

CD22413, CD22414 Types

Preliminary Data

CMOS Pulse Code
Modulation Sampled —
Data Filters

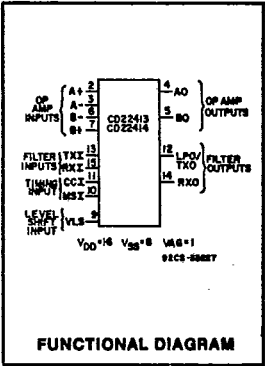
The RCA-CD22413 and CD22414 are sampled-data, switched-capacitor filters intended for use in PCM CODEC systems or other telecommunication systems requiring band limiting. Transmit and receive filters in both devices are 5-pole elliptical types, operating at a sample rate of 128 kHz. In addition, the CD22413 contains a 3-pole Chebyshev high-pass filter in the transmit section that provides 50/60 Hz and 15 Hz rejection. Both devices also include two operational amplifiers which may be used as building blocks in a system.

A 50% duty-cycle clock on the convert-clock input (CCI) determines the cutoff frequencies for the filters. The cutoff frequency (f_c) is given by the equation; $f_c = 0.02422 \times \text{Clock Frequency}$. Normally, the clock frequency is 128 kHz for a cutoff frequency of 3100 Hz. The master sync input (MSI) should be 8 kHz and have its low-to-high transition coincide with each new PAM sample received at Receive-Filter-In (RXI). RXI will accept 19% to 100% duty cycle PAM at 8 kHz.

Timing and synchronization signals (CCI and MSI) may be made either TTL- or CMOS-compatible through use of the Logic-Shift Voltage (VLS) input. Specific input conditions are listed in the table of Logic-Shift-Voltage Inputs. The analog ground (VAG) should be held at approximately $(V_{DD} - V_{SS})/2$. If VAG is within one volt of V_{DD} , the chip will be powered down. The CD22413 is pin-compatible with the MC14413; the CD22414 is pin-compatible with the MC14414.

The CD22413 and CD22414 are supplied in 16-lead hermetic dual-in-line ceramic packages (D and F suffix), 16-lead dual-in-line plastic packages (E suffix), and chip form (H suffix).

- Features:
- Single supply (10V-16V) or dual supply operation
 - Transmit bandpass and receive low pass filters (CD22413)
 - Transmit and receive low pass filters (CD22414)
 - 30 mW (typ.) operating power

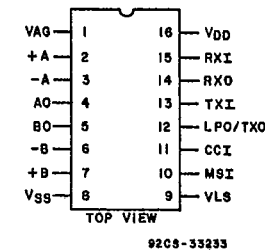


- MAXIMUM RATINGS, Absolute-Maximum Values:**
- DC SUPPLY-VOLTAGE RANGE, (V_{DD}) -0.5 to +18 V
(Voltages referenced to V_{SS} Terminal)
- INPUT VOLTAGE RANGE, ALL INPUTS -0.5 to $V_{DD} + 0.5$ V
- DC INPUT CURRENT, ANY ONE INPUT ± 10 mA
- POWER DISSIPATION PER PACKAGE (P_D)
- For $T_A = -40$ to $+60^\circ\text{C}$ (PACKAGE TYPE E) 500 mW
- For $T_A = +60$ to $+85^\circ\text{C}$ (PACKAGE TYPE E) Derate Linearly at 12 mW/ $^\circ\text{C}$ to 200 mW
- For $T_A = -55$ to $+100^\circ\text{C}$ (PACKAGE TYPES D, F) 500 mW
- For $T_A = +100$ to $+125^\circ\text{C}$ (PACKAGE TYPES D, F) Derate Linearly at 12 mW/ $^\circ\text{C}$ to 200 mW
- DEVICE DISSIPATION PER OUTPUT TRANSISTOR
- For $T_A = \text{FULL PACKAGE-TEMPERATURE RANGE (All Package Types)}$ 100 mW
- OPERATING-TEMPERATURE RANGE (T_A)
- PACKAGE TYPES D, F, H -55 to $+125^\circ\text{C}$
- PACKAGE TYPE E -40 to $+85^\circ\text{C}$
- STORAGE TEMPERATURE RANGE (T_{stg}) -65 to $+150^\circ\text{C}$
- LEAD TEMPERATURE (DURING SOLDERING):
- At distance $1/16 \pm 1/32$ Inch (1.59 ± 0.79 mm) from case for 10 s max. $+265^\circ\text{C}$

RECOMMENDED OPERATING CONDITIONS

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following ranges:

CHARACTERISTIC	Terminal Designation	LIMITS			UNITS
		Min.	Typ.	Max.	
DC Supply Voltage (For $T_A = \text{Full Package Temperature Range}$)	$V_{DD} - V_{SS}$	10	12	16	Vdc
Convert Clock Frequency	CCI	50	128	400	kHz
Master Sync Frequency	MSI	—	8	32	



TERMINAL ASSIGNMENTS

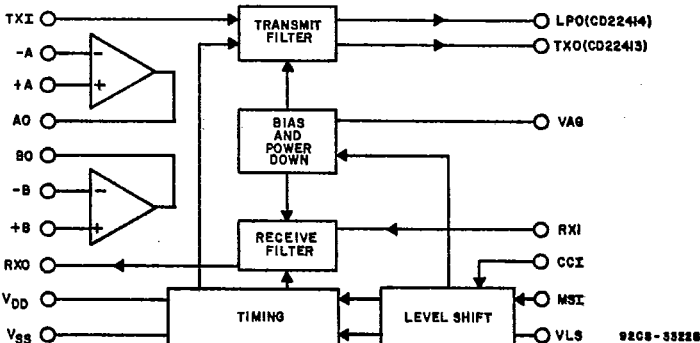


Fig. 1 - Block diagram of CD22413 and CD22414.

