

Features

- Programmability
- High Rate Slew 30V/μs
- Wide Gain Bandwidth 40MHz
- High Gain 150kV/V
- Low Offset Current 5nA
- High Input Impedance 30MΩ
- Single Capacitor Compensation
- DTL/TTL Compatible Inputs

Description

HA-2400/04/05 comprise a series of four-channel programmable amplifiers providing a level of versatility unsurpassed by any other monolithic operational amplifier. Versatility is achieved by employing four input amplifier channels, any one (or none) of which may be electronically selected and connected to a single output stage through DTL/TTL compatible address inputs. The device formed by the output and the selected pair of inputs is an op amp which delivers excellent slew rate, gain bandwidth and power bandwidth performance. Other advantageous features for these dielectrically isolated amplifiers include high voltage gain and input impedance coupled with low input offset voltage and offset current. External compensation is not required on this device at closed loop gains greater than 10.

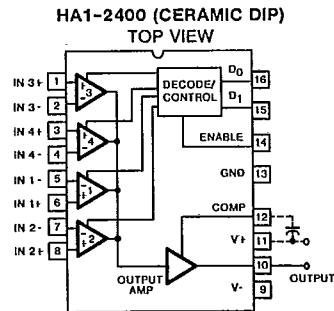
Applications

- Thousands of Applications; Program:
 - ▶ Signal Selection/Multiplexing
 - ▶ Operational Amplifier Gain
 - ▶ Oscillator Frequency
 - ▶ Filter Characteristics
 - ▶ Add-Subtract Functions
 - ▶ Integrator Characteristics
 - ▶ Comparator Levels
- For Further Design Ideas, See App. Note 514.

Each channel of the HA-2400/04/05 can be controlled and operated with suitable feedback networks in any of the standard op amp configurations. This specialization makes these amplifiers excellent components for multiplexing signal selection, and mathematical function designs. With 30V/μs slew rate, 40MHz gain bandwidth, and 30M ohms input impedance these devices are ideal building blocks for signal generators, active filters, and data acquisition designs. Programmability coupled with 2mV typical offset voltage and 5nA offset current makes these amplifiers outstanding components for signal conditioning circuits.

HA-2400/04/05 are available in a 16 pin Dual-In-Line package. HA-2400 is specified from -55°C to +125°C. HA-2404 is specified over the -25°C to +85°C range, while HA-2405 operates from 0°C to +75°C.

Pinout



TRUTH TABLE

D ₁	D ₀	EN	SELECTED CHANNEL
L	L	H	1
L	H	H	2
H	L	H	3
H	H	H	4
X	X	L	NONE

Schematic

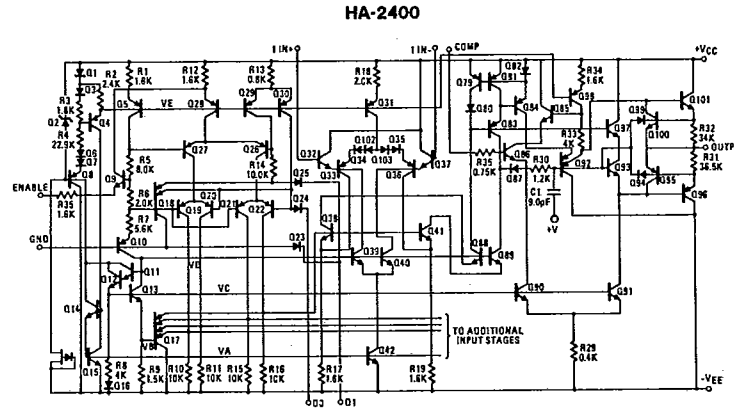


Diagram Includes: One Input Stage, Decode Control, Bias Network, and Output Stage.

