

# Digital-to-Analog Converters with Serial Interface

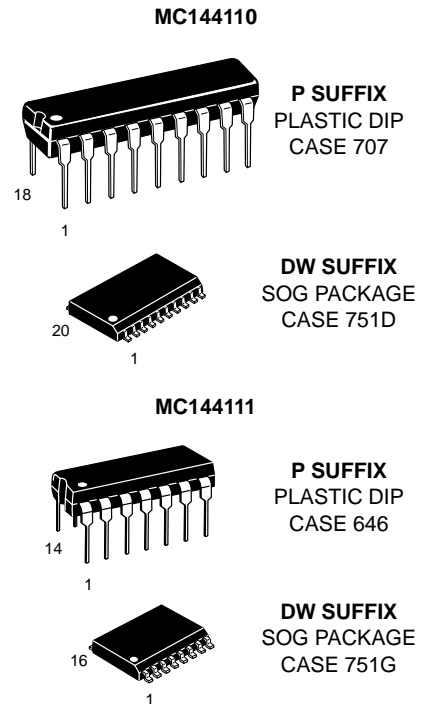
## CMOS LSI

The MC144110 and MC144111 are low-cost 6-bit D/A converters with serial interface ports to provide communication with CMOS microprocessors and microcomputers. The MC144110 contains six static D/A converters; the MC144111 contains four converters.

Due to a unique feature of these DACs, the user is permitted easy scaling of the analog outputs of a system. Over a 5 to 15 V supply range, these DACs may be directly interfaced to CMOS MPUs operating at 5 V.

- Direct R-2R Network Outputs
- Buffered Emitter-Follower Outputs
- Serial Data Input
- Digital Data Output Facilitates Cascading
- Direct Interface to CMOS  $\mu$ P
- Wide Operating Voltage Range: 4.5 to 15 V
- Wide Operating Temperature Range: 0 to 85°C
- Software Information is Contained in Document M68HC11RM/AD

