HARRIS

NOT RECOMMENDED FOR NEW DESIGNS
SEE ICL 8021 or LM 4250

HA-2720/25

Wide Range Programmable Operational Amplifier

February 1990

Features

- Wide Programming Range
  - Slew Rate ..... 0.06 to 6V/μs
  - Bandwidth ..... 5KHz to 10MHz
  - Bias Current ..... 0.4 to 50nA
  - Supply Current ..... 1μA to 1.5mA
  - Power Consumption 75mW
  - Supply Voltage Range ..... ±2V to ±20V
- Wide Power Supply Range ..... ±1.2 to ±18V
- Constant AC Performance Over Supply Range

Applications

- Active Filters
- Current Controlled Oscillators
- Variable Active Filters
- Modulators
- Battery-Powered Equipment

Description

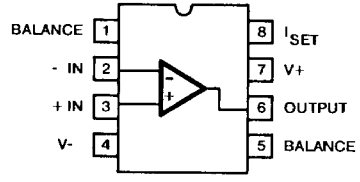
HA-2720/2725 programmable amplifiers are internally compensated monolithic devices offering a wide range of performance, that can be controlled by adjusting the circuits' 'set' current (I_{SET}). By means of adjusting an external resistor or current source, power dissipation, slew rate, bandwidth, output current and input noise can be programmed to desired levels. This versatile adjustment capability enables HA-2720/2725 to provide optimum design solutions by delivering the required level of performance with minimum possible power dissipation. HA-2720 and HA-2725 can, therefore, be utilized as the standard amplifier for a variety of designs simply of adjusting their programming current.

A major advantage of HA-2720/2725 is that operating characteristics remain virtually constant over a wide supply range (±1.2V to ±15V), allowing the amplifiers to offer maximum performance in almost any system including battery-operated equipment. A primary application for HA-2720/2725 is in active filters for a wide variety of signals that differ in frequency and amplitude. Also, by modulating the 'set' current, HA-2720/2725 can be used for designs such as current controlled oscillators modulators, sample and hold circuits and variable active filters.

HA-2720 is guaranteed over -55°C to +125°C. HA-2725 is specified from 0°C to +75°C. Both parts are available in TO-99 cans or dice form.

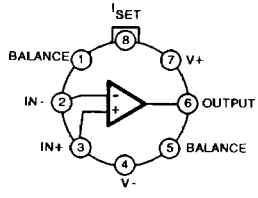
Pinouts

HA1-2720/2725 (CERAMIC MINI-DIP)
TOP VIEW

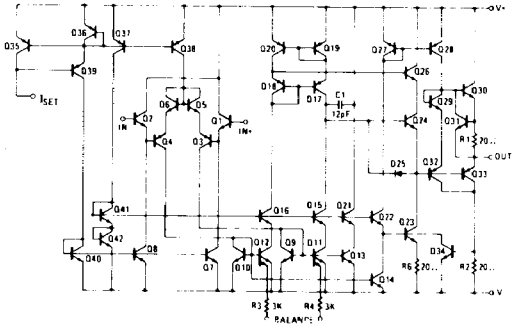


Note: Case tied to V-

HA2-2720/2655 (TO-99 METAL CAN)
TOP VIEW



Schematic



Absolute Maximum Ratings

Voltage Between V+ and V- Terminals 45V
Differential Input Voltage ..... ±30V
Input Voltage (Note 1) ..... ±15V
I_{SET} (Current at I_{SET}) 500µA
V_{SET} (Voltage to GND at I_{SET}) ..... $V+ -2V \leq V_{SET} \leq V+$
Power Dissipation (Note 2) TO-99 ..... 300mW

Operating Temperature Ranges

HA-2720 ..... $-55^oC \leq TA \leq +125^oC$
HA-2725 ..... $0^oC \leq TA \leq +75^oC$
Storage Temperature Range ..... $-65^oC \leq TA \leq +150^oC$

Electrical Specifications

V+ = +3V D.C., V- + -3V.

