HARRIS HA-5141/42/44

Single/Dual/Quad Ultra-Low Power Operational Amplifiers

May 1990

Features

- Low Supply Current 45μA/Amp
- Wide Supply Voltage Range..... Single 3V to 30V or Dual ±1.5V to ±15V
- High Slew Rate 1.5V/μs
- High Gain 100kV/V
- Unity Gain Stable
- Available in Singles, Duals and Quads

Applications

- Portable Instruments
- Meter Amplifiers
- Telephone Headsets
- Microphone Amplifiers
- Instrumentation
- For Further Design Ideas See Application Note 544

Description

The HA-5141/42/44 ultra-low power operational amplifiers provide AC and DC performance characteristics similar to or better than most general purpose amplifiers while only drawing 1/30 of the supply current of most general purpose amplifiers. In applications which require low power dissipation and good A.C. electrical charactersistics, this family offers the industry's best speed/power ratio.

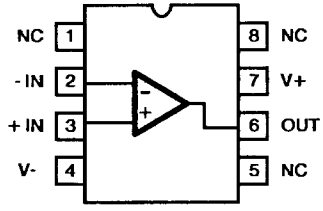
The HA-5141/42/44 provides accurate signal processing by virtue of their low input offset voltage (0.5mV), low input bias current (45nA), high open loop gain (100kV/V) and low noise, for low power operational amplifiers ($20nV/\sqrt{Hz}$). These characteristics coupled with a 1.5/μs slew rate and a 400kHz bandwidth make the HA-5141/42/44 ideal for use in low power instrumentation, audio amplifier and active filter designs. The wide range of supply voltages (3V to 30V) also allow these amplifiers to be very useful in low voltage battery powered equipment. These parts are also tested and guaranteed at both ±15V and single ended +5V supplies.

These amplifiers are available in singles (HA-5141, SOIC, Can or Mini-DIP), duals (HA-5142, SOIC, Can or Mini-DIP) or quads (HA-5144, SOIC or DIP) with industry standards pinouts which allow the HA-5141/5142/5144's to be interchangeable with most other operational amplifiers. For military grade product refer to the 5141, 5142, 5144/883 data sheet.

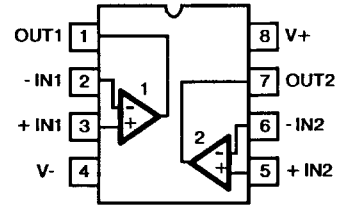
Pinouts

TOP VIEWS

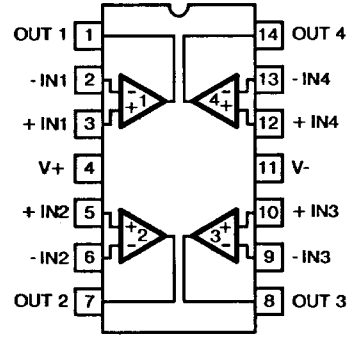
HA1-5141 (CERAMIC MINI-DIP)
HA3-5141 (PLASTIC MINI-DIP)



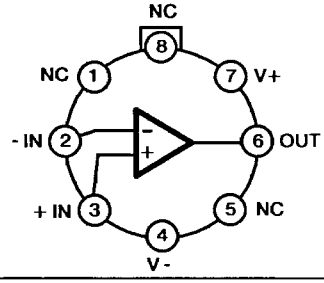
HA3-5142 (PLASTIC MINI-DIP)
HA7-5142 (CERAMIC DIP)



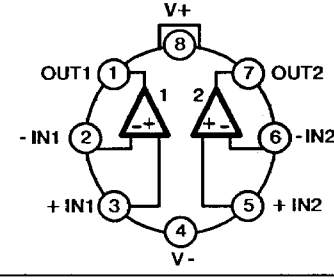
HA1-5144 (CERAMIC DIP)
HA3-5144 (PLASTIC DIP)



HA2-5141 (TO-99 METAL CAN)



HA2-5142 (TO-99 METAL CAN)



CAUTION: These devices are sensitive to electrostatic discharge. Proper IC handling procedures should be followed.

Absolute Maximum Ratings (Note 1)

Voltage Between V+ and V- Terminals 35V
Differential Input Voltage ..... ±7V
Output Current ..... S/C Protected
Internal Power Dissipation 500mW

Operating Temperature Range

HA-5141/42/44-5 ..... $0^oC \leq T_A \leq +75^oC$
HA-5141/42/44-2 ..... $-55^oC \leq T_A \leq +125^oC$
HA-5141/42/44-9 ..... $-40^oC \leq T_A \leq +85^oC$
Storage Temperature Range ..... $-65^oC \leq T_A \leq +150^oC$
Maximum Junction Temperature ..... $+175^oC$

Electrical Specifications $R_S = 100\Omega$, $C_L \leq 10pF$ Unless Otherwise Specified.