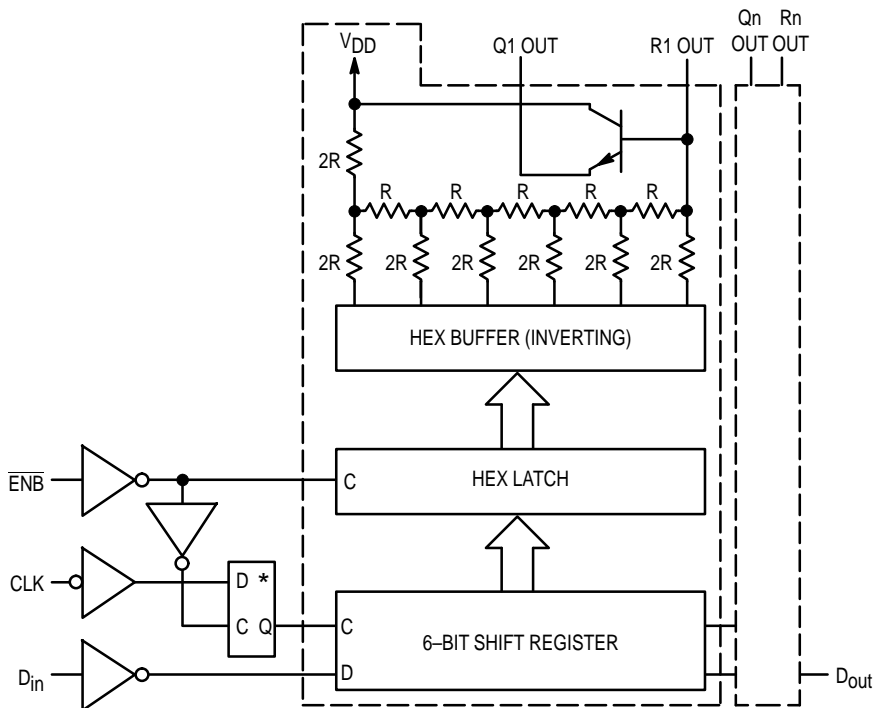
## MC144110 MC144111



### ORDERING INFORMATION

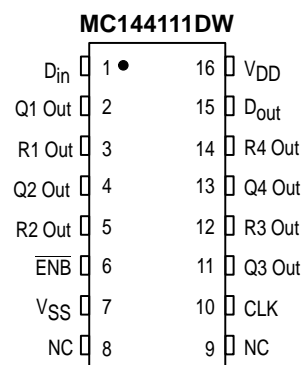
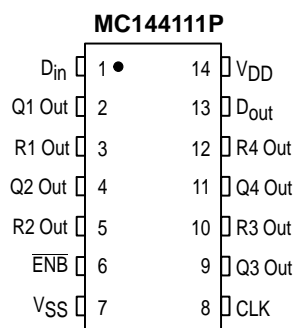
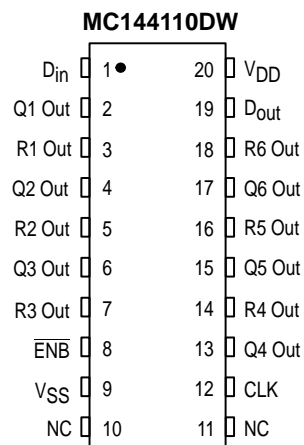
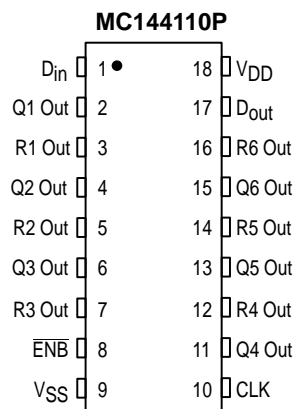
MC144110P	Plastic DIP
MC144110DW	SOG Package
MC144111P	Plastic DIP
MC144111DW	SOG Package

### BLOCK DIAGRAM



\* Transparent Latch

## PIN ASSIGNMENTS



NC = NO CONNECTION

**MAXIMUM RATINGS\*** (Voltages referenced to  $V_{SS}$ )

Parameter	Symbol	Value	Unit
DC Supply Voltage	$V_{DD}$	- 0.5 to + 18	V
Input Voltage, All Inputs	$V_{in}$	- 0.5 to $V_{DD} + 0.5$	V
DC Input Current, per Pin	I	$\pm 10$	mA
Power Dissipation (Per Output) $T_A = 70^\circ\text{C}$ , MC144110 MC144111 $T_A = 85^\circ\text{C}$ , MC144110 MC144111	$P_{OH}$	30 50 10 20	mW
Power Dissipation (Per Package) $T_A = 70^\circ\text{C}$ , MC144110 MC144111 $T_A = 85^\circ\text{C}$ , MC144110 MC144111	$P_D$	100 150 25 50	mW
Storage Temperature Range	$T_{stg}$	- 65 to + 150	$^\circ\text{C}$

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

This device contains protection circuitry to guard against damage due to high static voltages or electric fields; however, it is advised that precautions be taken to avoid application of voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation it is recommended that  $V_{in}$  and  $V_{out}$  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  $V_{DD}$ ).

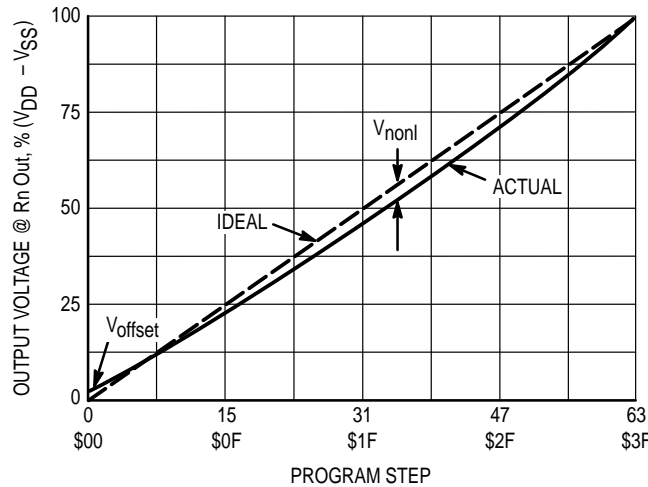
**ELECTRICAL CHARACTERISTICS** (Voltages referenced to  $V_{SS}$ ,  $T_A = 0$  to  $85^\circ\text{C}$  unless otherwise indicated)