PARAMETER	TEMP.	HA-2720 -55°C to +125°C						HA-2725 0°C to +75°C						UNITS
		I_{SET} = 1.5µA			I_{SET} = 15µA			I_{SET} = 1.5µA			I_{SET} = 15µA			
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
INPUT CHARACTERISTICS														
Offset Voltage	+25°C		2.0	3.0		2.0	3.0		2.0	5.0		2.0	5.0	mV
	Full			5.0			5.0			7.0			7.0	mV
OffsetCurrent	+25°C		0.5	3.0		1.0	10		0.5	5.0		1.0	10	nA
	Full			7.5			20			7.5			20	nA
Bias Current	+25°C		2.0	5.0		8.0	20		2.0	10		8.0	30	nA
	Full			10			40			10			40	nA
Input Resistance (Note 10)	+25°C		50			5			50			5		MΩ
Input Capacitance	+25°C		3.0			3.0			3.0			3.0		pF
TRANSFER CHARACTERISTICS														
Large Signal Voltage Gain (Note 9)	+25°C	15K	40K		15K	40K		15K	40K		15K	40K		V/V
	Full	15K			10K			10K			10K			V/V
Common Mode Rejection Ratio (Note 4)	Full	80			80			74			74			dB
OUTPUT CHARACTERISTICS														
Output Voltage Swing (Note 3)	+25°C	±2.0	±2.2		±2.0	±2.2		±2.0	±2.2		±2.0	±2.2		V
	Full	±2.0			±2.0			±2.0			±2.0			V
Output Current (Note 5)	+25°C		±0.2			±0.2			±0.2			±2.0		mA
Output Resistance	+25°C		2K			500			2K			500		Ω
Output Short-Circuit Current	+25°C		2.8			14			2.8			14		mA
TRANSIENT RESPONSE														
Rise Time (Note 6)	+25°C		2.5			0.25			2.5			0.25		µs
Overshoot (Note 6)	+25°C		5			10			5			10		%
Slew Rate (Note 7)	+25°C		0.07			0.70			0.07			0.70		V/µs
POWER SUPPLY CHARACTERISTICS														
Supply Current	+25°C		15			170			15			170		µA
	Full			25			250			25			250	µA
Power Supply Rejection Ratio (Note 8)	Full	80			80			76			76			dB

NOTES:
1. For supply voltages less than ±15.0V, the absolute maximum input voltage is equal to supply voltage.
2. Derate at 6.8mW/°C for operation ambient temperatures above 75°C.

	V_{SUPPLY} = ±3.0V	V_{SUPPLY} = ±15.0V	I_{SET} = 1.5µA	I_{SET} = 15µA
3.	T = +25°C and Full	T = +25°C	R_L = 75KΩ	R_L = 5KΩ
	—	T = Full	R_L = 75KΩ	R_L = 75KΩ
4.	V_{CM} = ±1.5V	V_{CM} = ±5.0V		
5.	V_O = ±2.0V	V_O = ±10.0V		
6.	←	A_V = +1, V_{IN} = 400mV, R_L = 5K, C_L = 100pF		→
7.	V_O = ±2.0v	V_O = ±10.0V	R_L = 20K	R_L = 5K
8.	ΔV = ±1.5V	ΔV = ±5.0V		
9.	V_O = ±1.0V	V_O = ±10.0V		

10. This parameter based upon design calculations.

Electrical Specifications (Continued) V+ = +15V, V- + -15V.