PARAMETER	TEMP	-2, -5 V+ = +5V, V- = 0V			-2, -5 V+ = +15V, V- = -15V			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS								
Offset Voltage (Note 11)	+25°C	-	2	6	-	2	6	mV
	Full	-	-	8	-	-	8	mV
Average Offset Voltage Drift	Full	-	3	-	-	3	-	µV/°C
Bias Current (Note 11)	+25°C	-	45	100	-	45	100	nA
	Full	-	-	125	-	-	125	nA
Offset Current (Note 11)	+25°C	-	0.3	10	-	0.3	10	nA
	Full	-	-	20	-	-	20	nA
Common Mode Range	Full	0 to 3	-	-	±10	-	-	V
Differential Input Resistance	+25°C	-	0.6	-	-	0.6	-	MΩ
Input Noise Voltage (f = 1kHz)	+25°C	-	20	-	-	20	-	$nV/\sqrt{Hz}$
Input Noise Current (f = 1kHz)	+25°C	-	0.25	-	-	0.25	-	$pA/\sqrt{Hz}$
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Notes 2, 4)	+25°C	20k	100k	-	20k	100k	-	V/V
	Full	15k	-	-	15k	-	-	V/V
Common Mode Rejection Ratio (Note 7)	Full	77	105	-	77	105	-	dB
Bandwidth (Notes 2, 3)	+25°C	-	0.4	-	-	0.4	-	MHz
OUTPUT CHARACTERISTICS								
Output Voltage Swing (Notes 2, 10)	+25°C	1.0 to 3.8	0.7 to 4.2	-	±10	±13	-	V
	Full	1.2 to 3.5	0.9 to 4.0	-	±10	±13	-	V
Full Power Bandwidth (Notes 2, 4, 8)	+25°C	-	240	-	-	24	-	kHz
TRANSIENT RESPONSE (Notes 2, 3)								
Rise Time	+25°C	-	600	-	-	600	-	ns
Slew Rate (Note 6)	+25°C	0.8	1.5	-	0.8	1.5	-	V/µs
Settling Time (Note 5)	+25°C	-	10	-	-	10	-	µs
POWER SUPPLY CHARACTERISTICS								
Supply Current	+25°C	-	45	80	-	100	150	µA/Amp
	Full	-	-	100	-	-	200	µA/Amp
Power Supply Rejection Ratio (Note 9)	Full	77	105	-	77	105	-	dB

NOTES:

1. Absolute maximum ratings are limiting values, applied individually beyond which the serviceability of the circuit may be impaired. Functional operability under any of these conditions is not necessarily implied.
2. $R_L = 50k\Omega$
3. $C_L = 50pF$
4. $V_O = 1.4$ to 2.5V for $V_{CC} = +5, 0V$; $V_O = \pm 10V$ for $V_{CC} = \pm 15V$.
5. Settling Time is specified to 0.1% of final value for a 3V output step and $A_V = -1$ for $V_{CC} = +5V, 0V$. Output step = 10V for $V_{CC} = \pm 15V$.
6. Maximum input slew rate = 10V/µs.
7. $V_{CM} = 0$ to 3V for $V_{CC} = +5, 0V$; $V_{CM} = \pm 10V$ for $V_{CC} = \pm 15V$
8. Full Power Bandwidth is guaranteed by equation:
   $$\text{Full Power Bandwidth} = \frac{\text{Slew Rate}}{2\pi V \text{ Peak}}$$
9. $\Delta V_S = +10V$ for $V_{CC} = +5, 0V$; $\Delta V_S = \pm 5V$ for $V_{CC} = \pm 15V$.
10. For $V_{CC} = +5, 0V$ terminate R_L at +2.5V. Typical output current is ±3mA.
11. $V_O = 1.4V$ for $V_{CC} = +5V, 0V$.

Electrical Specifications R_S = 100Ω, C_L < 10pF Unless Otherwise Specified.