CD22413, CD22414 Types

DIGITAL ELECTRICAL CHARACTERISTICS ($V_{SS} = 0$ V, $T_A = 25^\circ$ C)

CHARACTERISTIC	V_{DD} Vdc	LIMITS			UNITS
		Min.	Typ.	Max.	
Operating Current I	12	—	2.5	3.5	mA
Power-Down Current, ($PDI = V_{SS}$) I_{PD}	12	—	10	50	μ A
Input Capacitance C_{IN}	12	—	5	7.5	pF

MODE CONTROL LOGIC LEVELS

CHARACTERISTIC	V_{DD} Vdc	LIMITS			UNITS
		Min.	Typ.	Max.	
VLS Power-Down Mode V_{IH}	12	11	—	—	V
	15	14	—	—	
VLS TTL Mode	12	2	—	10	V
	15	2	—	13	
VLS CMOS Mode V_{IL}	12	—	—	0.8	V
	15	—	—	0.8	
VAG Power-Down Mode V_{IH}	12	11	—	—	V
	15	14	—	—	
VAG Analog-Ground Mode V_{IL}	12	—	—	8	V
	15	—	—	11	

CMOS LOGIC LEVELS ($V_{LS} = V_{SS}$)

CHARACTERISTIC	V_{DD} Vdc	LIMITS			UNITS
		Min.	Typ.	Max.	
Input Current I_{IN}					
CCI	12	—	± 0.00001	± 0.3	μ A
MSI "1" Level	—	—	30	—	
(Internal Pulldown Resistors) "0" Level	—	—	-0.00001	-0.3	
Input Voltage CCI, MSI					
"0" Level V_{IL}	12	—	5.25	3.6	V
	15	—	6.75	4	
"1" Level V_{IH}	12	8.4	6.75	—	
	15	11	8.25	—	

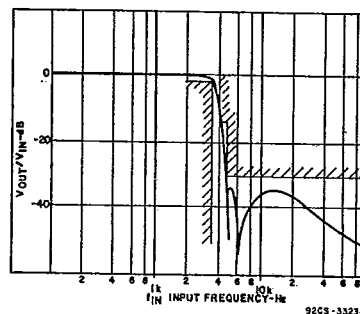
TTL LOGIC LEVELS ($V_{LS} = 6$ V, $V_{SS} = 0$ V)

CHARACTERISTIC	V_{DD} Vdc	LIMITS			UNITS
		Min.	Typ.	Max.	
Input Current I_{IN}					
CCI	12	—	± 0.00001	± 0.3	μ A
MSI "1" Level	—	—	3	—	
(Internal Pulldown Resistor) "0" Level	—	—	-0.00001	-0.3	
Input Voltage CCI, MSI					
"0" Level V_{IL}	12	—	—	VLS + 0.8	V
"1" Level V_{IH}	12	VLS + 2	—	—	

CD22413, CD22414 Types

ANALOG ELECTRICAL CHARACTERISTICS ($V_{DD} = 12\text{ V}$, $T_A = 25^\circ\text{C}$)

CHARACTERISTIC		LIMITS			UNITS
		Min.	Typ.	Max.	
Input Current, (RXI, TXI, VAG)	I_{IN}	—	± 0.00001	± 0.03	μA
AC Input Impedance (1 kHz) (RXI, TXI, VAG)	Z_{IN}	—	2	—	$\text{M}\Omega$
Input Common Mode Voltage Range (TXI, RXI, +A, -A, +B, -B)	V_{ICR}	1.5	—	10.5	V
Input Offset Current (+A to -A, +B to -B)	I_{IO}	—	± 10	—	nA
Input Bias Current (+A, -A, +B, -B)	I_{IB}	—	± 0.10	± 1	
Input Offset Voltage (+A to -A, +B to -B)	V_{IO}	—	± 10	± 25	mV
Output Voltage Range (AO, BO, TXO, LPO, RXO) ($R_L = 20\text{ k}\Omega$ to VAG, $R_B = \infty$) ($R_L = 600\text{ }\Omega$ to VAG, $R_B = 1.6\text{ k}\Omega$ to V_{DD}) ($R_L = 900\text{ }\Omega$ to VAG, $R_B = 1.8\text{ k}\Omega$ to V_{DD})	V_{OR}	1.5 4.3 4	— — —	10.5 7.9 8.2	V
Small Signal Output Impedance (1 kHz) (TXO CD22413) (LPO CD22414) (RXO)	Z_o	— — —	50 50 50	— — —	Ω
Output Current ($V_{OH} = 11\text{V}$). (TXO, LPO, RXO, AO, BO)	I_{OH}	—	-400	—	μA
($V_{OL} = 1\text{V}$) (TXO, LPO, RXO, AO, BO)	I_{OL}	—	5	—	mA

Fig. 3 - Receive filter typical and minimum performance for CD22413 or CD22414 with $\sin x$ correction included.RECEIVE FILTER SPECIFICATIONS ($V_{DD} - V_{EE} = 12\text{V}$, $CCI = 128\text{ kHz}$, $MSI = 8\text{ kHz}$. Includes $\sin x$ correction, $V_{in} = 0\text{ dBm}$, full scale = $+3\text{ dBm}$, 7 V_{P-P} , $T_A = 25^\circ\text{C}$)

CHARACTERISTIC		LIMITS			UNITS
		Min.	Typ.	Max.	
Gain (1020 Hz)		-0.2	0	+0.2	dB
Passband Ripple (50 Hz to 300 Hz)		—	0.24	0.3	
Out of Band Rejection	See Note 1				
3400 Hz		—	-0.8	-1.5	
4000 to 4600 Hz		-14	-15.5	—	dB
4600 to 64 kHz		-30	-33	—	
Output Noise (RXI = VAG)	See Note 2	—	10	15	dBrnc0
Dynamic Range		78	83	—	dB
Differential Group Delay					μs
1150 to 2300 kHz Delay		—	12	22	
1000 to 2500 kHz Delay		—	25	35	
800 to 2700 kHz Delay		—	31	41	

Note 1: Referenced to passband minimum.

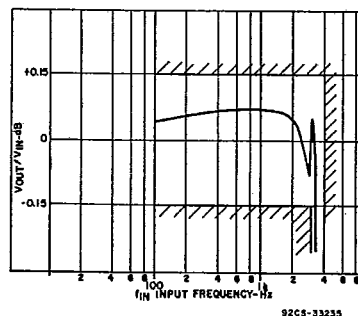
Note 2: Referenced to 900 Ω .

Fig. 4 - Receive filter typical and minimum passband performance for CD22413 or CD22414.

CD22413, CD22414 Types

TRANSMIT FILTER SPECIFICATIONS ($V_{DD}-V_{EE} = 12\text{ V}$, $CCI = 128\text{ kHz}$
 $MSI = 8\text{ kHz}$, $V_{in} = 0\text{ dBm0}$, full scale = +3 dBm0, 7 V_{p-p}, $T_A = 25^\circ$)

CHARACTERISTIC	LIMITS			UNITS
	Min.	Typ.	Max.	
Gain (1020 Hz)	-0.15	—	+0.15	
Passband Ripple (300 Hz to 3000 Hz)	—	0.22	0.3	
Rejection				dB
60 Hz	-20	-24	—	
180 Hz	—	-0.6	-1	
3400 Hz	—	-0.8	-1.5	
4000 to 4600 Hz	-14	-15.5	—	
4600 to 64 kHz	-32	-33	—	
Output Noise (300 to 3400 Hz)	—	—	—	dBm0
	—	8	12	
Dynamic Range (7 V _{pp} Max)	81	87	—	dB
Differential Group Delay				μs
1150 to 2300 kHz Delay	—	12	22	
1000 to 2500 kHz Delay	—	25	35	
800 to 2700 kHz Delay	—	31	41	

Note 1: Referenced to passband minimum.

