



HARRIS

**NOT RECOMMENDED
FOR NEW DESIGNS**
SEE ICL 8021 or LM 4050

HA-2720/25

Wide Range Programmable Operational Amplifier

February 1990

Features

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

Applications

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

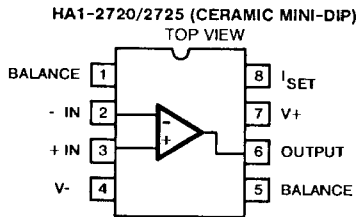
Description

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.

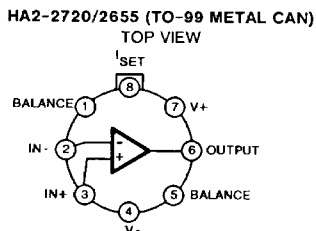
A major advantage of HA-2720/2725 is that operating characteristics remain virtually constant over a wide supply range (± 1.2 V to ± 15 V), allowing the amplifiers to offer maximum performance in almost any system including battery-operated equipment. A primary application for HA-2720/2725 is in active 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 $+125^{\circ}\text{C}$. HA-2725 is specified from 0°C to $+75^{\circ}\text{C}$. Both parts are available in TO-99 cans or dice form.

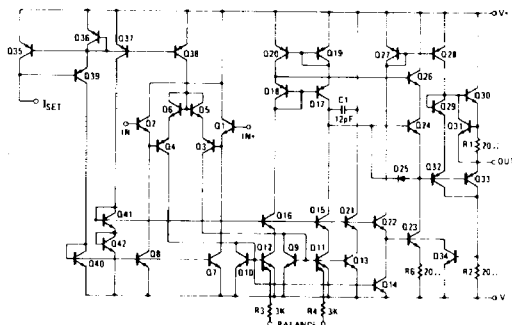
Pinouts



Note: Case tied to V-



Schematic



3
OPERATIONAL
AMPLIFIERS

Specifications HA-2720/2725

Absolute Maximum Ratings

Voltage Between V+ and V- Terminals 45V
 Differential Input Voltage $\pm 30V$
 Input Voltage (Note 1) $\pm 15V$
 I_{SET} (Current at I_{SET}) 500 μA
 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 $-55^{\circ}C \leq T_A \leq +125^{\circ}C$
 HA-2725 $0^{\circ}C \leq T_A \leq +75^{\circ}C$
 Storage Temperature Range $-65^{\circ}C \leq T_A \leq +150^{\circ}C$

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 Full		2.0	3.0		2.0	3.0		2.0	5.0		2.0	5.0	mV mV
Offset Current	+25°C Full		0.5	3.0 7.5		1.0	10 20		0.5	5.0 7.5		1.0	10 20	nA nA
Bias Current	+25°C Full		2.0	5.0 10		8.0	20 40		2.0	10 10		8.0	30 40	nA 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 Full	15K 15K	40K		15K 10K	40K		15K 10K	40K		15K 10K	40K		V/V V/V
Common Mode Rejection Ratio (Note 4)	Full	80			80			74			74			dB
OUTPUT CHARACTERISTICS														
Output Voltage Swing (Note 3)	+25°C Full	±2.0 ±2.0	±2.2		±2.0 ±2.0	±2.2		±2.0 ±2.0	±2.2		±2.0 ±2.0	±2.2		V V
Output Current (Note 5)	+25°C		±0.2			±0.2			±0.2			±0.2		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 Full		15		25		170 250		15		25		170 250	μA μA
Power Supply Rejection Ratio (Note 8)	Full	80			80			76			76			dB

NOTES: 1. For supply voltages less than $\pm 15.0V$, the absolute maximum input voltage is equal to supply voltage.

2. Derate at 6.8mW/ $^{\circ}C$ for operation ambient temperatures above 75°C.

$V_{SUPPLY} = \pm 3.0V$	$V_{SUPPLY} = \pm 15.0V$	$I_{SET} = 1.5\mu A$	$I_{SET} = 15\mu A$
3. $T = +25^{\circ}C$ and Full	$T = +25^{\circ}C$	$R_L = 75K\Omega$	$R_L = 5K\Omega$
—	$T = Full$	$R_L = 75K\Omega$	$R_L = 75K\Omega$
4. $V_{CM} = \pm 1.5V$	$V_{CM} = \pm 5.0V$		
5. $V_O = \pm 2.0V$	$V_O = \pm 10.0V$		
6. $\leftarrow A_V = +1, V_{IN} = 400mV, R_L = 5K, C_L = 100pF \rightarrow$			
7. $V_O = \pm 2.0v$	$V_O = \pm 10.0V$	$R_L = 20K$	$R_L = 5K$
8. $\Delta V = \pm 1.5V$	$\Delta V = \pm 5.0V$		
9. $V_O = \pm 1.0V$	$V_O = \pm 10.0V$		