PARAMETER	TEMP.	HA-2720 -55°C to +125°C						HA-2725 0°C to +75°C						UNITS
		I_{SET} = 1.5µA			I_{SET} = 15µA			I_{SET} = 1.5µA			I_{SET} = 15µA			
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
INPUT CHARACTERISTICS														
Offset Voltage	+25°C		2.0	3.0		2.0	3.0		2.0	5.0		2.0	5.0	mV
	Full			5.0			5.0			7.0			7.0	mV
OffsetCurrent	+25°C		0.5	3.0		1.0	10		0.5	5.0		1.0	10	nA
	Full			7.5			20			7.5			20	nA
Bias Current	+25°C		2.0	5.0		8.0	20		2.0	10		8.0	30	nA
	Full			10			40			10			40	nA
Input Resistance (Note 10)	+25°C		50			5			50			5		MΩ
Input Capacitance	+25°C		3.0			3.0			3.0			3.0		pF
TRANSFER CHARACTERISTICS														
Large Signal Voltage Gain (Note 3 & 9)	+25°C	30K	100K		30K	120K		25K	40K		25K	120K		V/V
	Full	20K			20K			20K			20K			V/V
Common Mode Rejection Ratio	+25°C		90			90			90			90		dB
(Note 4)	Full	80			80			74			74			dB
OUTPUT CHARACTERISTICS														
Output Voltage Swing (Note 3)	+25°C	±12	±13.5		±12	±13.5		±12	±13.5		±12	±13.5		V
	Full	±10			±10			±10			±10			V
Output Current (Note 5)	+25°C		±0.5			±5.0			±0.5			±5.0		mA
Output Resistance	+25°C		2K			500			2K			500		Ω
Output Short-Circuit Current	+25°C		3.7			19			3.7			19		mA
TRANSIENT RESPONSE														
Rise Time (Note 6)	+25°C		2.0			0.2			2.0			0.2		µs
Overshoot (Note 6)	+25°C		5			15			5			15		%
Slew Rate (Note 7)	+25°C		0.1			0.8			0.1			0.8		V/µs
POWER SUPPLY CHARACTERISTICS														
Supply Current	+25°C		20			210			20			210		µA
	Full			50			450			50			450	µA
Power Supply Rejection Ratio (Note 8)	Full	80			80			76			76			dB

NOTES:

1. For supply voltages less than ±15.0V, the absolute maximum input voltage is equal to supply voltage.
2. Derate at 6.8mW/°C for operation ambient temperatures above 75°C.

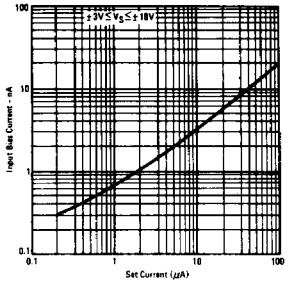
	V_{SUPPLY} = ±3.0V	V_{SUPPLY} = ±15.0V	I_{SET} = 1.5µA	I_{SET} = 15µA
3.	T = +25°C and Full	T = +25°C	R_L = 75KΩ	R_L = 5KΩ
	—	T = Full	R_L = 75KΩ	R_L = 75KΩ
4.	V_{CM} = ±1.5V	V_{CM} = ±5.0V		
5.	V_O = ±2.0V	V_O = ±10.0V		
6.	←	A_V = +1, V_{IN} = 400mV, R_L = 5K, C_L = 100pF	→	
7.	V_O = ±2.0v	V_O = ±10.0V	R_L = 20K	R_L = 5K
8.	ΔV = ±1.5V	ΔV = ±5.0V		
9.	V_O = ±1.0V	V_O = ±10.0V		

10. This parameter based upon design calculations.

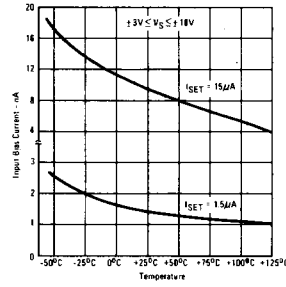
Typical Performance Curves

T_A = +25°C, V_S = ±15V D.C. Unless Otherwise Specified.