Symbol	Parameter	Test Conditions	$V_{DD}$	Min	Max	Unit
$V_{IH}$	High-Level Input Voltage ( $D_{in}$ , $\overline{ENB}$ , CLK)		5 10 15	3.0 3.5 4	—	V
$V_{IL}$	Low-Level Input Voltage ( $D_{in}$ , $\overline{ENB}$ , CLK)		5 10 15	— — —	0.8 0.8 0.8	V
$I_{OH}$	High-Level Output Current ( $D_{out}$ )	$V_{out} = V_{DD} - 0.5 \text{ V}$	5	- 200	—	$\mu\text{A}$
$I_{OL}$	Low-Level Output Current ( $D_{out}$ )	$V_{out} = 0.5 \text{ V}$	5	200	—	$\mu\text{A}$
$I_{DD}$	Quiescent Supply Current MC144110 MC144111	$I_{out} = 0 \mu\text{A}$	15 15	— —	12 8	mA
$I_{in}$	Input Leakage Current ( $D_{in}$ , $\overline{ENB}$ , CLK)	$V_{in} = V_{DD}$ or 0 V	15	—	$\pm 1$	$\mu\text{A}$
$V_{nonl}$	Nonlinearity Voltage ( $R_n$ Out)	See Figure 1	5 10 15	— — —	100 200 300	mV
$V_{step}$	Step Size ( $R_n$ Out)	See Figure 2	5 10 15	19 39 58	137 274 411	mV
$V_{offset}$	Offset Voltage from $V_{SS}$	$D_{in} = \$00$ , See Figure 1	—	—	1	LSB
$I_E$	Emitter Leakage Current	$V_{Rn \text{ Out}} = 0 \text{ V}$	15	—	10	$\mu\text{A}$
$h_{FE}$	DC Current Gain	$I_E = 0.1$ to $10.0 \text{ mA}$ $T_A = 25^\circ\text{C}$	—	40	—	—
$V_{BE}$	Base-to-Emitter Voltage Drop	$I_E = 1.0 \text{ mA}$	—	0.4	0.7	V

## SWITCHING CHARACTERISTICS

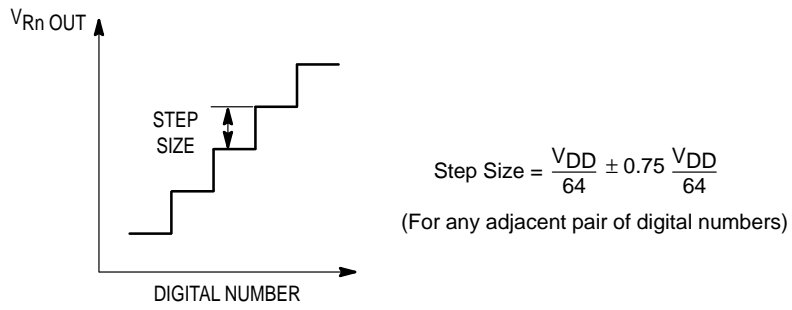
(Voltages referenced to  $V_{SS}$ ,  $T_A = 0$  to  $85^\circ\text{C}$ ,  $C_L = 50$  pF, Input  $t_r = t_f = 20$  ns unless otherwise indicated)

Symbol	Parameter	$V_{DD}$	Min	Max	Unit
$t_{wH}$	Positive Pulse Width, CLK (Figures 3 and 4)	5	2	—	$\mu\text{s}$
		10	1.5	—	
		15	1	—	
$t_{wL}$	Negative Pulse Width, CLK (Figure 3 and 4)	5	5	—	$\mu\text{s}$
		10	3.5	—	
		15	2	—	
$t_{su}$	Setup Time, $\overline{\text{ENB}}$ to CLK (Figures 3 and 4)	5	5	—	$\mu\text{s}$
		10	3.5	—	
		15	2	—	
$t_{su}$	Setup Time, $D_{in}$ to CLK (Figures 3 and 4)	5	1000	—	ns
		10	750	—	
		15	500	—	
$t_h$	Hold Time, CLK to $\overline{\text{ENB}}$ (Figures 3 and 4)	5	5	—	$\mu\text{s}$
		10	3.5	—	
		15	2	—	
$t_h$	Hold Time, CLK to $D_{in}$ (Figures 3 and 4)	5	5	—	$\mu\text{s}$
		10	3.5	—	
		15	2	—	
$t_r, t_f$	Input Rise and Fall Times	5 – 15	—	2	$\mu\text{s}$
$C_{in}$	Input Capacitance	5 – 15	—	7.5	pF