10. This parameter based upon design calculations.

Specifications HA-2720/2725

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

PARAMETER	TEMP.	HA-2720 -55°C to +125°C						HA-2725 0°C to +75°C						UNITS
		ISET = 1.5μA			ISET = 15μA			ISET = 1.5μA			ISET = 15μA			
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
INPUT CHARACTERISTICS														
Offset Voltage	+25°C Full		2.0	3.0 5.0		2.0	3.0 5.0		2.0	5.0 7.0		2.0	5.0 7.0	mV mV
Offset Current	+25°C Full		0.5	3.0 7.5		1.0	10 20		0.5	5.0 7.5		1.0	10 20	nA nA
Bias Current	+25°C Full		2.0	5.0 10		8.0	20 40		2.0	10 10		8.0	30 40	nA 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 Full	30K 20K	100K		30K 20K	120K		25K 20K	40K		25K 20K	120K		V/V V/V
Common Mode Rejection Ratio (Note 4)	+25°C Full	80	90		80	90		74	90		74	90		dB dB
OUTPUT CHARACTERISTICS														
Output Voltage Swing (Note 3)	+25°C Full	±12 ±10	±13.5		±12 ±10	±13.5		±12 ±10	±13.5		±12 ±10	±13.5		V 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 Full		20	50		210	450		20	50		210	450	μA μA
Power Supply Rejection Ratio (Note 8)	Full	80			80			76			76			dB

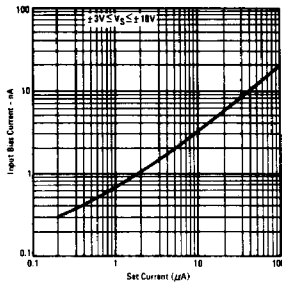
- NOTES: 1. For supply voltages less than $\pm 15.0V$, the absolute maximum input voltage is equal to supply voltage.
2. Derate at 6.8mW/°C for operation ambient temperatures above 75°C.

	$V_{SUPPLY} = \pm 3.0V$	$V_{SUPPLY} = \pm 15.0V$	$I_{SET} = 1.5\mu A$	$I_{SET} = 15\mu A$
3.	$T = +25^\circ C$ and Full	$T = +25^\circ C$	$R_L = 75K\Omega$	$R_L = 5K\Omega$
	—	$T = Full$	$R_L = 75K\Omega$	$R_L = 75K\Omega$
4.	$V_{CM} = \pm 1.5V$	$V_{CM} = \pm 5.0V$		
5.	$V_O = \pm 2.0V$	$V_O = \pm 10.0V$		
6.	←	$A_V = +1, V_{IN} = 400mV, R_L = 5K, C_L = 100pF$	→	
7.	$V_O = \pm 2.0v$	$V_O = \pm 10.0V$	$R_L = 20K$	$R_L = 5K$
8.	$\Delta V = \pm 1.5V$	$\Delta V = \pm 5.0V$		
9.	$V_O = \pm 1.0V$	$V_O = \pm 10.0V$		

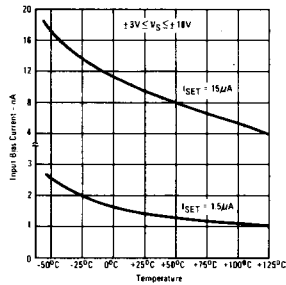
10. This parameter based upon design calculations.

Typical Performance Curves $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V D.C.}$ Unless Otherwise Specified.