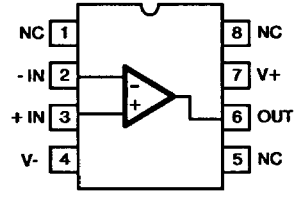
PARAMETER	TEMP	-9 V+ = +5V, V- = 0V			-9 V+ = +15V, V- = -15V			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS								
Offset Voltage (Note 11)	+25°C	-	2	6	-	2	6	mV
	Full	-	-	8	-	-	8	mV
Average Offset Voltage Drift	Full	-	3	-	-	3	-	µV/°C
Bias Current (Note 11)	+25°C	-	45	100	-	45	100	nA
	Full	-	-	125	-	-	125	nA
Offset Current (Note 11)	+25°C	-	0.3	10	-	0.3	10	nA
	Full	-	-	20	-	-	20	nA
Common Mode Range	Full	0 to 3	-	-	±10	-	-	V
Differential Input Resistance	+25°C	-	0.6	-	-	0.6	-	MΩ
Input Noise Voltage (f = 1kHz)	+25°C	-	20	-	-	20	-	nV/√Hz
Input Noise Current (f = 1kHz)	+25°C	-	0.25	-	-	0.25	-	pA/√Hz
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Notes 2, 4)	+25°C	20k	100k	-	20k	100k	-	V/V
	Full	12k	-	-	12k	-	-	V/V
Common Mode Rejection Ratio (Note 7)	Full	70	105	-	70	105	-	dB
Bandwidth (Notes 2, 3)	+25°C	-	0.4	-	-	0.4	-	MHz
OUTPUT CHARACTERISTICS								
Output Voltage Swing (Notes 2, 10)	+25°C	1.0 to 3.8	0.7 to 4.2	-	±10	±13	-	V
	Full	1.2 to 3.5	0.9 to 4.0	-	±10	±13	-	V
Output Current	+25°C	-	-	-	-	-	-	V
Full Power Bandwidth (Notes 2, 4, 8)	+25°C	-	240	-	-	24	-	kHz
TRANSIENT RESPONSE (Notes 2, 3)								
Rise Time	+25°C	-	600	-	-	600	-	ns
Slew Rate (Note 6)	+25°C	0.8	1.5	-	0.8	1.5	-	V/µs
Settling Time (Note 5)	+25°C	-	10	-	-	10	-	µs
POWER SUPPLY CHARACTERISTICS								
Supply Current	+25°C	-	45	80	-	100	150	µA/Amp
	Full	-	-	100	-	-	200	µA/Amp
Power Supply Rejection Ratio (Note 9)	Full	70	105	-	70	105	-	dB

NOTE: The notes from the -2, -5 table apply to this -9 table. Absolute maximum ratings and the operating temperature ranges also apply.

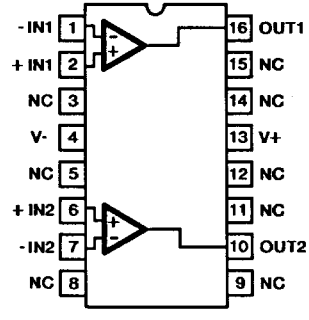
SOIC Pinouts

TOP VIEWS

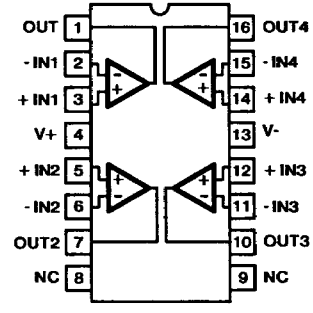
HA9P5141 (SOIC)



HA9P5142 (SOIC)

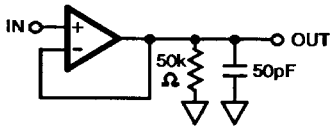


HA9P5144 (SOIC)

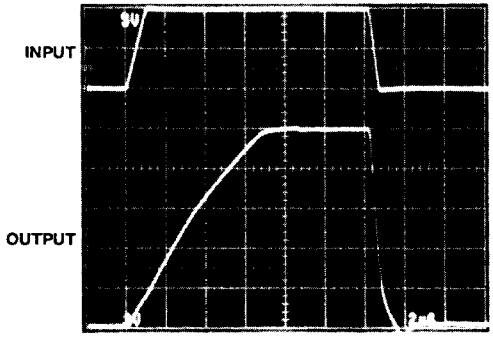


Test Circuits

SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT



LARGE SIGNAL RESPONSE
Vertical Scale: (Volts: Input = 5V/Div.; Output = 2V/Div.)
Horizontal Scale: (Time: 2µs/Div.)