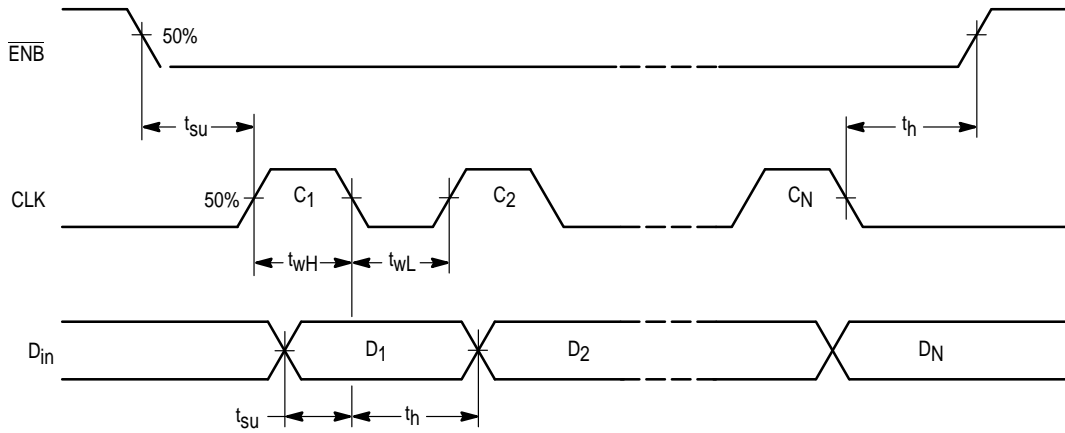


**LINEARITY ERROR** (integral linearity). A measure of how straight a device's transfer function is, it indicates the worst-case deviation of linearity of the actual transfer function from the best-fit straight line. It is normally specified in parts of an LSB.

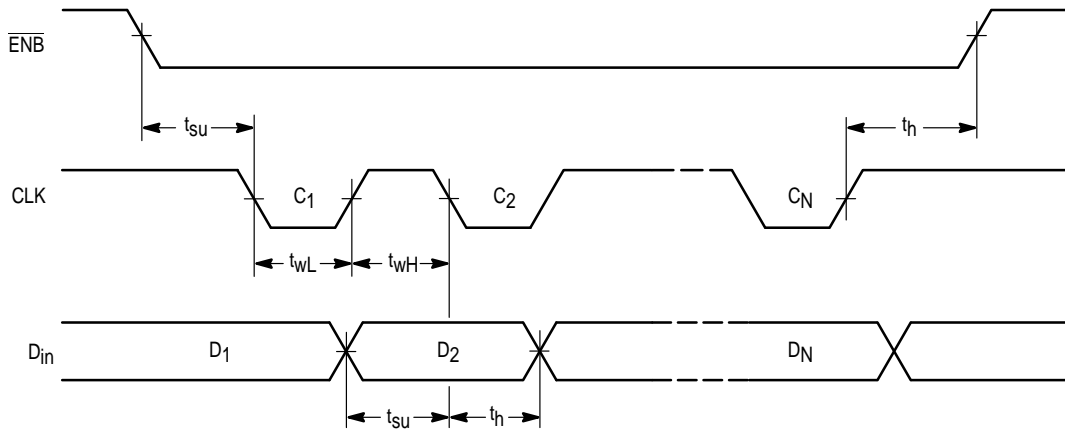
**Figure 1. D/A Transfer Function**



**Figure 2. Definition of Step Size**



**Figure 3. Serial Input, Positive Clock**



**Figure 4. Serial Input, Negative Clock**

## PIN DESCRIPTIONS

### INPUTS

#### **D<sub>in</sub>** **Data Input**

Six-bit words are entered serially, MSB first, into digital data input, D<sub>in</sub>. Six words are loaded into the MC144110 during each D/A cycle; four words are loaded into the MC144111.

The last 6-bit word shifted in determines the output level of pins Q1 Out and R1 Out. The next-to-last 6-bit word affects pins Q2 Out and R2 Out, etc.