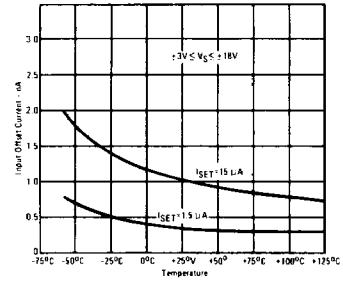
INPUT BIAS CURRENT vs SET CURRENT



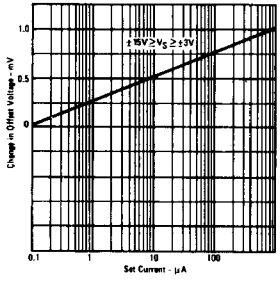
INPUT BIAS CURRENT vs TEMPERTURE



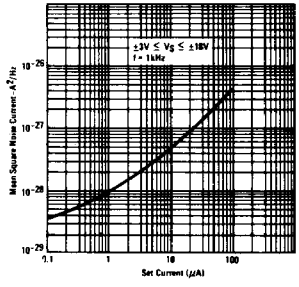
INPUT OFFSET CURRENT vs TEMPERATURE



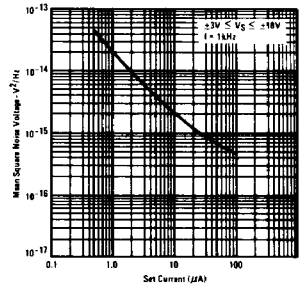
CHANGE IN OFFSET VOLTAGE vs I_{SET} (UNNULLED)



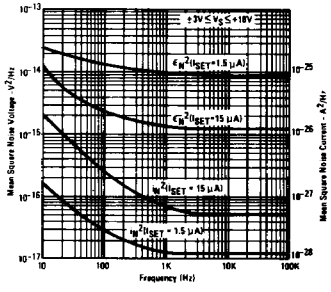
INPUT NOISE CURRENT vs I_{SET}



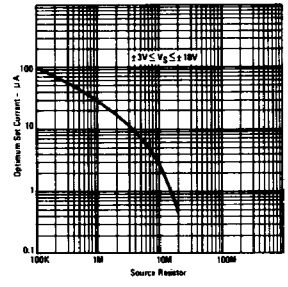
INPUT NOISE VOLTAGE vs I_{SET}



INPUT NOISE VOLTAGE AND CURRENT vs FREQUENCY

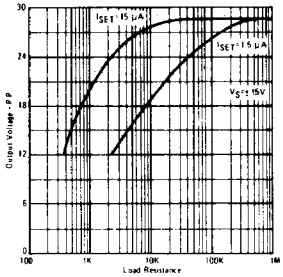


OPTIMUM SET CURRENT FOR MINIMUM NOISE vs SOURCE RESISTOR

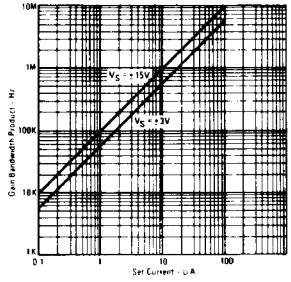


Typical Performance Curves (Continued) $T_A = +25^oC$, $V_S = \pm15V$ D.C. Unless Otherwise Specified.

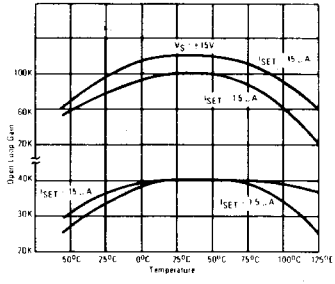
MAXIMUM OUTPUT VOLTAGE SWING vs LOAD RESISTANCE