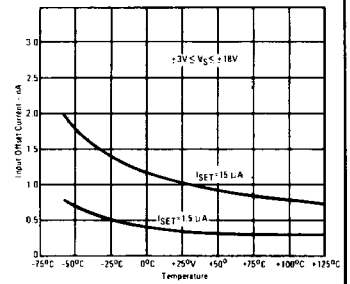
**INPUT BIAS CURRENT
vs SET CURRENT**



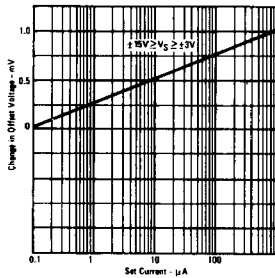
**INPUT BIAS CURRENT
vs TEMPERATURE**



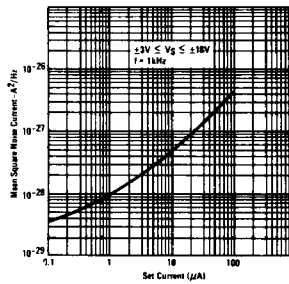
**INPUT OFFSET CURRENT
vs TEMPERATURE**



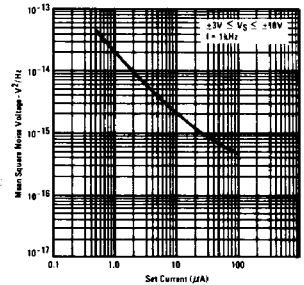
**CHANGE IN OFFSET VOLTAGE
vs I_SET (UNNULLED)**



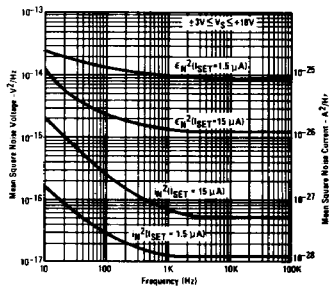
**INPUT NOISE CURRENT
vs I_SET**



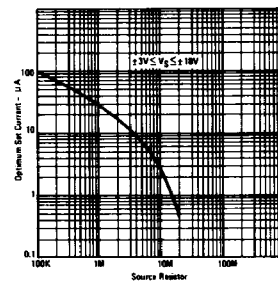
**INPUT NOISE VOLTAGE
vs I_SET**



**INPUT NOISE VOLTAGE AND CURRENT
vs FREQUENCY**

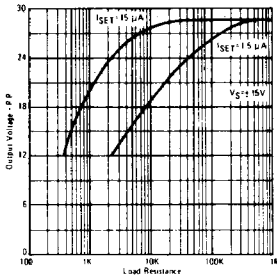


**OPTIMUM SET CURRENT FOR MINIMUM
NOISE vs SOURCE RESISTOR**

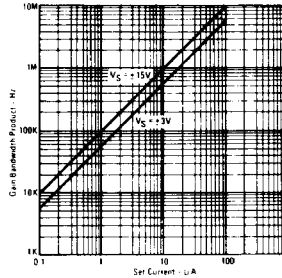


Typical Performance Curves (Continued) $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$ D.C. Unless Otherwise Specified.

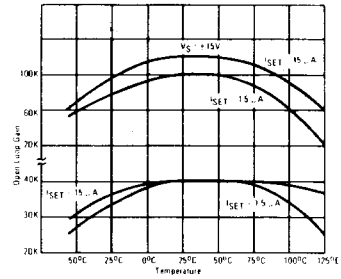
**MAXIMUM OUTPUT VOLTAGE SWING
vs LOAD RESISTANCE**



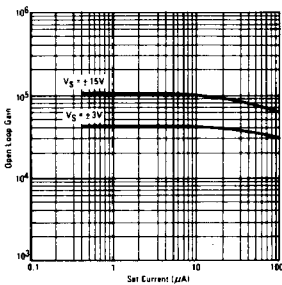
**GAIN BANDWIDTH PRODUCT
vs ISET**



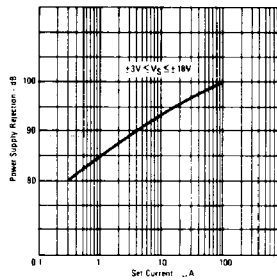
**OPEN LOOP VOLTAGE GAIN
vs TEMPERATURE**



