip oscillator provides the low frequency scanning clock which drives the multiplexer output selector. The frequency of the oscillator can be controlled externally by a capacitor between pins 3 and 4, or it can be overridden and driven with an external clock at pin 4. Multiple devices can be cascaded using the overflow output, which provides one

pulse for every 1000 counts.

The Master Reset input, when taken high, initializes the three BCD counters and the multiplexer scanning circuit. While Master Reset is high the digit scanner is set to digit one; but all three digit select outputs are disabled to prolong display life, and the scan oscillator is inhibited. The Disable input, when high, prevents the input clock from reaching the counters, while still retaining the last count. A pulse shaping circuit at the clock input permits the counters to continue operating on input pulses with very slow rise times. Information present in the counters when the latch input goes high, will be stored in the latches and will be retained while the latch input is high, independent of other inputs. Information can be recovered from the latches after the counters have been reset if Latch Enable remains high during the entire reset cycle.

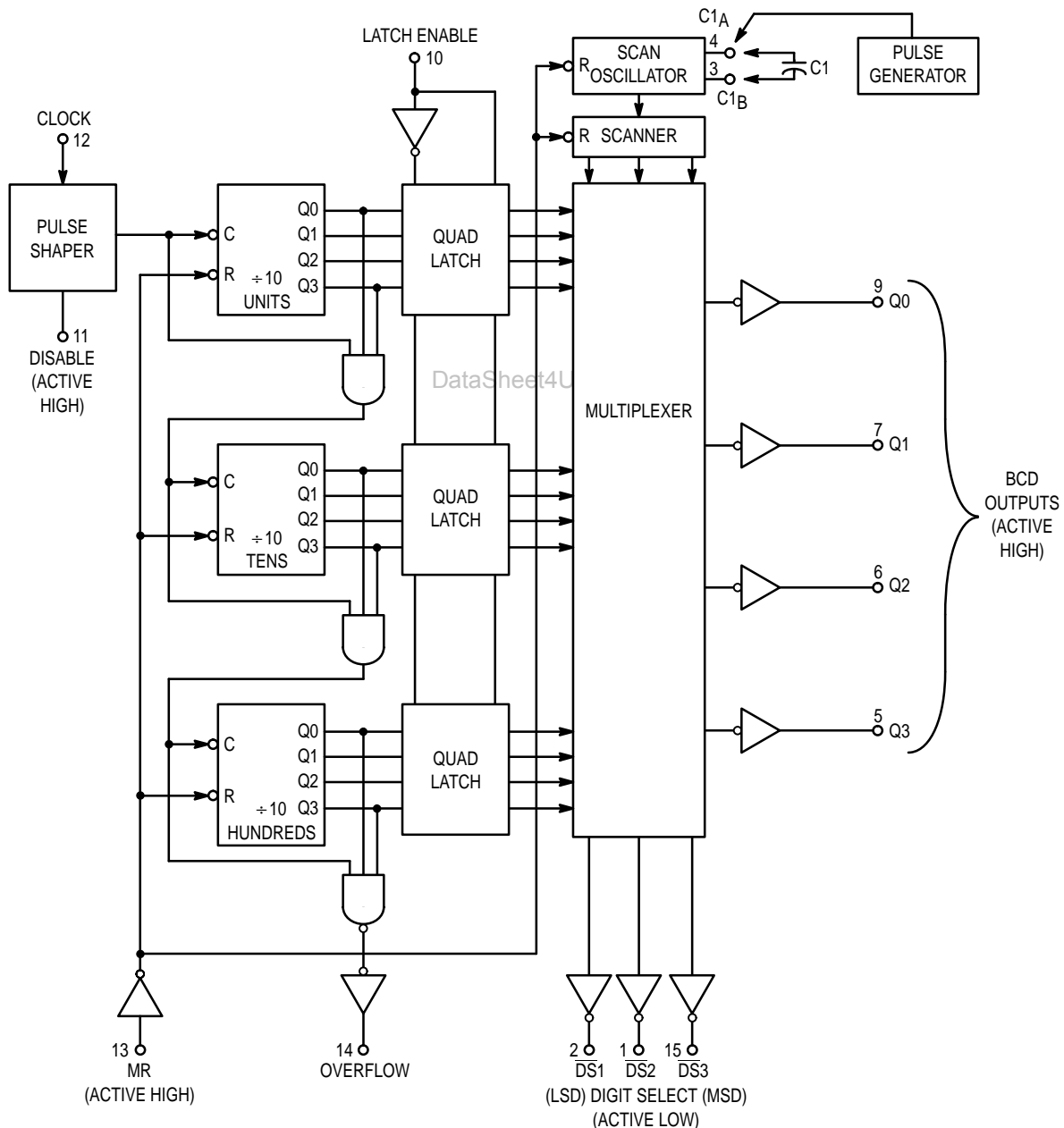
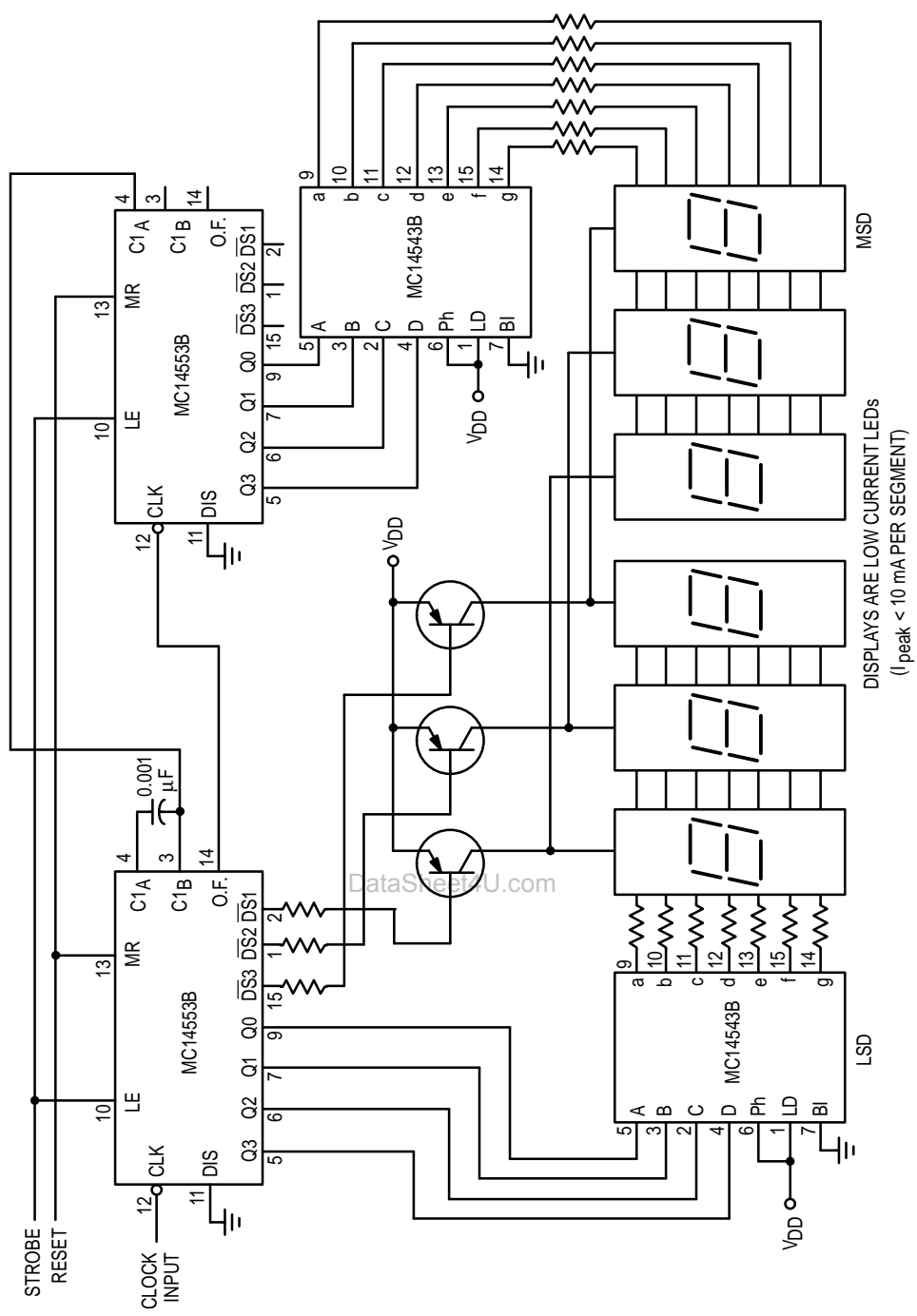