SWITCHING CHARACTERISTICS ($V_{DD} - V_{SS} = 10\text{ V}$, $T_A = 25^\circ\text{C}$)

CHARACTERISTIC		LIMITS			UNITS
		Min.	Typ.	Max.	
Input Rise and Fall Time, t_r , t_f	CCI, MSI	—	—	4	μs
Pulse Width, t_{WH}	CCI, MXI	100	50	—	ns
Clock Pulse Frequency, f_{CL}	CCI	50	—	500	kHz
Set Up Time, t_{SU}					
MSI Rising Edge to CCI Rising Edge (CCI = 128 kHz)*		-3	—	+3	μs

*Specifications assume use of 50% duty cycle for clocks.

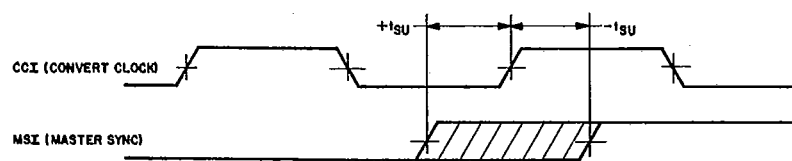


Fig. 2 - Switching characteristics wave forms.

LOGIC SHIFT VOLTAGE INPUTS

VLS PIN	LOGIC INPUT (CCI AND MSI)
$V_{SS} < V_{LS} < V_{SS} + 0.8\text{ V}$	CMOS
$V_{DD} - 1\text{ V} < V_{LS} < V_{DD}$	POWER DOWN
$V_{SS} + 2\text{ V} < V_{LS} < V_{DD} - 2\text{ V}$	TTL ($V_{LS} + 0.8\text{ V} < \text{INPUT} < V_{LS} + 2\text{ V}$)

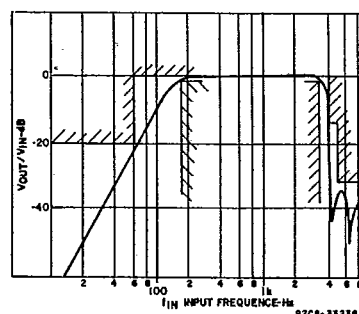


Fig. 5 - Transmit filter typical and minimum performance for CD22413 or CD22414 using Figs. 11 and 12.

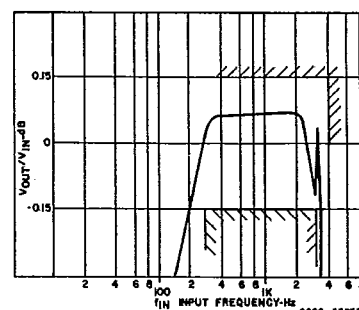


Fig. 6 - Transmit filter typical and minimum passband performance for CD22413 or CD22414 using Figs. 11 or 12.

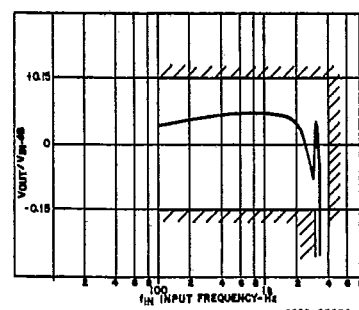


Fig. 7 - Transmit filter typical and minimum passband performance for CD22414.

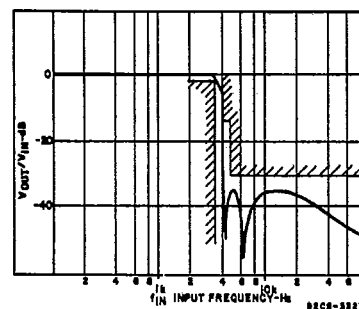


Fig. 8 - Transmit filter typical and minimum performance for CD22414.

CD22413, CD22414 Types

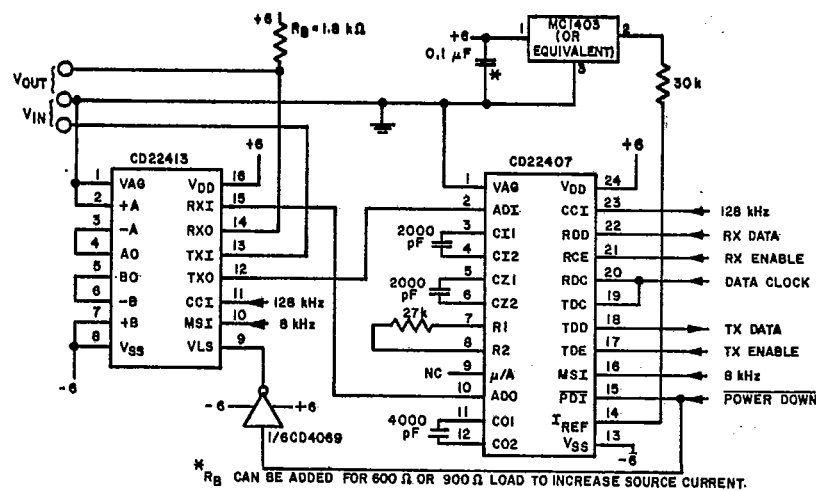


Fig. 9 - Typical circuit configuration using the CD22407 CODEC and CD22413 filter (split supply).

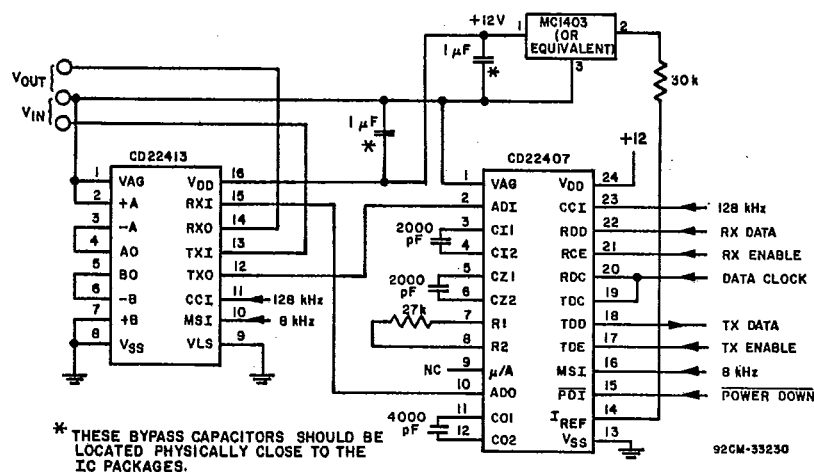


Fig. 10 - Typical circuit configuration using the CD22407 CODEC and CD22413 filter (single supply).