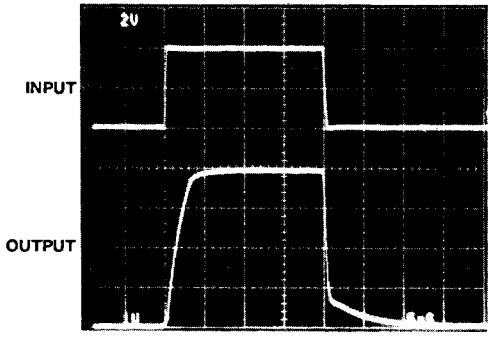


$+V_{SUPPLY}$ = +15V, $-V_{SUPPLY}$ = -15V

SMALL SIGNAL RESPONSE
Vertical Scale: (Volts: Input = 100mV/Div.; Output = 50mV/Div.)
Horizontal Scale: (Time: 2µs/Div.)

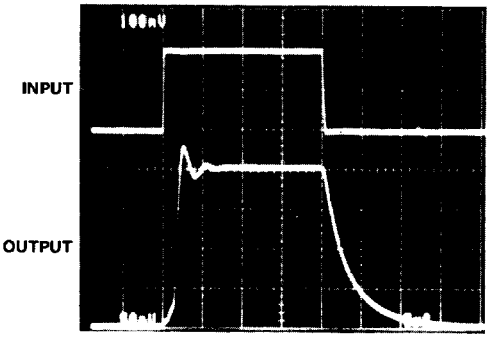
$+V_{SUPPLY}$ = +15V, $-V_{SUPPLY}$ = -15V

LARGE SIGNAL RESPONSE
Vertical Scale: (Volts: Input = 2V/Div.; Output = 1V/Div.)
Horizontal Scale: (Time: 5µs/Div.)



$+V_{SUPPLY}$ = +5V, $-V_{SUPPLY}$ = 0V

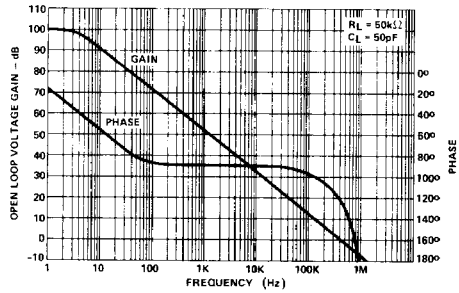
SMALL SIGNAL RESPONSE
Vertical Scale: (Volts: Input = 100mV/Div.; Output = 50mV/Div.)
Horizontal Scale: (Time: 5µs/Div.)



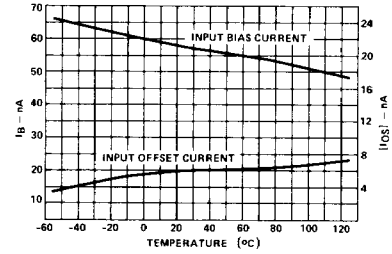
$+V_{SUPPLY}$ = +5V, $-V_{SUPPLY}$ = 0V

Performance Curves $V_S = \pm 2.5V$, $T_A = +25^oC$ Unless Otherwise Specified

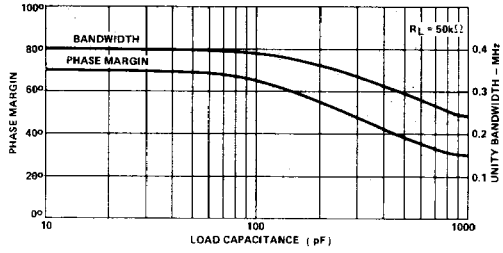
OPEN LOOP FREQUENCY RESPONSE



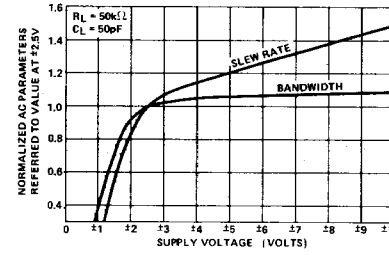
INPUT OFFSET CURRENT AND BIAS CURRENT vs. TEMPERATURE



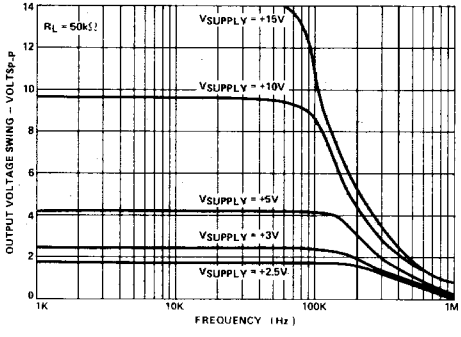
BANDWIDTH AND PHASE MARGIN vs. LOAD CAPACITANCE



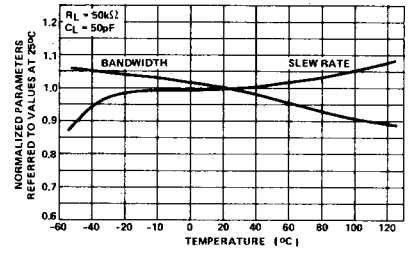
NORMALIZED AC PARAMETERS vs. SUPPLY VOLTAGE