#### **$\overline{\text{ENB}}$**

#### **Negative Logic Enable**

The  $\overline{\text{ENB}}$  pin must be low (active) during the serial load. On the low-to-high transition of  $\overline{\text{ENB}}$ , data contained in the shift register is loaded into the latch.

#### **CLK**

#### **Shift Register Clock**

Data is shifted into the register on the high-to-low transition of CLK. CLK is fed into the D-input of a transparent latch, which is used for inhibiting the clocking of the shift register when  $\overline{\text{ENB}}$  is high.

The number of clock cycles required for the MC144110 is usually 36. The MC144111 usually uses 24 cycles. See Table 1 for additional information.

## OUTPUTS

#### **D<sub>out</sub>** **Data Output**

The digital data output is primarily used for cascading the DACs and may be fed into D<sub>in</sub> of the next stage.

#### **R1 Out through R<sub>n</sub> Out** **Resistor Network Outputs**

These are the R-2R resistor network outputs. These outputs may be fed to high-impedance input FET op amps to bypass the on-chip bipolar transistors. The R value of the resistor network ranges from 7 to 15 k $\Omega$ .

#### **Q1 Out through Q<sub>n</sub> Out** **NPN Transistor Outputs**

Buffered DAC outputs utilize an emitter-follower configuration for current-gain, thereby allowing interface to low-impedance circuits.

## SUPPLY PINS

#### **V<sub>SS</sub>** **Negative Supply Voltage**

This pin is usually ground.

#### **V<sub>DD</sub>** **Positive Supply Voltage**

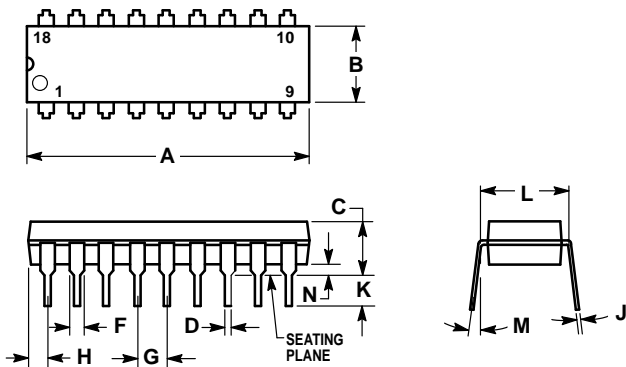
The voltage applied to this pin is used to scale the analog output swing from 4.5 to 15 V p-p.

**Table 1. Number of Channels vs Clocks Required**

Number of Channels Required	Number of Clock Cycles	Outputs Used on MC144110	Outputs Used on MC144111
1	6	Q1/R1	Q1/R1
2	12	Q1/R1, Q2/R2	Q1/R1, Q2/R2
3	18	Q1/R1, Q2/R2, Q3/R3	Q1/R1, Q2/R2, Q3/R3
4	24	Q1/R1, Q2/R2, Q3/R3, Q4/R4	Q1/R1, Q2/R2, Q3/R3, Q4/R4
5	30	Q1/R1, Q2/R2, Q3/R3, Q4/R4, Q5/R5	Not Applicable
6	36	Q1/R1, Q2/R2, Q3/R3, Q4/R4, Q5/R5, Q6/R6	Not Applicable