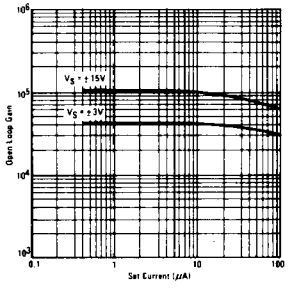
GAIN BANDWIDTH PRODUCT vs I_{SET}



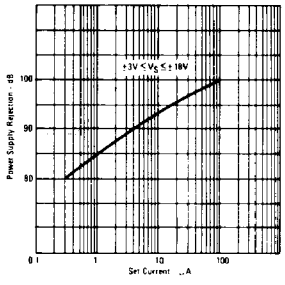
OPEN LOOP VOLTAGE GAIN vs TEMPERATURE



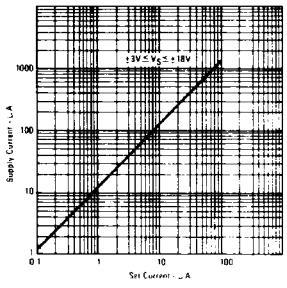
OPEN LOOP VOLTAGE GAIN vs I_{SET}



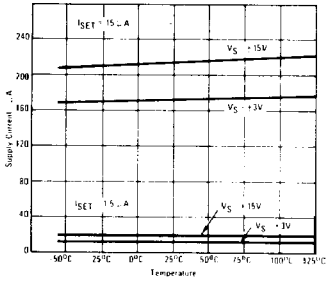
POWER SUPPLY REJECTION vs I_{SET}



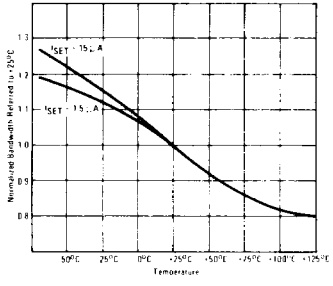
STANDBY SUPPLY CURRENT vs I_{SET}



SUPPLY CURRENT vs TEMPERATURE

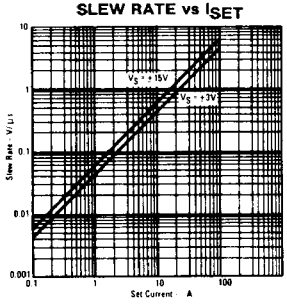


NORMALIZED BANDWIDTH vs TEMPERATURE

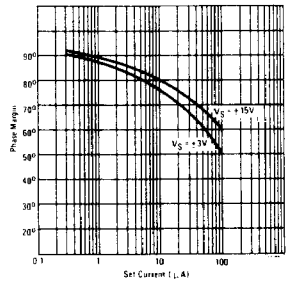


Typical Performance Curves (Continued) TA = +25°C, VS = ±15V D.C. Unless Otherwise Specified.