OUTPUT VOLTAGE SWING vs. FREQUENCY AND SINGLE SUPPLY VOLTAGE

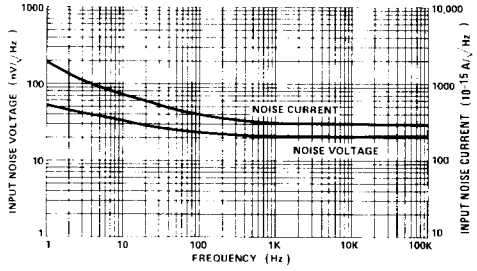


NORMALIZED AC PARAMETERS vs. TEMPERATURE

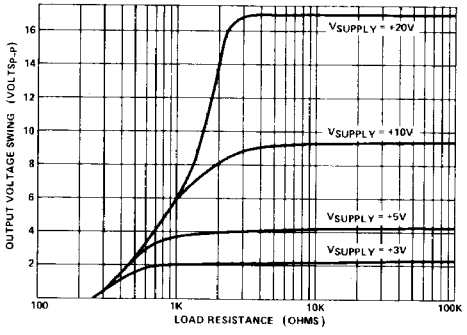


Performance Curves (Continued) $V_S = \pm 2.5V$, $T_A = +25^oC$ Unless Otherwise Specified