# PACKAGE DIMENSIONS

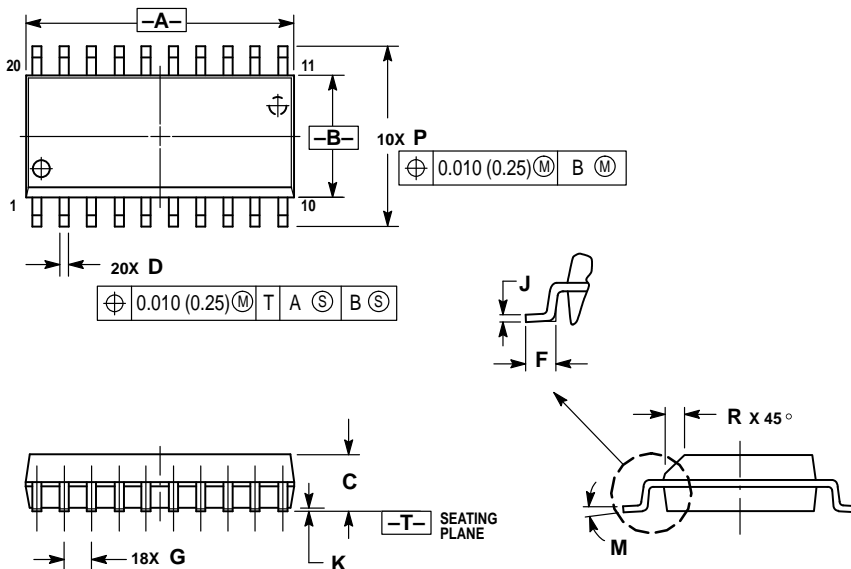
## P SUFFIX PLASTIC DIP CASE 707-02



- NOTES:
1. POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25 (0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
  2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
  3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	22.22	23.24	0.875	0.915
B	6.10	6.60	0.240	0.260
C	3.56	4.57	0.140	0.180
D	0.36	0.56	0.014	0.022
F	1.27	1.78	0.050	0.070
G	2.54 BSC		0.100 BSC	
H	1.02	1.52	0.040	0.060
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040

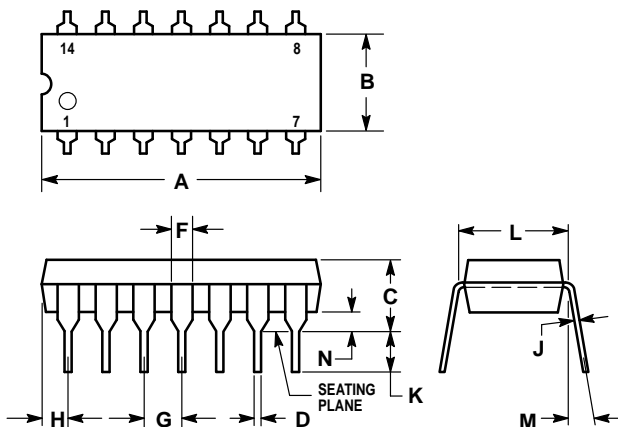
## DW SUFFIX SOG PACKAGE CASE 751D-04



- 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 0.150 (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	12.65	12.95	0.499	0.510
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

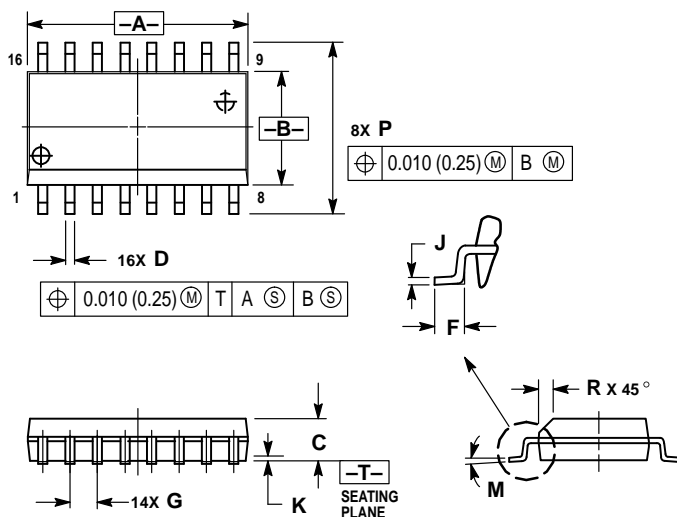
**P SUFFIX  
PLASTIC DIP  
CASE 646-06**



- NOTES:
- LEADS WITHIN 0.13 (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
  - DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
  - DIMENSION B DOES NOT INCLUDE MOLD FLASH.
  - ROUNDED CORNERS OPTIONAL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.715	0.770	18.16	19.56
B	0.240	0.260	6.10	6.60
C	0.145	0.185	3.69	4.69
D	0.015	0.021	0.38	0.53
F	0.040	0.070	1.02	1.78
G	0.100 BSC		2.54 BSC	
H	0.052	0.095	1.32	2.41
J	0.008	0.015	0.20	0.38
K	0.115	0.135	2.92	3.43
L	0.300 BSC		7.62 BSC	
M	0°	10°	0°	10°
N	0.015	0.039	0.39	1.01

**DW SUFFIX  
SOG PACKAGE  
CASE 751G-02**



- NOTES:
- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  - CONTROLLING DIMENSION: MILLIMETER.
  - DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
  - MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  - 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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