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

Absolute Maximum Ratings

Voltage between V+ and V- Terminals 45.0V
 Differential Input Voltage ±V_{SUPPLY}
 Digital Input Voltage -0.76V to +10.0V
 Output Current Short Circuit Protected
 (I_{SC} < ±33mA)
 Internal Power Dissipation (Note 13) 300mW

Operating Temperature Ranges

HA-2400 -55°C ≤ T_A ≤ +125°C
 HA-2404 -25°C ≤ T_A ≤ +85°C
 HA-2405 0°C ≤ T_A ≤ +75°C
 Storage Temperature Range -65°C ≤ T_A ≤ +150°C

Electrical Specifications

Test Conditions: V_{SUPPLY} = ±15.0V Unless Otherwise Specified.
 Digital Inputs: V_{IL} = +0.5V, V_{IH} = +2.4. Limits apply to each of the four channels, when addressed.

PARAMETER	TEMP	HA-2400/04 LIMITS			HA-2405 LIMITS			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS								
Offset Voltage	+25°C	-	4	9	-	4	9	mV
	Full	-	-	11	-	-	11	mV
Bias Current (Note 12)	+25°C	-	50	200	-	50	250	nA
	Full	-	-	400	-	-	500	nA
Offset Current (Note 12)	+25°C	-	5	50	-	5	50	nA
	Full	-	-	100	-	-	100	nA
Input Resistance (Note 12)	+25°C	-	30	-	-	30	-	MΩ
Common Mode Range	Full	±9.0	-	-	±9.0	-	-	V
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Notes 1, 5)	+25°C	50k	150k	-	50k	150k	-	V/V
	Full	25K	-	-	25K	-	-	V/V
Common Mode Rejection Ratio (Note 2)	+25°C	80	100	-	74	100	-	dB
	Full	-	-	-	-	-	-	-
Gain Bandwidth (Notes 3,14)	+25°C	20	40	-	20	40	-	MHz
	+25°C	4	8	-	4	8	-	MHz
OUTPUT CHARACTERISTICS								
Output Voltage Swing (Note 1)	Full	±10.0	±12.0	-	±10.0	±12.0	-	V
Output Current	+25°C	10	20	-	10	20	-	mA
Full Power Bandwidth (Notes 3,5,15)	+25°C	200	500	-	200	500	-	kHz
	+25°C	100	200	-	100	200	-	kHz
TRANSIENT RESPONSE								
Rise Time (Notes 4,6)	+25°C	-	20	45	-	20	50	ns
Overshoot (Notes 4,6)	+25°C	-	25	40	-	25	40	%
Slew Rate (Notes 3,7)	+25°C	20	30	-	20	30	-	V/μs
	+25°C	6	8	-	6	8	-	V/μs
Settling Time (Notes 4,7,8,14)	+25°C	-	1.5	2.5	-	1.5	2.5	μs
CHANNEL SELECT CHARACTERISTICS								
Digital Input Current (V _{IN} = 0V)	Full	-	1	1.5	-	1	1.5	mA
Digital Input Current (V _{IN} = +5.0V)	Full	-	5	-	-	5	-	nA
Output Delay (Notes 9,14)	+25°C	-	100	250	-	100	250	ns
Crosstalk (Note 10)	+25°C	-80	-110	-	-74	-110	-	dB
POWER SUPPLY CHARACTERISTICS								
Supply Current	+25°C	-	4.8	6.0	-	4.8	6.0	mA
Power Supply Rejection Ratio (Note 11)	Full	74	90	-	74	90	-	dB

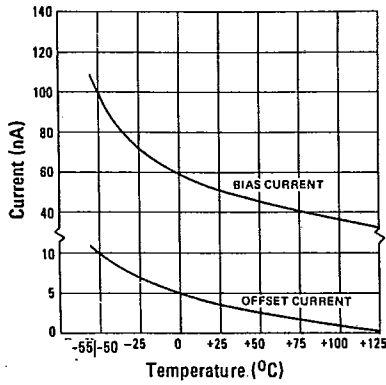
NOTES:

- R_L = 2kΩ
- V_{CM} = ±5VDC
- A_V = +10, C_{COMP} = 0, R_L = 2kΩ, C_L = 50pF.
- A_V = +1, C_{COMP} = 15pF, R_L = 2kΩ, C_L = 50pF.
- V_{OUT} = 20V peak to peak.
- V_{OUT} = 200mV peak.
- V_{OUT} = 10.0V peak to peak.
- To 0.1% of final value.
- To 10% of final value; output then slews at normal rate to final value.
- Unselected input to output; V_{IN} = ±10V D.C.
- V_{SUPPLY} = ±10V D.C. to ±20V D.C.
- Unselected channels have approximately the same input parameters.
- Derate by 4.3mW/°C above 105°C.
- Guaranteed by design.
- Full Power Bandwidth based on slew rate measurement using:

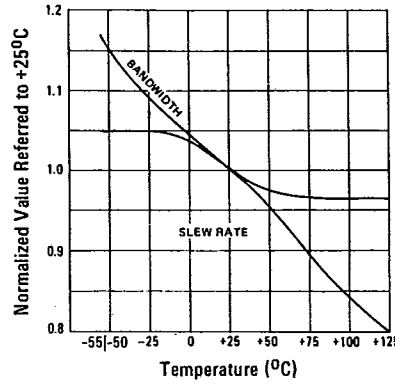
$$FPBW = \frac{S.R.}{2\pi V_{peak}}$$

Typical Performance Curves $V_+ = +15V$ D.C., $V_- = -15V$ D.C., $T_A = +25^\circ C$, Unless Otherwise Specified.

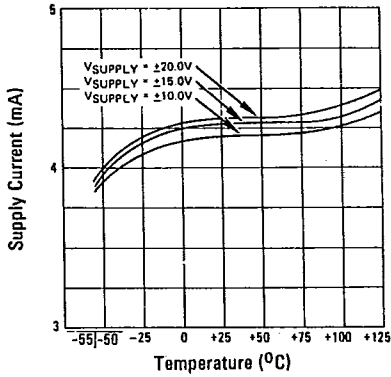
INPUT BIAS CURRENT AND OFFSET CURRENT AS A FUNCTION OF TEMPERATURE



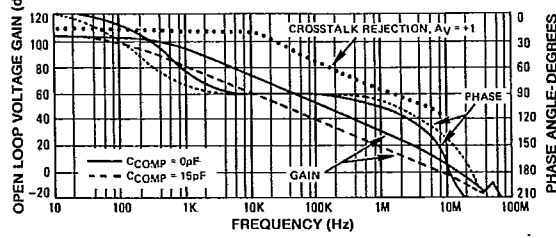
NORMALIZED A.C. PARAMETERS vs. TEMPERATURE