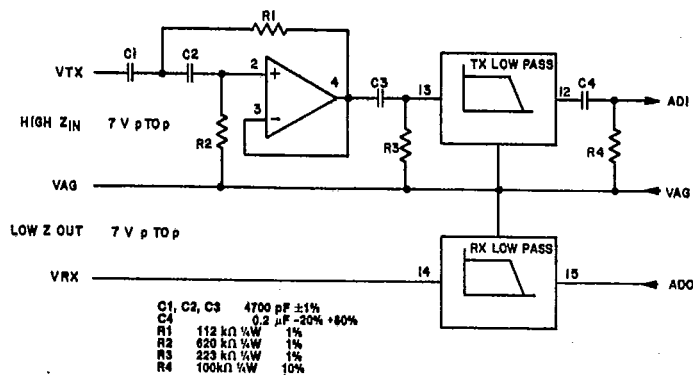


Fig. 11 - Filter schematic for CD22413 with 60-Hz reject filter.

VAG — (Analog Ground) This pin should be held at approximately $(V_{DD} - V_{EE})/2$. All analog inputs and outputs are referenced to this pin. If this pin is brought to within approximately 1 V of V_{DD} , the chip will be powered down.

+A Non-inverting input of op-amp A.

-A Inverting input of op-amp A.

A0 Output of uncommitted op-amp A

B0 Output of uncommitted op-amp B

-B Inverting input of op-amp B

+B Non-inverting input of op-amp B

VSS This is the most negative supply pin and digital ground for the package.

VLS (Logic Shift Voltage) The voltage on this pin determines the logic compatibility for the CCI and MSI inputs. If VLS is within 0.8 V of V_{SS} , the thresholds will be for CMOS operating between V_{DD} and V_{SS} . If VLS is within 1 V of V_{DD} , the chip will power down. If VLS is between $V_{DD} - 2$ V and $V_{SS} + 2$ V, the thresholds for logic inputs at CCI and MSI will be between $VLS + 0.8$ V and $VLS + 2$ V for TTL compatibility.

CCI (Convert Clock Input) Normally, a 128 kHz clock signal should be applied to this pin to operate both filters at $f_c = 3100$ Hz. For other break frequencies use the following equation: $f_c = 0.02422 f$ clock.

MSI (Master Sync Input) This pin should receive a low-to-high transition concurrent with each new PAM sample received at the receive filter input, ADI. A new transmit filter output sample will be presented at this time.

TXO (Transmit Bandpass Output — CD22413) This is the output of the transmit-bandpass filter. It is 100% duty cycle PAM at 8 kHz.

LPO (Transmit Lowpass Output — CD22414) This is the output of the transmit-lowpass filter. It is 100% duty cycle PAM at 128 kHz.

TXI (Transmit Input) This is the transmit-filter input.

RXO (Receive Output) This pin is the output of the receive filter. It is 100% duty cycle PAM at the same frequency as the CCI pin, normally 128 kHz.

RXI (Receive Input) This is the receive filter input. It will accept 3/16 to 100% duty cycle PAM at 8 kHz.

VDD Nominally 12 volts.

NOTE: Both VAG and VLS are high-impedance units.

CD22413, CD22414 Types

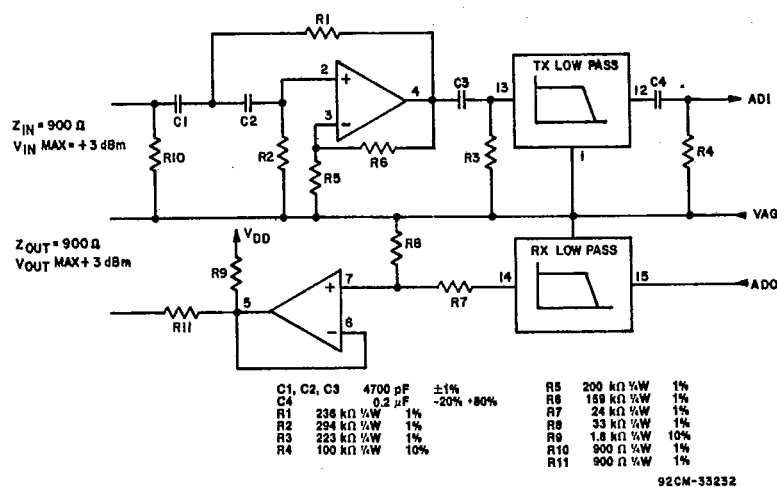


Fig. 12 - Filter schematic for CD22414 with 60-Hz rejection and 900-Ω termination.

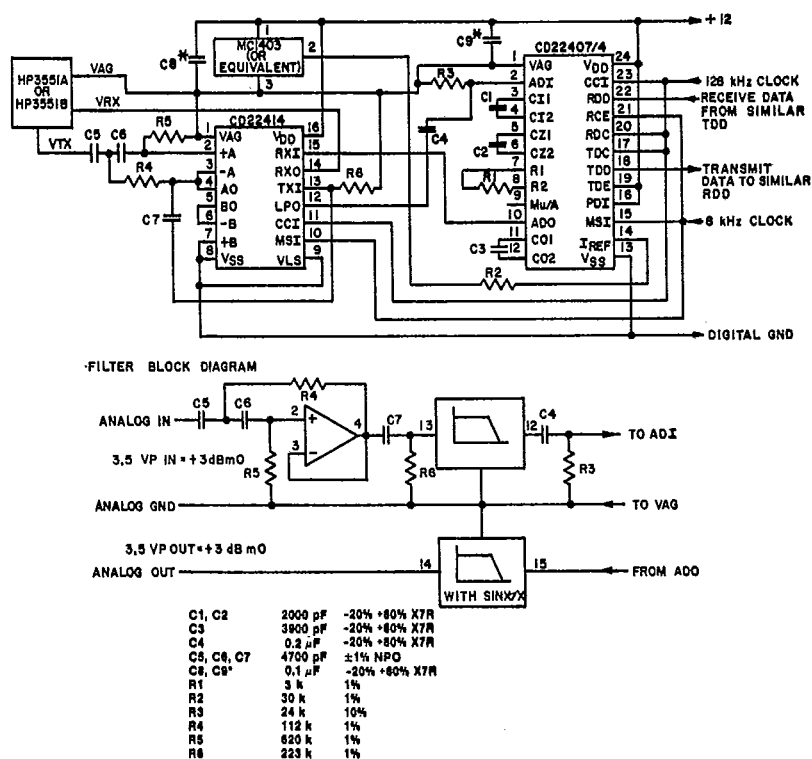


Fig. 13 - Analog transmission test circuit for CD22414 PCM filter and CD22407/CD22404 PCM CODEC.

CD22413, CD22414 Types

TYPICAL END TO END PERFORMANCE OF RCA CODEC & FILTER

All measurements made using HP3779B PCM Test Set. See Fig. 13.