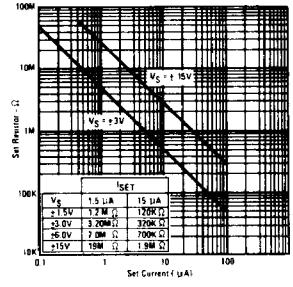
SLEW RATE vs I_{SET}



PHASE MARGIN vs SET CURRENT

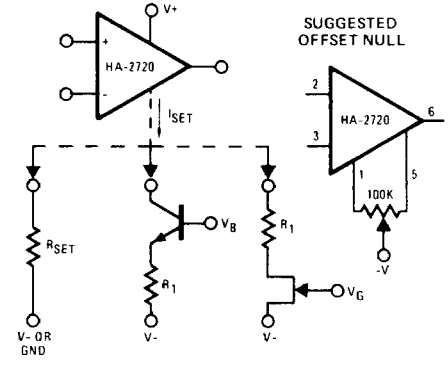


SET CURRENT vs SET RESISTOR

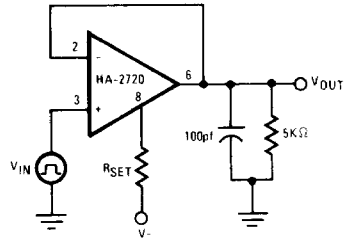


Test Circuits

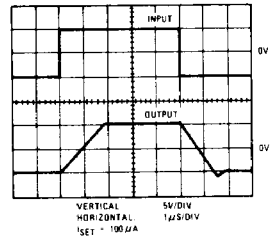
TYPICAL BIASING CIRCUITS



TRANSIENT RESPONSE/SLEW RATE CIRCUIT



SLEWING WAVEFORM



Die Characteristics

Transistor Count 44

Die Dimensions ..... 60 x 44 x 19mils

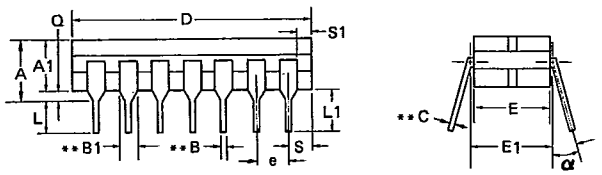
Substrate Potential ..... Unbiased

Thermal Constants (°C/W)	θja	θjc
HA2-Metal Can (-2, -5)	212	58
HA2-Metal Can (-8)	173	52
HA7-Ceramic DIP (-2, -5)	218	123
HA7-Ceramic DIP (-8)	143	69
HA3-Plastic Mini-DIP (-5)	98	46

Package Configuration

T-90-20

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



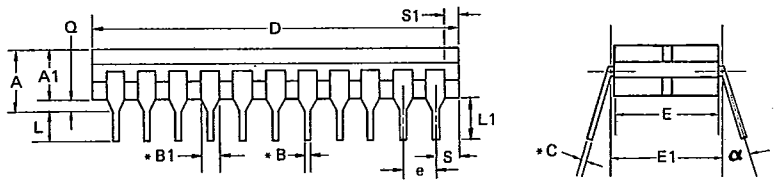
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
A	8 SSI	— .200	.140 .160	.016 .023	.050 .065	.008 .015	.375 .395	.245 .265	.290 .310	.100 BSC	.125 .150	.150 —	— .055	.005 —	.015 .060	0° 15°
B1	14 MSI	— .200	.140 .170	.016 .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



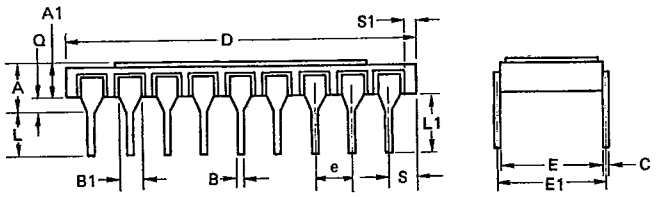
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
F .400	22 LSI	— .225	.150 .180	.016 .023	.050 .065	.008 .015	1.055 1.085	.375 .395	.395 .415	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°
G .600	24 LSI	— .225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

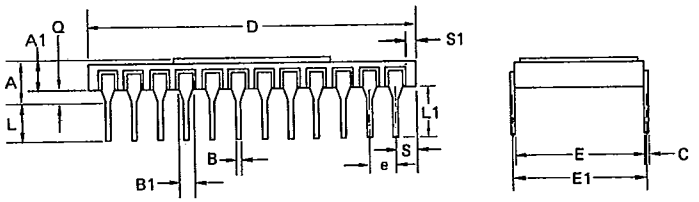
Package Configuration

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



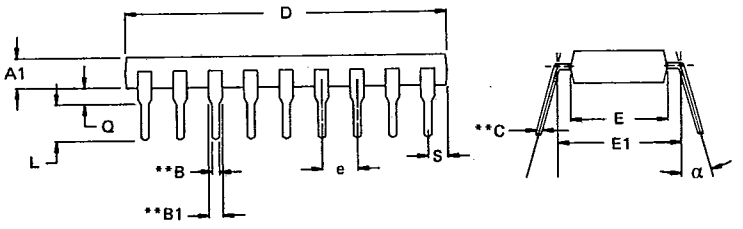
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q
J	24	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.185 1.215	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.040 .060
K	28	— .225	.080 .110	.016 .023	.040 .054	.008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