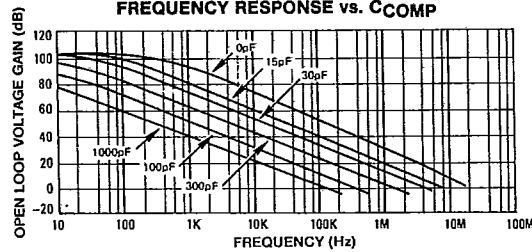
POWER SUPPLY CURRENT DRAIN AS A FUNCTION OF TEMPERATURE



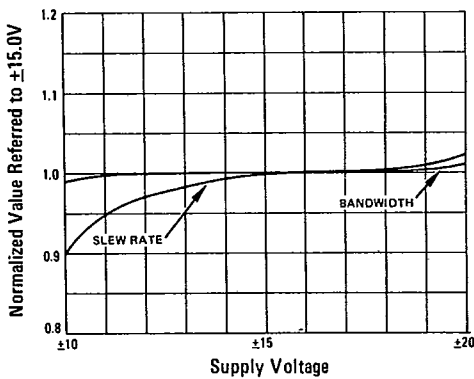
OPEN LOOP FREQUENCY AND PHASE RESPONSE



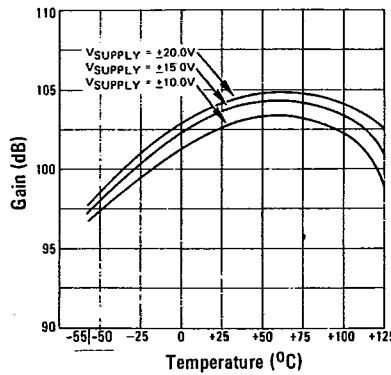
FREQUENCY RESPONSE vs. CCOMP



NORMALIZED A.C. PARAMETERS vs. SUPPLY VOLTAGE

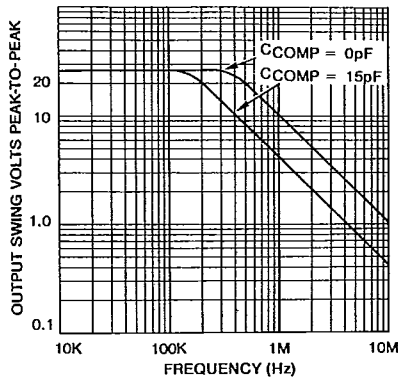


OPEN LOOP VOLTAGE GAIN vs. TEMPERATURE

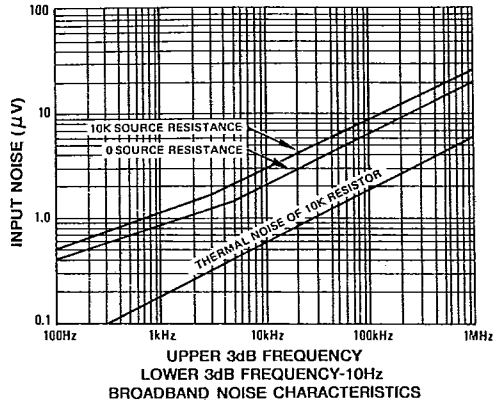


Typical Performance Curves (Continued)