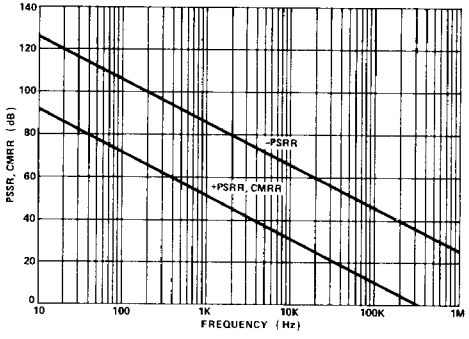
INPUT NOISE vs. FREQUENCY



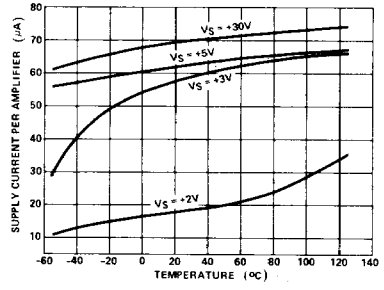
MAXIMUM OUTPUT VOLTAGE SWING vs. LOAD RESISTANCE AND SINGLE SUPPLY VOLTAGE



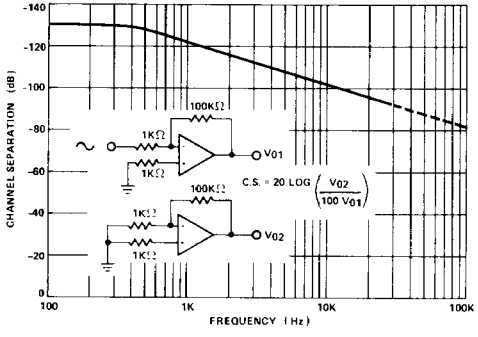
PSRR AND CMRR vs. FREQUENCY



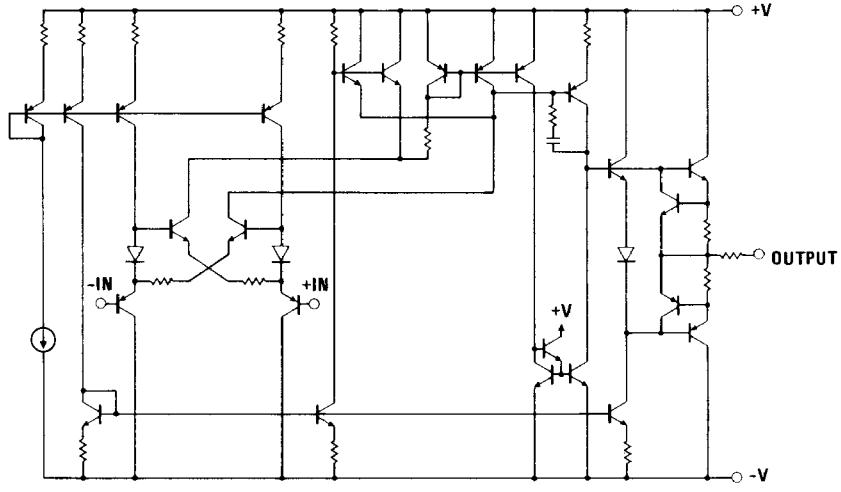
POWER SUPPLY CURRENT vs. TEMPERATURE AND SINGLE SUPPLY VOLTAGE



CHANNEL SEPARATION vs. FREQUENCY



Schematic



Die Characteristics

Transistor Count

- HA-5141 33
- HA-5142 66
- HA-5144 132

Substrate Potential* ..... V-

Process ..... Bipolar-DI

Thermal Constants (°C/W)	θ_{ja}	θ_{jc}
HA1-5144 (-2, -5, -7)	101	33
HA1-5144 (/883)	75	22
HA2-5144 (-2, -5, -7)	206	56
HA2-5141 (/883)	168	50
HA2-5142 (-2, -5, -7)	184	50
HA2-5142 (/883)	143	43
HA3-5141 (-5)	90	40
HA3-5142 (-5)	80	20
HA3-5144 (-5)	75	20
HA7-5141 (-2, -5, -7)	210	117
HA7-5141 (/833)	90	40
HA7-5142 (-2, -5, -7)	177	92
HA7-5142 (/883)	80	20
HA9P5141 (-5, -9)	161	42
HA9P5142 (-5, -9)	94	26
HA9P5144 (-5, -9)	90	26

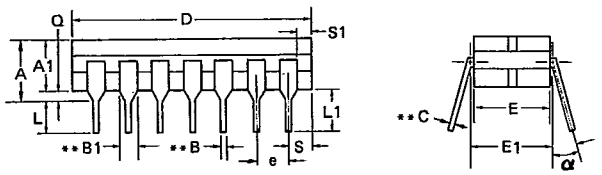
*The substrate may be left floating (Insulating Die Mount) or it may be mounted on a conductor at V- potential.

NOTE: Consult Harris for LCC/PLCC information.

Package Configuration

T-90-20

A B C D E .300 CERAMIC DUAL-IN-LINE



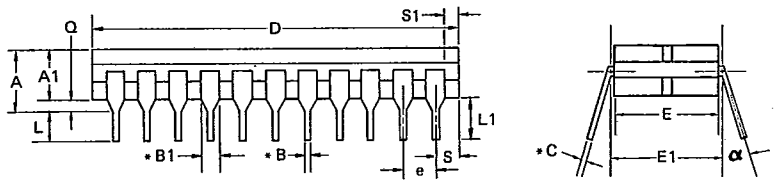
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
A	8 SSI	— .200	.140 .160	.016 .023	.050 .065	.008 .015	.375 .395	.245 .265	.290 .310	.100 BSC	.125 .150	.150 —	— .055	.005 —	.015 .060	0° 15°
B1	14 MSI	— .200	.140 .170	.016 .023	.050 .065	.008 .015	.753 .785	.265 .285	.290 .310	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
B2	14 LSI	— .200	.140 .170	.016 .023	.050 .065	.008 .015	.753 .785	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
C1	16* MSI	— .200	.140 .170	.016 .023	.050* .065*	.008 .015	.753 .785	.265 .285	.290 .310	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°
C2	16* LSI	— .200	.140 .170	.016 .023	.050* .065*	.008 .015	.753 .785	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°
D	18 LSI	— .200	.140 .170	.016 .023	.050* .065*	.008 .015	.882 .915	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
E	20 LSI	— .200	.140 .170	.016 .023	.050* .065*	.008 .015	.940 .970	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°

* End leads are half leads where B remains the same and B1 is $\frac{0.035}{0.045}$

** Solder dip finish add +0.003 inches

F .400 CERAMIC DUAL-IN-LINE

G H .600 CERAMIC DUAL-IN-LINE



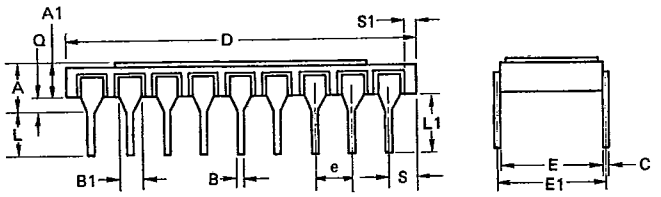
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
F .400	22 LSI	— .225	.150 .180	.016 .023	.050 .065	.008 .015	1.055 1.085	.375 .395	.395 .415	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°
G .600	24 LSI	— .225	.150 .180	.016 .023	.050 .065	.008 .015	1.24 1.27	.515 .535	.595 .615	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
H .600	28 LSI	— .225	.160 .190	.016 .023	.050 .065	.008 .015	1.44 1.47	.515 .535	.595 .615	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°

* Solder dip finish add +0.003 inches.

NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$. Dimensions are in inches. BSC means basic spacing between centerlines.

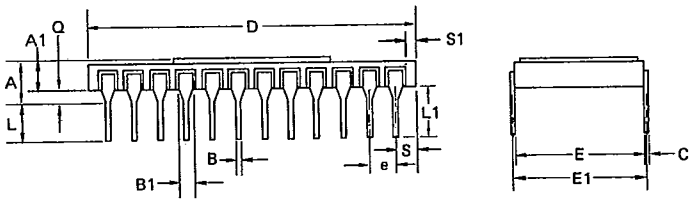
Package Configuration

I .300 SIDEBRAZE DUAL-IN-LINE



PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q
I	18	— .200	.080 .110	.016 .023	.045 .060	.008 .015	.890 .910	.280 .300	.290 .310	.100 BSC	.125 .180	.150 —	— .098	.005 —	.025 .045

J K L .600 SIDEBRAZE DUAL-IN-LINE



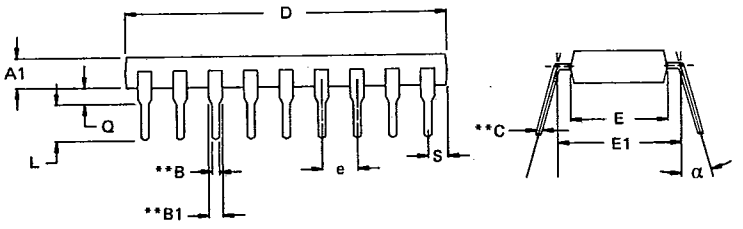
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q
J	24	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.185 1.215	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.040 .060
K	28	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.385 1.415	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.030 .060
L	40	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.980 2.020	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.040 .060

NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$. Dimensions are in inches.

BSC means basic spacing between centerlines.

Package Configuration

M N O P Q .300 PLASTIC DUAL-IN-LINE

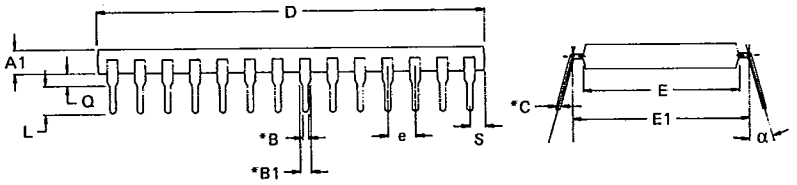


PKG. CODE	LEAD COUNT	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. S	DIM. Q	DIM. α
M	8	.125/.140	.016/.023	.050/.070	.008/.015	.370/.390	.245/.265	.290/.310	.090/.110	.110/.150	.030/.050	.020/.040	0°/15°
N	14	.125/.140	.016/.023	.050/.070	.008/.015	.750/.770	.245/.265	.290/.310	.090/.110	.110/.150	.030/.050	.020/.040	0°/15°
O	16*	.125/.140	.016/.023	.050/.070	.008/.015	.750/.770	.245/.265	.290/.310	.090/.110	.110/.150	.025/.035	.020/.040	0°/15°
P	18	.125/.140	.016/.023	.050/.070	.008/.015	.900/.920	.245/.265	.290/.310	.090/.110	.110/.150	.040/.060	.020/.040	0°/15°
Q	20	.130/.145	.016/.023	.050/.070	.008/.015	1.030/1.050	.250/.270	.290/.310	.090/.110	.110/.150	.060/.080	.020/.040	0°/15°

* End leads are half leads where B remains the same and B1 is 0.035/0.045

** Solder dip finish add 0.003 inches.

R S .600 PLASTIC DUAL-IN-LINE



PKG. CODE	LEAD COUNT	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. S	DIM. Q	DIM. α
R	24	.145/.155	.016/.023	.050/.070	.008/.015	1.24/1.26	.540/.560	.590/.610	.090/.110	.110/.150	.045/.095	.020/.040	0°/15°
S	28	.145/.155	.016/.023	.050/.070	.008/.015	1.54/1.57	.540/.560	.590/.610	.090/.110	.110/.150	.110/.160	.020/.040	0°/15°

* Solder dip finish add 0.003 inches.

NOTE: Dimensions are Min/Max. Dimensions are in inches.