Figure 3. Expanded Block Diagram

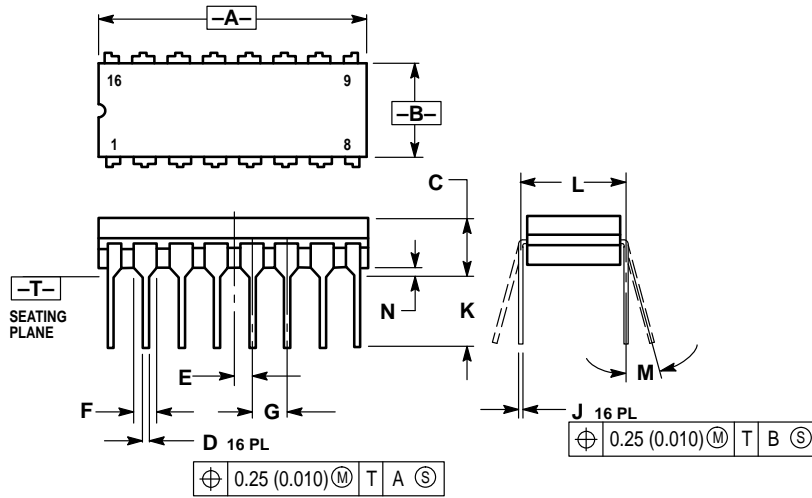


DISPLAYS ARE LOW CURRENT LEDs  
 ( $I_{peak} < 10 \text{ mA PER SEGMENT}$ )

Figure 4. Six-Digit Display

### OUTLINE DIMENSIONS

#### L SUFFIX CERAMIC DIP PACKAGE CASE 620-10 ISSUE V

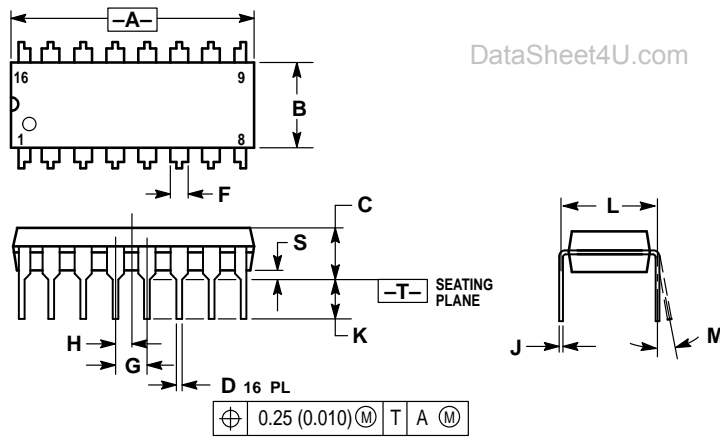


NOTES:

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



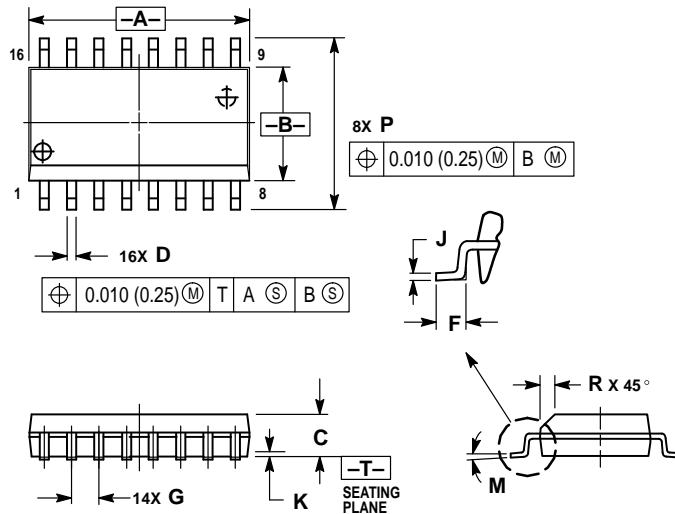
NOTES:

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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