SPECIFICATION	Performance of CD22407/4 CODEC & CD22414 Filter	Bell System D3 Voice Freq. Requirements PUB 43801	CCITT G7.12 Voice Freq. Requirements
Channel Saturation	+3 dBm0	+3 dBm0	+3 dBm0
Gain Tracking with 1 kHz tone			
+3 to -40 dBm0	± 0.3 dB	$\leq \pm 0.5$ dB	$\leq \pm 0.5$ dB
-40 to -50 dBm0	± 0.6 dB	$\leq \pm 1$ dB	$\leq \pm 1$ dB
-55 dBm0	± 2 dB	$\leq \pm 3$ dB	$\leq \pm 3$ dB
Quantizing Distortion @ 1 kHz			
+3 to -30 dBm0	37 dB	≥ 33 dB	> 33 dB
-35 dBm0	34 dB	≥ 30 dB	≥ 30 dB
-40 dBm0	31 dB	≥ 27 dB	≥ 27 dB
-45 dBm0	26 dB	≥ 22 dB	≥ 22 dB
Idle Channel Noise with VTX = VAG	17 dBmnc0	≤ 23 dBmnc0	≤ -64 dBm0P
Quiet Code Noise (all 1's at decoder (RDD) Input)	15 dBmnc0	≤ 15 dBmnc0	≤ -75 dBm0P
Selective Response @ multiples of 8 kHz	-60 dBm0	See Frequency Response	≤ -50 dBm0
Frequency Response @ 0 dBm0 Input			
50 Hz gain	-26 dB	—	≤ -24 dB
60 Hz gain	-22 dB	≤ -20 dB	—
200 to 300 Hz ripple	45 dB	≤ 0.6 dB	≤ 1 dB
3400 Hz gain	-1.6 dB	≥ -3 dB	≥ -1.8 dB
4000 Hz gain	-35 dB	≤ -28 dB	≤ -28 dB
≥ 4600 Hz gain	< -62 dB	≤ -60 dB	≤ -60 dB
Single Frequency Spurious Response			
In band with Input 1 kHz @ 0 dBm	≤ -44 dB	≤ -40 dB	≤ -40 dB
Out of band with Input 0 to 12 kHz @ 0 dBm	≤ -32.5 dB	≤ -28 dB	≤ -25 dB
Differential Delay Distortion			
1150 to 2300	58 μ s	≤ 60 μ s	—
1000 to 2500	72 μ s	≤ 100 μ s	—
900 to 2700	91 μ s	≥ 200 μ s	—

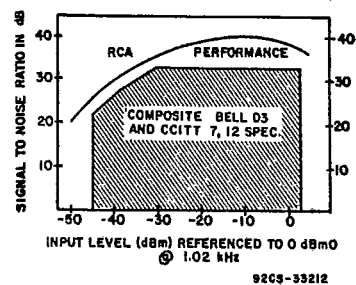


Fig. 14 - Signal-to-noise performance for CD22407 and CD22414. (See Fig. 13.)

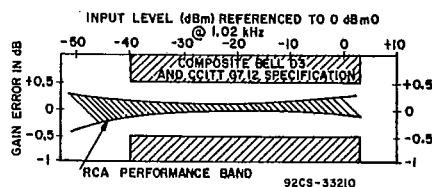


Fig. 15 - Gain tracking error for CD22407 and CD22414. (See Fig. 13.)

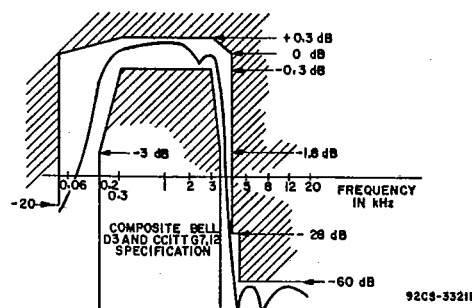
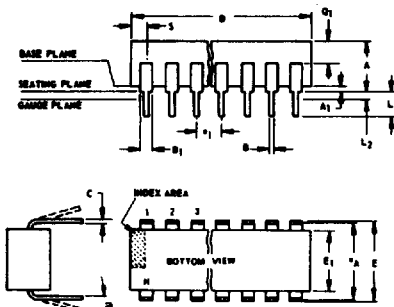


Fig. 16 - Frequency response of CD22407 and CD22414 CODEC and filter. (See Fig. 13.)

Dimensional Outlines

Dual-In-Line Welded-Seal Ceramic Packages



NOTES:

Refer to Rules for Dimensioning (JEDEC Publication No. 95) for Axial Lead Product Outlines.

- When this device is supplied solder-dipped, the maximum lead thickness (narrow portion) will not exceed 0.013" (0.33 mm).
- Leads within 0.005" (0.12 mm) radius of True Position (TP) at gauge plane with maximum material condition and unit installed.
- e_A applies in zone L_2 when unit installed.
- a applies to spread leads prior to installation.
- N is the maximum quantity of lead positions.
- N_1 is the quantity of allowable missing leads.

(D) SUFFIX (JEDEC MO-001-AD)
14-Lead Dual-In-Line Welded-Seal
Ceramic Package

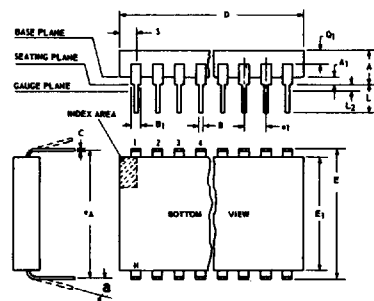
SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.120	0.180		3.05	4.06
A ₁	0.020	0.085		0.51	1.65
B	0.014	0.020		0.356	0.508
B ₁	0.060	0.065		1.27	1.65
C	0.008	0.012	1	0.204	0.304
D	0.745	0.770		18.93	19.55
E	0.300	0.325		7.62	8.25
E ₁	0.240	0.260		6.10	6.60
e ₁	0.100 TP		2	2.54 TP	
e _A	0.300 TP		2, 3	7.62 TP	
L	0.125	0.150		3.18	3.81
L ₂	0.000	0.030		0.000	0.76
a	0°	15°	4	0°	15°
N	14		5	14	
N ₁	0		6	0	
Q ₁	0.050	0.085		1.27	2.15
S	0.085	0.090		1.66	2.28

92SS-4411R2

(D) SUFFIX (JEDEC MO-001-AE)
16-Lead Dual-In-Line Welded-Seal
Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.120	0.160		3.05	4.06
A ₁	0.020	0.065		0.51	1.65
B	0.014	0.020		0.356	0.508
B ₁	0.035	0.065		0.89	1.65
C	0.008	0.012	1	0.204	0.304
D	0.745	0.785		18.93	19.93
E	0.300	0.325		7.62	8.25
E ₁	0.240	0.260		6.10	6.60
e ₁	0.100 TP		2	2.54 TP	
e _A	0.300 TP		2, 3	7.62 TP	
L	0.125	0.150		3.18	3.81
L ₂	0.000	0.030		0.000	0.76
a	0°	15°	4	0°	15°
N	16		5	16	
N ₁	0		6	0	
Q ₁	0.050	0.085		1.27	2.15
S	0.015	0.060		0.39	1.52

92SS-4286R5



NOTES:

Refer to Rules for Dimensioning (JEDEC Publication No. 95) for Axial Lead Product Outlines.