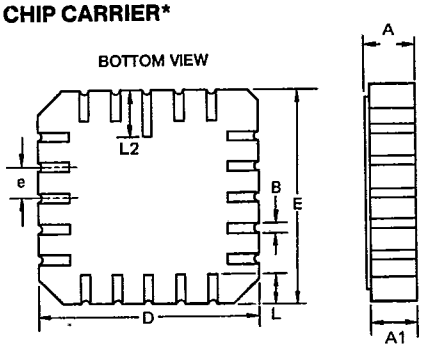
BSC means basic spacing between centerlines.

Package Configuration

T .350 CERAMIC LEADLESS CHIP CARRIER*

U .450 CERAMIC LEADLESS CHIP CARRIER*

V .650 CERAMIC LEADLESS CHIP CARRIER*

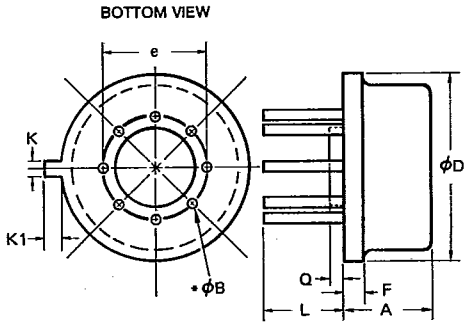


PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. D	DIM. E	DIM. e	DIM. L	DIM. L2
T	20 .350 SQ	.073 .089	.063 .077	.022 .028	.342 .358	.342 .358	.050 BSC	.045 .055	.075 .095
U	28 .450 SQ	.074 .088	.064 .076	.022 .028	.442 .458	.442 .458	.050 BSC	.045 .055	.075 .095
V	44 .650 SQ	.073 .089	.063 .077	.022 .028	.643 .662	.643 .662	.050 BSC	.045 .055	.075 .095

* Solder dip finish for military parts conform to MIL-M-38510, Type A.

W TO-99 METAL CAN

X TO-100 METAL CAN



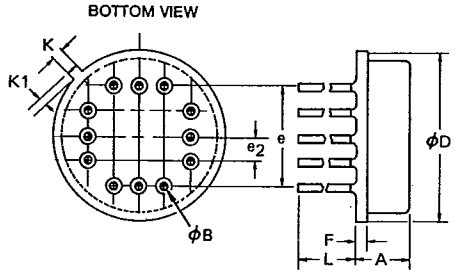
PKG. CODE	LEAD COUNT	DIM. A	DIM. ϕB	DIM. ϕD	DIM. e	DIM. F	DIM. K	DIM. K1	DIM. L	DIM. Q
W	8 TO-99	.165 .185	.016 .018	.345 .365	.190 .210	.020 .040	.028 .034	.028 .040	.505 .550	.015 .040
X	10 TO-100	.165 .185	.016 .018	.345 .365	.220 .240	.020 .040	.028 .034	.028 .040	.505 .550	.015 .040

* Solder dip finish add +0.003 inches.

NOTE: Dimensions are Min/Max. Dimensions are in inches.

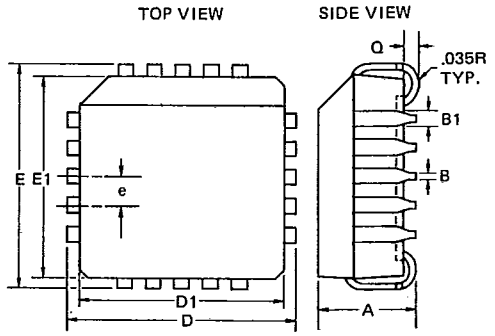
BSC means basic spacing between centerlines.

Y TO-8 METAL CAN



PKG. CODE	LEAD COUNT	DIM. A	DIM. ϕB	DIM. ϕD	DIM. e	DIM. e2	DIM. F	DIM. K	DIM. K1	DIM. L
Y	12 TO-8	.130 / .150	.016 / .021	.585 / .615	.400 / BSC	.100 / BSC	.020 / .040	.027 / .034	.027 / .045	.500 / .550

AA AB AC PLASTIC LEADED CHIP CARRIER



PKG. CODE	LEAD COUNT	DIM. A	DIM. B	DIM. B1	DIM. D/E	DIM. D1/E1	DIM. e	DIM. Q
AA	20	.165 / .180	.013 / .021	.026 / .032	.385 / .395	.350 / .356	.050 / BSC	.020 / —
AB	28	.165 / .180	.013 / .021	.026 / .032	.485 / .495	.450 / .456	.050 / BSC	.020 / —
AC	44	.165 / .180	.013 / .021	.026 / .032	.685 / .695	.650 / .656	.050 / BSC	.020 / —

NOTE: Dimensions are Min / Max. Dimensions are in inches. BSC means basic spacing between centerlines.