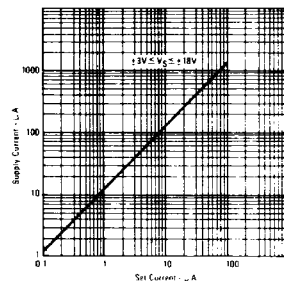
**OPEN LOOP VOLTAGE GAIN
vs ISET**



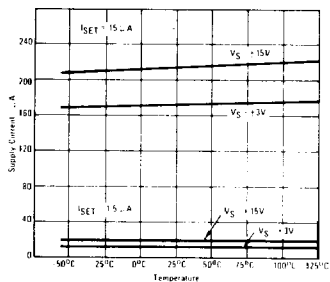
**POWER SUPPLY REJECTION
vs ISET**



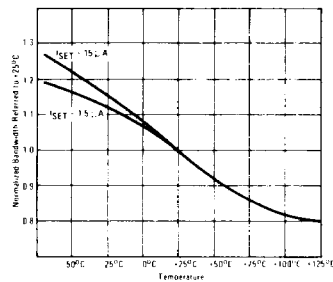
**STANDBY SUPPLY CURRENT
vs ISET**



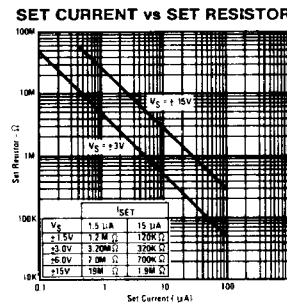
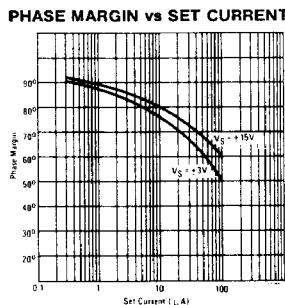
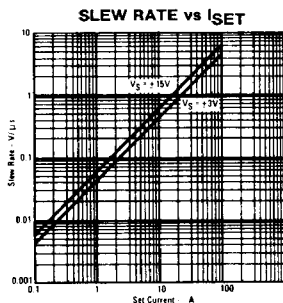
**SUPPLY CURRENT vs
TEMPERATURE**



**NORMALIZED BANDWIDTH
vs TEMPERATURE**

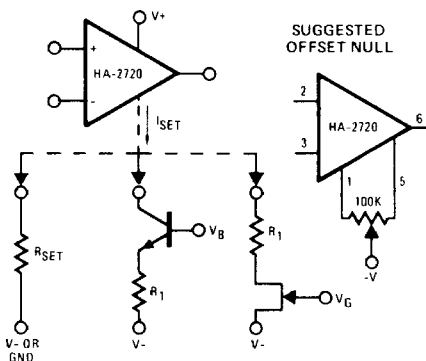


Typical Performance Curves (Continued) $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V D.C.}$ Unless Otherwise Specified.

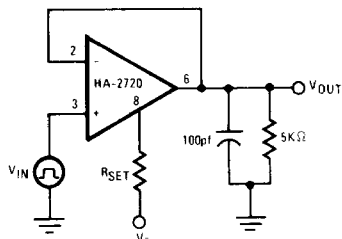


Test Circuits

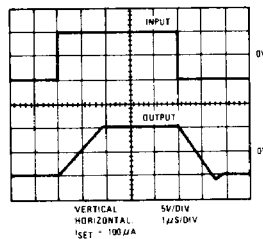
TYPICAL BIASING CIRCUITS



TRANSIENT RESPONSE/SLEW RATE CIRCUIT



SLEWING WAVEFORM



Die Characteristics

Transistor Count..... 44

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

Substrate Potential..... Unbiased

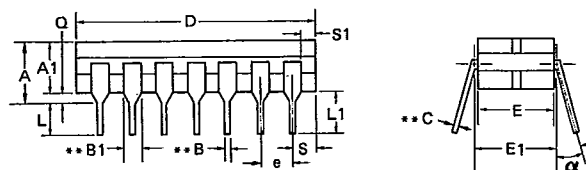
Thermal Constants ($^\circ\text{C/W}$)	θ_{ja}	θ_{jc}
HA2-Metal Can (-2, -5)	212	58
HA2-Metal Can (-8)	173	52
HA7-Ceramic DIP (-2, -5)	218	123
HA7-Ceramic DIP (-8)	143	69
HA3-Plastic Mini-DIP (-5)	98	46

HARRIS SEMICONDUCTOR

Package Configuration

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

T-90-20

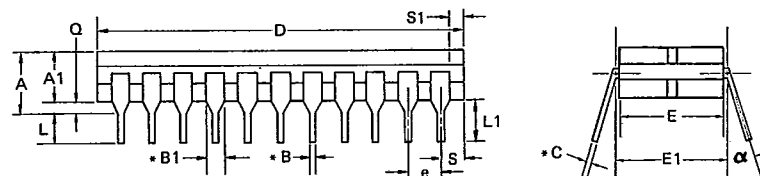


PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
A	8 SSI	—	.140 .200	.016 .023	.050 .065	.008 .015	.375 .395	.245 .265	.290 .310	.100 BSC	.125 .180	.150 —	— .055	.005 —	.015 .060	0° 15°
B1	14 MSI	—	.140 .170	.016 .023	.050 .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	—	.150 .225	.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	—	.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	—	.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°

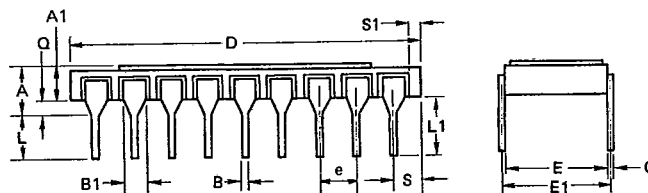
* Solder dip finish add +0.003 inches.