- When this device is supplied solder-dipped, the maximum lead thickness (narrow portion) will not exceed 0.013" (0.33 mm).
- Leads within 0.005" (0.12 mm) radius of True Position (TP) at gauge plane with maximum material condition and unit installed.
- e_A applies in zone L_2 when unit installed.
- a applies to spread leads prior to installation.
- N is the maximum quantity of lead positions.
- N_1 is the quantity of allowable missing leads.

(D) SUFFIX (JEDEC MO-015-AG)
24-Lead Dual-In-Line Welded-Seal
Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.090	0.200		2.29	5.08
A ₁	0.020	0.070		0.51	1.78
B	0.015	0.020		0.381	0.508
B ₁	0.045	0.055		1.143	1.397
C	0.008	0.012	1	0.204	0.304
D	1.15	1.22		29.21	30.98
E	0.600	0.625		15.24	15.87
E ₁	0.480	0.520		12.20	13.20
e ₁	0.100 TP		2	2.54 TP	
e _A	0.600 TP		2, 3	15.24 TP	
L	0.100	0.180		2.54	4.57
L ₂	0.000	0.030		0.00	0.76
a	0°	15°	4	0°	15°
N	24		5	24	
N ₁	0		6	0	
Q ₁	0.020	0.080		0.51	2.03
S	0.020	0.060		0.51	1.52

92CS-19948R4

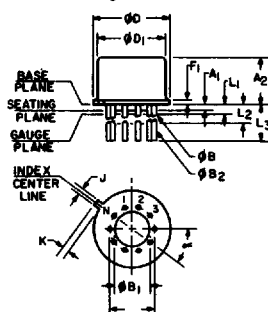
(D) SUFFIX (JEDEC MO-015-AH)
28-Lead Dual-In-Line Welded-Seal
Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.090	0.200		2.29	5.08
A ₁	0	0.070	2	0	1.77
B	0.015	0.020		0.381	0.508
B ₁	0.015	0.065		0.39	1.39
C	0.008	0.012	1	0.204	0.304
D	1.380	1.420		35.06	36.06
E	0.600	0.625		15.24	15.87
E ₁	0.485	0.515		12.32	13.08
e ₁	0.100 TP		2	2.54 TP	
e _A	0.600 TP		2, 3	15.24 TP	
L	0.100	0.200		2.54	5.08
L ₂	0	0.030		0	0.76
a	0°	15°	4	0°	15°
N	28		5	28	
N ₁	0		6	0	
Q ₁	0.020	0.070		0.51	1.77
S	0.040	0.070		1.02	1.77

92CM-20250R2

TO-5 Style Package

(T) SUFFIX (JEDEC MO-006-AG)
12-Lead Metal Package



92CS-19774

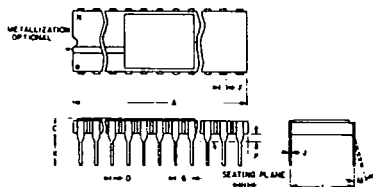
SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
a	0.230		2	5.84 TP	
A ₁	0	0		0	0
A ₂	0.165	0.185		4.19	4.70
φB	0.016	0.019	3	0.407	0.482
φB ₁	0	0		0	0
φB ₂	0.016	0.021	3	0.407	0.533
φD	0.335	0.370		8.51	9.39
φD ₁	0.305	0.335		7.75	8.50
F ₁	0.020	0.040		0.51	1.01
J	0.028	0.034		0.712	0.863
k	0.029	0.045	4	0.74	1.14
L ₁	0.000	0.050	3	0.00	1.27
L ₂	0.250	0.500	3	6.4	12.7
L ₃	0.500	0.562	3	12.7	14.27
a	30° TP			30° TP	
N	12		6	12	
N ₁	1		5	1	

NOTES:

- Refer to Rules for Dimensioning Axial Lead Product Outlines.
- Leads at gauge plane within 0.007" (0.178 mm) radius of True Position (TP) at maximum material condition.
- φB applies between L₁ and L₂. φB₂ applies between L₂ and 0.500" (12.70 mm) from seating plane. Diameter is uncontrolled in L₁ and beyond 0.500" (12.70 mm).
- Measure from Max. φD.
- N₁ is the quantity of allowable missing leads.
- N is the maximum quantity of lead positions.

Dimensional Outlines (Cont'd)

DUAL-IN-LINE SIDE-BRAZED CERAMIC PACKAGES



- NOTES:
1. Leads within 0.005" (0.13 mm)-radius of True Position at maximum material condition.
 2. Dimension "L" to center of leads when formed parallel.
 3. When this device is supplied solder-dipped, the maximum lead thickness (narrow portion) will not exceed 0.013" (0.33 mm).

(D) SUFFIX 18-Lead Dual-In-Line Side-Brazed Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.890	0.915		22.606	23.241
C	—	0.200		—	5.080
D	0.015	0.021		0.381	0.533
F	0.054	REF.	1	1.371	REF.
G	0.100	BSC	1	2.54	BSC
H	0.035	0.065		0.889	1.651
J	0.008	0.012	3	0.203	0.304
K	0.125	0.150		3.175	3.810
L	0.290	0.310	2	7.366	7.874
M	0°	15°		0°	15°
P	0.025	0.045		0.635	1.143
N	18			18	

92CS-27231R1

(D) SUFFIX 22-Lead Dual-In-Line Side-Brazed Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	1.065	1.100		27.05	27.94
C	0.085	0.145		2.16	3.68
D	0.017	0.023		0.43	0.58
F	0.040	REF.	1	1.02	REF.
G	0.100	BSC	1	2.54	BSC
H	0.030	0.070		0.76	1.78
J	0.008	0.012	3	0.20	0.30
K	0.125	0.175		3.18	4.45
L	0.380	0.420	2	9.65	10.67
M	—	7°		—	7°
P	0.025	0.050		0.64	1.27
N	22			22	

92CS-25186R2

(D) SUFFIX 24-Lead Dual-In-Line Side-Brazed Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	1.180	1.220		29.98	30.98
C	0.085	0.145		2.16	3.68
D	0.015	0.023		0.39	0.58
F	0.040	REF.		1.02	REF.
G	0.100	BSC	1	2.54	BSC
H	0.030	0.070		0.77	1.77
J	0.008	0.012	3	0.21	0.30
K	0.125	0.175		3.18	4.44
L	0.580	0.620	2	14.74	15.74
M	—	7°		—	7°
P	0.025	0.050		0.64	1.27
N	24			24	