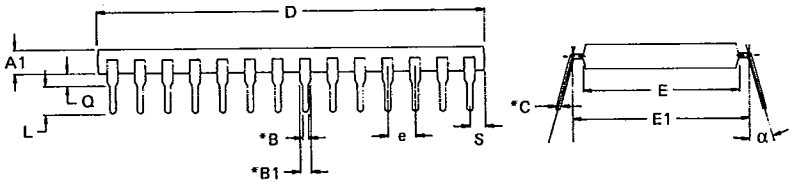


PKG. CODE	LEAD COUNT	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. S	DIM. Q	DIM. α
M	8	.125/.140	.016/.023	.050/.070	.008/.015	.370/.390	.245/.265	.290/.310	.090/.110	.110/.150	.030/.050	.020/.040	0°/15°
N	14	.125/.140	.016/.023	.050/.070	.008/.015	.750/.770	.245/.265	.290/.310	.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.

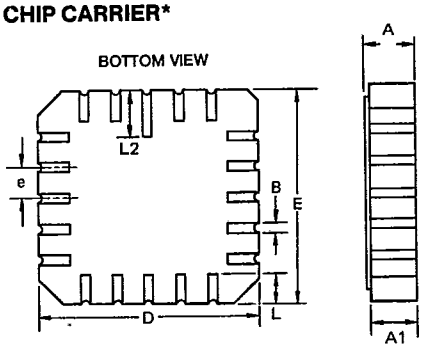
BSC means basic spacing between centerlines.

Package Configuration

T .350 CERAMIC LEADLESS CHIP CARRIER*

U .450 CERAMIC LEADLESS CHIP CARRIER*

V .650 CERAMIC LEADLESS CHIP CARRIER*

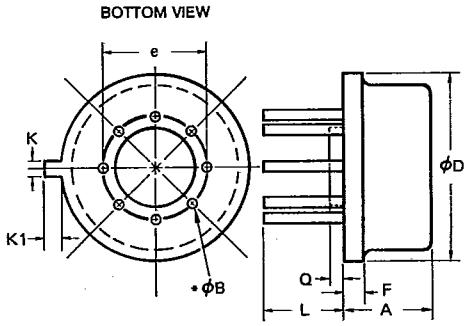


PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. D	DIM. E	DIM. e	DIM. L	DIM. L2
T	20 .350 SQ	.073 .089	.063 .077	.022 .028	.342 .358	.342 .358	.050 BSC	.045 .055	.075 .095
U	28 .450 SQ	.074 .088	.064 .076	.022 .028	.442 .458	.442 .458	.050 BSC	.045 .055	.075 .095
V	44 .650 SQ	.073 .089	.063 .077	.022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



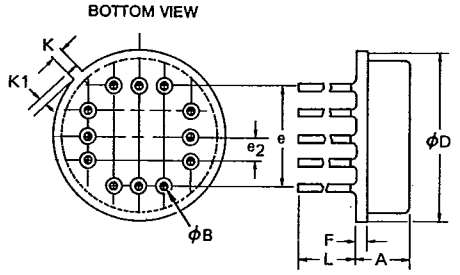
PKG. CODE	LEAD COUNT	DIM. A	DIM. ϕB	DIM. ϕD	DIM. e	DIM. F	DIM. K	DIM. K1	DIM. L	DIM. Q
W	8 TO-99	.165 .185	.016 .018	.345 .365	.190 .210	.020 .040	.028 .034	.028 .040	.505 .550	.015 .040
X	10 TO-100	.165 .185	.016 .018	.345 .365	.220 .240	.020 .040	.028 .034	.028 .040	.505 .550	.015 .040

* Solder dip finish add +0.003 inches.

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

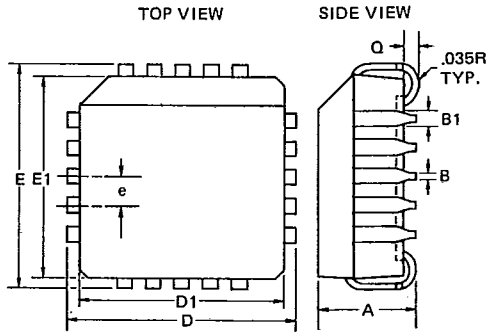
BSC means basic spacing between centerlines.

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.