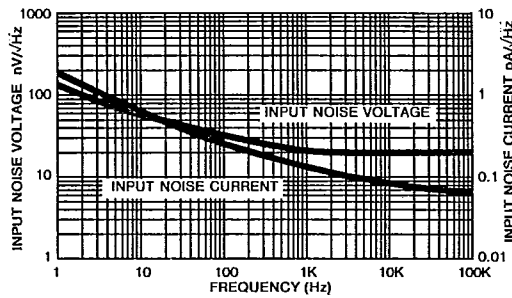
OUTPUT VOLTAGE SWING vs. FREQUENCY



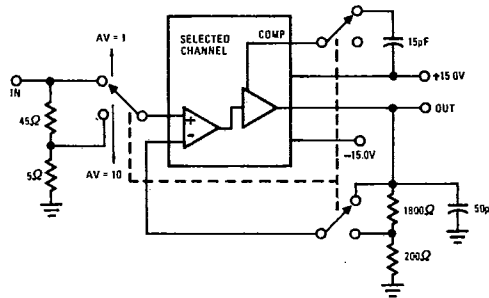
EQUIVALENT INPUT NOISE vs. BANDWIDTH



INPUT NOISE vs. FREQUENCY

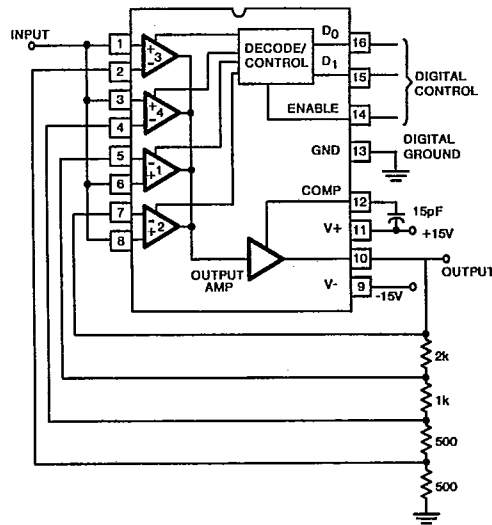


SLEW RATE AND TRANSIENT RESPONSE

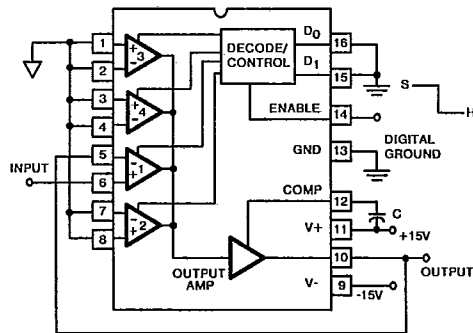


Typical Applications

HA-2400 AMPLIFIER, NON-INVERTING PROGRAMMABLE GAIN



HA-2400 SAMPLE AND HOLD



Sample Charging Rate = $\frac{I_1}{C}$ V/Sec. $I_1 \approx 150 \times 10^{-6} \text{A}$
 Hold Drift Rate = $\frac{I_2}{C}$ V/Sec. $I_2 \approx 200 \times 10^{-9} \text{A}$ @ +25°C
 $\approx 600 \times 10^{-9} \text{A}$ @ -55°C
 $100 \times 10^{-9} \text{A}$ @ +125°C
 Switch Pedestal Error = $\frac{Q}{C}$ Volts $Q \approx 2 \times 10^{-12} \text{Coul.}$

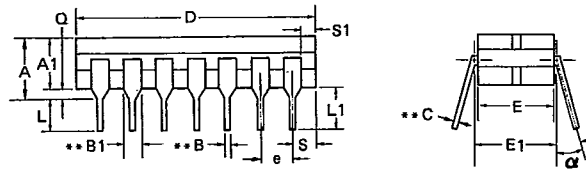
For More Examples, See Harris Application Note 514

HARRIS SEMICOND SECTOR

Package Configuration

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

T-90-20

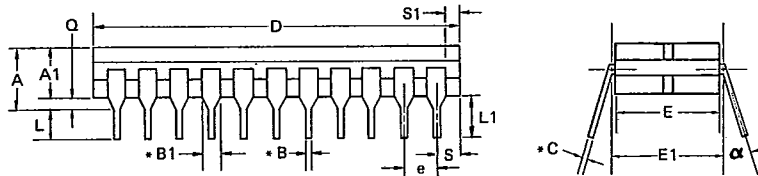


PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
A	8 SSI	—	.140 .160	.016 .023	.050 .065	.008 .015	.375 .395	.245 .265	.290 .310	.100 BSC	.125 .180	.150 —	— .055	.005 —	.015 .060	0° 15°
B1	14 MSI	—	.140 .170	.016 .023	.050 .065	.008 .015	.763 .785	.265 .285	.290 .310	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
B2	14 LSI	—	.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	—	.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	—	.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	—	.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	—	.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 0.035
 ** Solder dip finish add +0.003 inches 0.045

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	26 LSI	— .225	.160 .190	.016 .023	.050 .065	.008 .015	1.44 1.47	.515 .535	.585 .615	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°

* Solder dip finish add +0.003 inches.

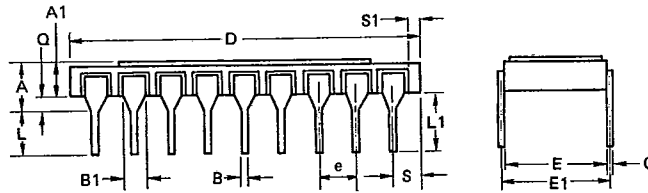
NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$ Dimensions are in inches.

BSC means basic spacing between centerlines.

Package Configuration

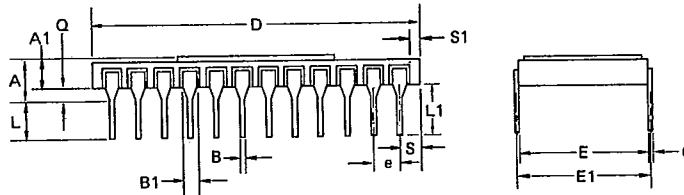
T-90-20

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



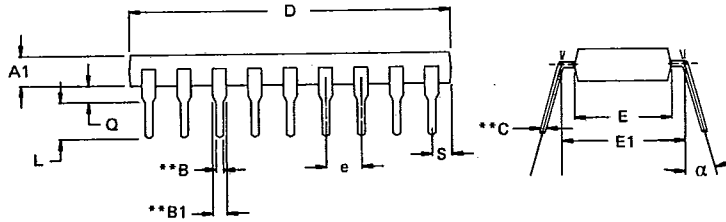
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q
J	24	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.185 1.215	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.040 .060
K	28	— .225	.080 .110	.016 .023	.040 .054	.008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