92CS-30986R1

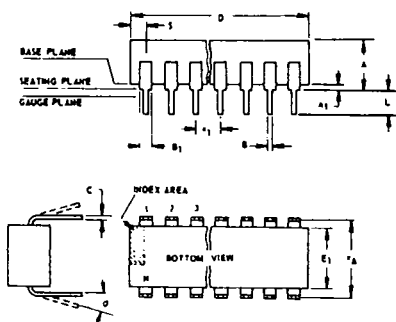
(D) SUFFIX 40-Lead Dual-In-Line Side-Brazed Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	1.980	2.020		50.30	51.30
C	0.095	0.155		2.43	3.93
D	0.017	0.023		0.43	0.58
F	0.050	REF.		1.27	REF.
G	0.100	BSC	1	2.54	BSC
H	0.030	0.070		0.76	1.78
J	0.008	0.012	3	0.20	0.30
K	0.125	0.175		3.18	4.45
L	0.580	0.620	2	14.74	15.74
M	—	7°		—	7°
P	0.025	0.050		0.64	1.27
N	40			40	

92CM-27029R2

Dual-In-Line Plastic and Frit-Seal Ceramic Packages

(E) SUFFIX (JEDEC MO-001-AN) 8-Lead Dual-In-Line Plastic (Mini-DIP) Package



SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.155	0.200		3.94	5.08
A ₁	0.020	0.050		0.508	1.27
B	0.014	0.020		0.356	0.508
B ₁	0.035	0.065		0.889	1.65
C	0.008	0.012	1	0.203	0.304
D	0.370	0.400		9.40	10.16
E	0.300	0.325		7.62	8.25
E ₁	0.240	0.260		6.10	6.60
E ₁	0.100	TP	2	2.54	TP
E ₁	0.300	TP	2, 3	7.62	TP
L	0.125	0.150		3.18	3.81
L ₂	0.000	0.030		0.000	0.762
a	0	15	4	0	15
N	8		5	8	
N ₁	0		6	0	
O ₁	0.040	0.075		1.02	1.90
S	0.015	0.060		0.381	1.52

92CS-24026 R1

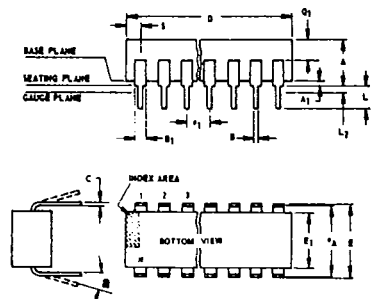
NOTES:

Refer to Rules for Dimensioning (JEDEC Publication No. 95) for Axial Lead Product Outlines.

1. When this device is supplied solder-dipped, the maximum lead thickness (narrow portion) will not exceed 0.013".
2. Leads within 0.005" (0.12 mm) radius of True Position (TP) at gauge plane with maximum material condition and unit installed.
3. E_A applies in zone L₂ when unit installed.
4. a applies to spread leads prior to installation.
5. N is the maximum quantity of lead positions.
6. N₁ is the quantity of allowable missing leads.

Dimensional Outlines (Cont'd)

Dual-In-Line Plastic and Frit-Seal Ceramic Packages (Cont'd)



NOTES:

Refer to Rules for Dimensioning (JEDEC Publication No. 95) for Axial Lead Product Outlines.

- When this device is supplied solder dipped, the maximum lead thickness (narrow portion) will not exceed 0.013" (0.33 mm).
- Leads within 0.005" (0.12 mm) radius of True Position (TP) at gauge plane with maximum material condition and unit installed.
- ϕA applies in zone L₂ when unit installed.
- ϕ applies to spread leads prior to installation.
- N is the maximum quantity of lead positions.
- N₁ is the quantity of allowable missing leads.

(E) and (F) SUFFIXES (JEDEC MO-001-AB)
14-Lead Dual-In-Line Plastic or
Frit-Seal Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.155	0.200		3.94	5.08
A ₁	0.020	0.060		0.51	1.27
B	0.014	0.020		0.356	0.508
B ₁	0.050	0.065		1.27	1.65
C	0.008	0.012	1	0.204	0.304
D	0.745	0.770		18.93	19.55
E	0.300	0.325		7.62	8.25
E ₁	0.240	0.260		6.10	6.60
$\phi 1$	0.100 TP		2	2.54 TP	
ϕA	0.300 TP		2, 3	7.62 TP	
L	0.125	0.150		3.18	3.81
L ₂	0.000	0.030		0.000	0.76
a	0°	15°	4	0°	15°
N	14		5	14	
N ₁	0		6	0	
Q ₁	0.040	0.075		1.02	1.90
S	0.065	0.090		1.66	2.28

92SS-4296R3

(E) and (F) SUFFIXES (JEDEC MO-001-AC)
16-Lead Dual-In-Line Plastic or
Frit-Seal Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.155	0.200		3.94	5.08
A ₁	0.020	0.050		0.51	1.27
B	0.014	0.020		0.356	0.508
B ₁	0.035	0.065		0.89	1.65
C	0.008	0.012	1	0.204	0.304
D	0.745	0.785		18.93	19.93
E	0.300	0.325		7.62	8.25
E ₁	0.240	0.260		6.10	6.60
$\phi 1$	0.100 TP		2	2.54 TP	
ϕA	0.300 TP		2, 3	7.62 TP	
L	0.125	0.150		3.18	3.81
L ₂	0.000	0.030		0.000	0.76
a	0°	15°	4	0°	15°
N	16		5	16	
N ₁	0		6	0	
Q ₁	0.040	0.075		1.02	1.90
S	0.015	0.060		0.39	1.52

92CM-15967R4

(E) SUFFIX
18-Lead Dual-In-Line
Plastic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.155	0.200		3.94	5.08
A ₁	0.020	0.050		0.508	1.27
B	0.014	0.020		0.356	0.508
B ₁	0.035	0.065		0.89	1.65
C	0.008	0.012	1	0.204	0.304
D	0.845	0.885		21.47	22.47
E ₁	0.240	0.260		6.10	6.60
$\phi 1$	0.100 TP		2	2.54 TP	
ϕA	0.300 TP		2, 3	7.62 TP	
L	0.125	0.150		3.18	3.81
a	0°	15°	4	0°	15°
N	18		5	18	
N ₁	0		6	0	
S	0.015	0.060		0.39	1.52