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

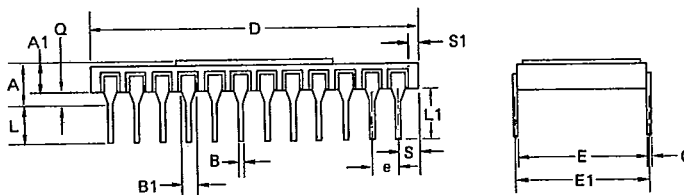
BSC means basic spacing between centerlines.

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

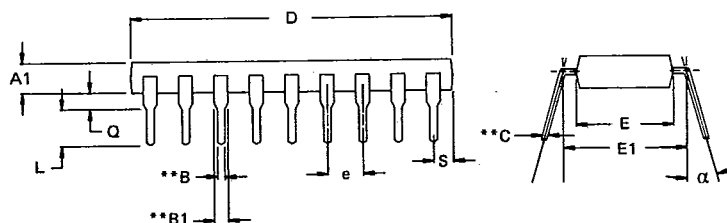
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q
J	24	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.185 1.215	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.040 .060
K	28	— .225	.080 .110	.016 .023	.040 .054	.008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

BSC means basic spacing between centerlines.

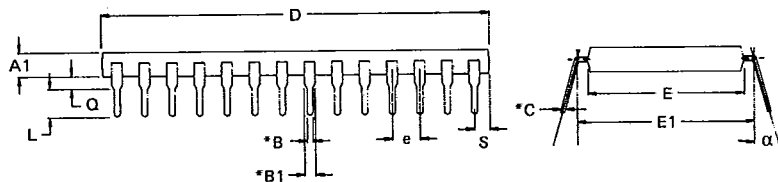
Package Configuration

T-90-20

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
 ** Solder dip finish add 0.003 inches. 0.045

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°

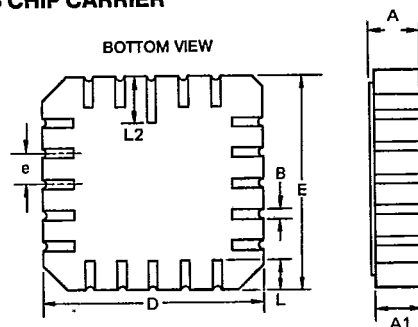
* Solder dip finish add 0.003 inches.

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

BSC means basic spacing between centerlines.

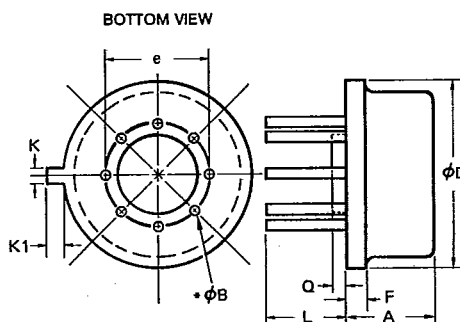
Package Configuration

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. 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

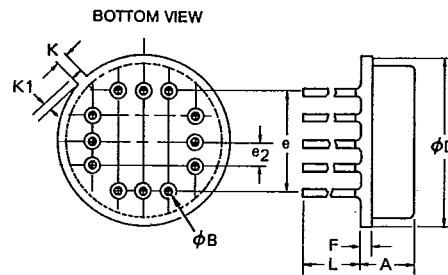
* Solder dip finish add +0.003 inches.

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

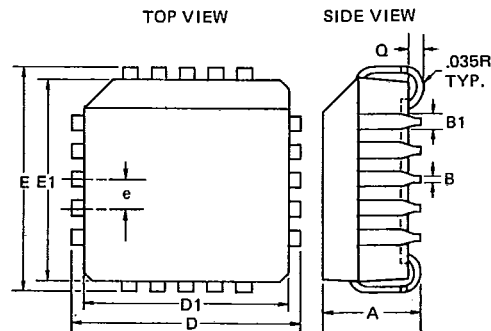
BSC means basic spacing between centerlines.

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	.165 .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.