11
PACKAGING

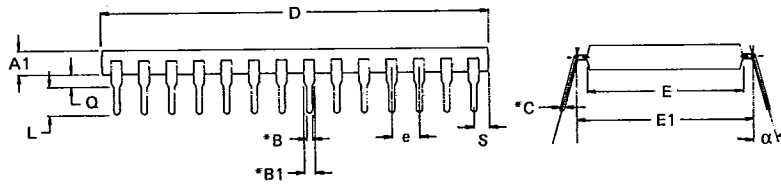
M N O P Q .300 PLASTIC DUAL-IN-LINE



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. alpha
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 $\frac{0.035}{0.045}$
 ** 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. alpha
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.

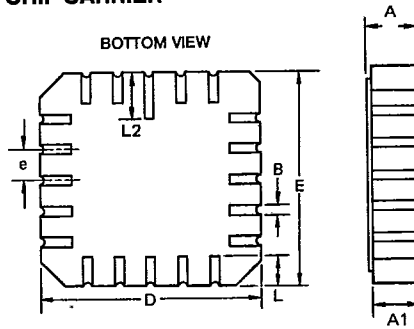
NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$. Dimensions are in inches.

BSC means basic spacing between centerlines.

Package Configuration

T-90-20

- T** .350 CERAMIC LEADLESS CHIP CARRIER*
- U** .450 CERAMIC LEADLESS CHIP CARRIER*
- V** .650 CERAMIC LEADLESS CHIP CARRIER*

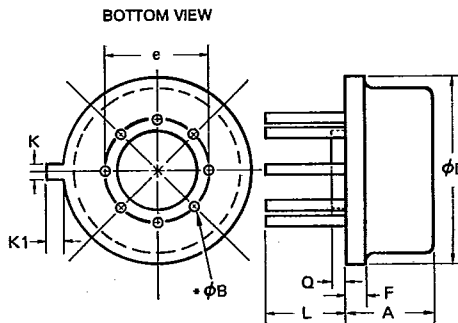


PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. D	DIM. E	DIM. e	DIM. L	DIM. L2
T	20 .350 SQ	.073 .089	.063 .077	.022 .028	.342 .358	.342 .358	.050 BSC	.045 .055	.075 .095
U	28 .450 SQ	.074 .088	.064 .076	.022 .028	.442 .458	.442 .458	.050 BSC	.045 .055	.075 .095
V	44 .650 SQ	.073 .089	.063 .077	.022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

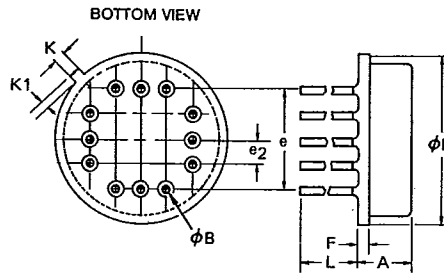
NOTE: Dimensions are $\frac{\text{Min.}}{\text{Max}}$. Dimensions are in inches.

BSC means basic spacing between centerlines.

Package Configuration

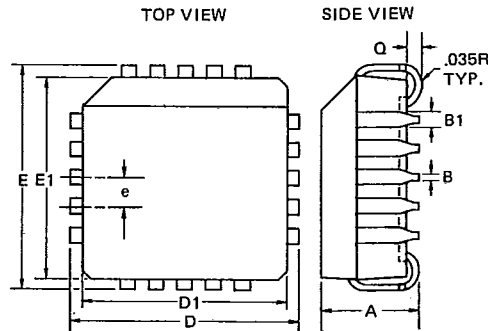
T-90-20

Y TO-8 METAL CAN



PKG. CODE	LEAD COUNT	DIM. A	DIM. phi B	DIM. phi D	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	.185 .180	.013 .021	.026 .032	.685 .695	.650 .656	.050 BSC	.020 —

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

BSC means basic spacing between centerlines.