92CS-30630

(E) SUFFIX
22-Lead Dual-In-Line
Plastic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.155	0.200		3.94	5.08
A ₁	0.020	0.050		0.508	1.27
B	0.015	0.020		0.381	0.508
B ₁	0.035	0.065		0.89	1.65
C	0.008	0.012	1	0.204	0.304
D		1.120			28.44
E	0.390	0.420		9.91	10.66
E ₁	0.345	0.355		8.77	9.01
$\phi 1$	0.100 TP		2	2.54 TP	
ϕA	0.400 TP		2, 3	10.16 TP	
L	0.125	0.150		3.18	3.81
L ₂	0	0.030		0	0.762
a	2°	15°	4	2°	15°
N	22		5	22	
N ₁	0		6	0	
Q ₁	0.055	0.085		1.40	2.15
S	0.015	0.060		0.381	1.27

92CS-30830

(F) SUFFIX (JEDEC MO-001-AG)
16-Lead Dual-In-Line
Frit-Seal Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.165	0.210		4.20	5.33
A ₁	0.015	0.045		0.381	1.14
B	0.015	0.020		0.381	0.508
B ₁	0.045	0.070		1.15	1.77
C	0.009	0.011	1	0.229	0.279
D	0.750	0.795		19.05	20.19
E	0.295	0.325		7.50	8.25
E ₁	0.245	0.300		6.23	7.62
$\phi 1$	0.100 TP		2	2.54 TP	
ϕA	0.300 TP		2, 3	7.62 TP	
L	0.120	0.160		3.05	4.06
L ₂	0.000	0.030		0.000	0.76
a	2°	15°	4	2°	15°
N	16		5	16	
N ₁	0		6	0	
Q ₁	0.050	0.080		1.27	2.03
S	0.010	0.060		0.254	1.52

92CM-22284R1

(E) and (F) SUFFIXES (JEDEC MO-015-AA)
24-Lead Dual-In-Line Plastic or
Frit-Seal Ceramic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.120	0.250		3.10	6.30
A ₁	0.020	0.070		0.51	1.77
B	0.016	0.020		0.407	0.508
B ₁	0.028	0.070		0.72	1.77
C	0.008	0.012	1	0.204	0.304
D	1.20	1.29		30.48	32.76
E	0.600	0.625		15.24	15.87
E ₁	0.515	0.580		13.09	14.73
$\phi 1$	0.100 TP		2	2.54 TP	
ϕA	0.600 TP		2, 3	15.24 TP	
L	0.100	0.200		2.54	5.00
L ₂	0.000	0.030		0.00	0.76
a	0°	15°	4	0°	15°
N	24		5	24	
N ₁	0		6	0	
Q ₁	0.040	0.075		1.02	1.90
S	0.040	0.100		1.02	2.54

92CS26938R2

(E) SUFFIX
40-Lead Dual-In-Line
Plastic Package

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.120	0.250		3.10	6.30
A ₁	0.020	0.070		0.51	1.77
B	0.016	0.020		0.407	0.508
B ₁	0.028	0.070		0.72	1.77
C	0.008	0.012	1	0.204	0.304
D	2.000	2.090		50.80	53.09
E ₁	0.515	0.580		13.09	14.73
$\phi 1$	0.100 TP		2	2.54 TP	
ϕA	0.600 TP		2, 3	15.24 TP	
L	0.100	0.200		2.54	5.00
L ₂	0.000	0.030		0.00	0.76
a	0°	15°	4	0°	15°
N	40		5	40	
N ₁	0		6	0	
Q ₁	0.065	0.095		1.66	2.41
S	0.040	0.100		1.02	2.54

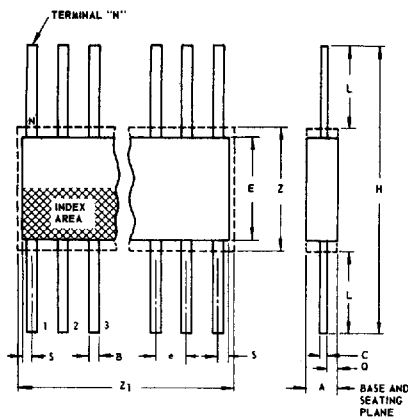
92CS-30959

T-90-20

Dimensional Outlines (Cont'd)

Ceramic Flat Packs

(K) SUFFIX (JEDEC MO-004-AF) 14-Lead



SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.008	0.100		0.21	2.54
B	0.015	0.019	1	0.381	0.482
C	0.003	0.006	1	0.077	0.152
e	0.050 TP		2	1.27 TP	
E	0.200	0.300		5.1	7.6
H	0.600	1.000		15.3	25.4
L	0.150	0.350		3.9	8.8
N	14		3	14	
Q	0.005	0.050		0.13	1.27
S	0.000	0.050		0.00	1.27
Z	0.300		4	7.62	
Z1	0.400		4	10.16	

92S8-4300R3

NOTES:

1. Refer to JEDEC Publication No. 95 for Rules for Dimensioning Peripheral Lead Outlines.
2. Leads within 0.005" (0.12 mm) radius of True Position (TP) at maximum material condition.
3. N is the maximum quantity of lead positions.
4. Z and Z1 determine a zone within which all body and lead irregularities lie.

(K) SUFFIX (JEDEC MO-004-AG) 16-Lead

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.008	0.100		0.21	2.54
B	0.015	0.019	1	0.381	0.482
C	0.003	0.006	1	0.077	0.152
e	0.050 TP		2	1.27 TP	
E	0.200	0.300		5.1	7.6
H	0.600	1.000		15.3	25.4
L	0.150	0.350		3.9	8.8
N	16		3	16	
Q	0.005	0.050		0.13	1.27
S	0.000	0.025		0.00	0.63
Z	0.300		4	7.62	
Z1	0.400		4	10.16	

92CS-17271R3

(K) SUFFIX 24-Lead

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.075	0.120		1.91	3.04
B	0.018	0.022	1	0.458	0.558
C	0.004	0.007	1	0.102	0.177
e	0.050 TP		2	1.27 TP	
E	0.600	0.700		15.24	17.78
H	1.150	1.350		29.21	34.29
L	0.225	0.325		5.72	8.25
N	24		3	24	
Q	0.035	0.070		0.89	1.77
S	0.060	0.110	1	1.53	2.79
Z	0.700		4	17.78	
Z1	0.750		4	19.05	

92CS-19949R2

(K) SUFFIX 28-Lead

SYMBOL	INCHES		NOTE	MILLIMETERS	
	MIN.	MAX.		MIN.	MAX.
A	0.075	0.120		1.91	3.04
B	0.018	0.022	1	0.458	0.558
C	0.004	0.007	1	0.102	0.177
e	0.050 TP		2	1.27 TP	
E	0.600	0.700		15.24	17.78
H	1.150	1.350		29.21	34.29
L	0.225	0.325		5.72	8.25
N	28		3	28	
Q	0.035	0.070		0.89	1.77
S	0	0.060	1	0	1.53
Z	0.700		4	17.78	
Z1	0.750		4	19.05	

92CS-20972