

PRAM Four-Channel Programmable Operational Amplifier

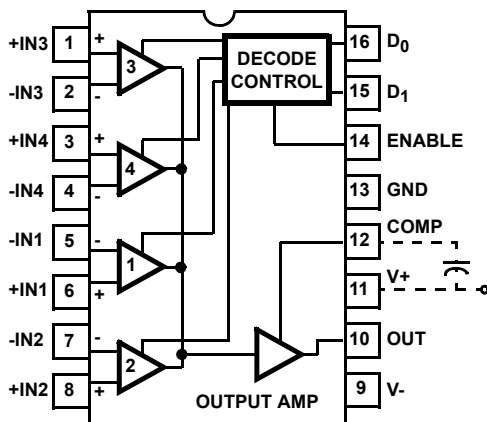
HA-2400/883

HA-2400/883 is a four-channel programmable amplifier 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.

Each channel of the HA-2400/883 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 20V/μs slew rate, 20MHz gain bandwidth and low input bias currents makes this device an ideal building block for signal generators, active filters and data acquisition designs. Programmability, coupled with 9mV typical offset voltage and 50nA offset current, makes these amplifiers outstanding components for signal conditioning circuits.

Pin Configuration

HA1-2400/883
(CERDIP)
TOP VIEW



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

Features

- This Circuit is Processed in Accordance to MIL-STD-883 and is Fully Conformant Under the Provisions of Paragraph 1.2.1.
- Digital Programmability
- High Slew Rate
 - Uncompensated 20V/μs Min
 - Compensated 6V/μs Min
- Wide Gain Bandwidth
 - Uncompensated 20MHz Min
 - Compensated 4MHz Min
- High Gain. 50kV/V
- Low Offset Current 50nA
- Single Capacitor Compensation for Unity Gain
- DTL/TTL Compatible Inputs

Applications

- Single Selection/Multiplexing
- Op Amp Gain Stage
- Frequency Oscillator
- Filter Characteristics
- Add-Subtract Functions
- Integrator Characteristics
- Comparator Levels

Ordering Information

PART #	PART MARKING	TEMP. RANGE (°C)	PACKAGE	PKG. DWG. #
HA1-2400/883	HA1-2400/883	-55 to +125	16 Ld CERDIP	F16.3

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Absolute Maximum Ratings

Voltage Between V+ and V- Terminals	45V
Differential Input Voltage	$\pm V_{\text{SUPPLY}}$
Voltage at Either Input Terminal	V+ to V-
Digital Input Voltage	-0.76V to +10V
Peak Output Current (Short Circuit Protected)	$I_{\text{SC}} < \pm 33\text{mA}$
ESD Rating	<2000V

Recommended Operating Conditions

Temperature Range	-55°C to +125°C
Supply Voltage	+15V
Negative Supply Voltage	-15V

Thermal Information

Thermal Resistance (Typical)	θ_{JA} (°C/W)	θ_{JC} (°C/W)
CerDIP Package (Note 1)	91	25
Internal Power Dissipation		
Package Power Dissipation Limit at +75°C for $T_{\text{J}} \leq +175^\circ\text{C}$		
CerDIP Package	1.11W	
Package Power Dissipation Derating Factor Above +75°C		
CerDIP Package	11.1mW/°C	
Junction Temperature (T_{J})	+175°C	
Storage Temperature Range	-65°C to +150°C	
Maximum Lead Temperature (Soldering 10s)	+300°C	

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.

NOTES:

- θ_{JA} is measured with the component mounted on a low effective thermal conductivity test board in free air. See Tech Brief [TB379](#) for details.

TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: V+ = +15V, V- = -15V, $R_{\text{S}} = 100\Omega$, $R_{\text{L}} = 500\text{k}\Omega$, $V_{\text{O}} = 0\text{V}$, unless otherwise specified. Digital Inputs: $V_{\text{IL}} = +0.5\text{V}$, $V_{\text{IH}} = +2.4\text{V}$, limits apply to each of the four channels, when addressed.

PARAMETER	SYMBOL	CONDITIONS	GROUP A SUBGROUPS	TEMP (°C)	MIN	MAX	UNITS
Offset Voltage	V_{IO}	$V_{\text{CM}} = 0\text{V}$	1	+25	-9	9	mV
			2, 3	+125, -55	-11	11	mV
Input Bias Current	+ I_{B}	$V_{\text{CM}} = 0\text{V}$, $+R_{\text{S}} = 100\text{k}\Omega$, $-R_{\text{S}} = 100\Omega$	1	+25	-200	200	nA
			2, 3	+125, -55	-400	400	nA
	- I_{B}	$V_{\text{CM}} = 0\text{V}$, $+R_{\text{S}} = 100\Omega$, $-R_{\text{S}} = 100\text{k}\Omega$	1	+25	-200	200	nA
			2, 3	+125, -55	-400	400	nA
Input Offset Current	I_{IO}	$V_{\text{CM}} = 0\text{V}$, $+R_{\text{S}} = 100\text{k}\Omega$, $-R_{\text{S}} = 100\text{k}\Omega$	1	+25	-50	50	nA
			2, 3	+125, -55	-100	100	nA
Common Mode Range	+CMR	V+ = +6V, V- = -24V, $V_{\text{OUT}} = -9\text{V}$	1	+25	9	-	V
			2, 3	+125, -55	9	-	V
	-CMR	V+ = +24V, V- = -6V, $V_{\text{OUT}} = +9\text{V}$	1	+25	-	-9	V
			2, 3	+125, -55	-	-9	V
Large Signal Voltage Gain	A_{V}	$V_{\text{OUT}} = -10\text{V to } +10\text{V}$, $R_{\text{L}} = 2\text{k}\Omega$	4	+25	50	-	kV/V
			5, 6	+125, -55	25	-	kV/V
Common Mode Rejection Ratio	+CMRR	$\Delta V_{\text{CM}} = +5\text{V}$, V+ = +10V, V- = -20V, $V_{\text{OUT}} = -5\text{V}$	1	+25	80	-	dB
			2, 3	+125, -55	80	-	dB
	-CMRR	$\Delta V_{\text{CM}} = -5\text{V}$, V+ = +20V, V- = -10V, $V_{\text{OUT}} = +5\text{V}$	1	+25	80	-	dB
			2, 3	+125, -55	80	-	dB
Output Voltage Swing	+ V_{OUT}	$R_{\text{L}} = 2\text{k}\Omega$	4	+25	10	-	V
			5, 6	+125, -55	10	-	V
	- V_{OUT}	$R_{\text{L}} = 2\text{k}\Omega$	4	+25	-	-10	V
			5, 6	+125, -55	-	-10	V
Output Current	+ I_{OUT}	$V_{\text{OUT}} = +10\text{V}$	4	+25	10	-	mA
	- I_{OUT}	$V_{\text{OUT}} = -10\text{V}$	4	+25	-	-10	mA

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TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)

Device Tested at: $V_+ = +15V$, $V_- = -15V$, $R_S = 100\Omega$, $R_L = 500k\Omega$, $V_O = 0V$, unless otherwise specified. Digital Inputs: $V_{IL} = +0.5V$, $V_{IH} = +2.4V$, limits apply to each of the four channels, when addressed.

PARAMETER	SYMBOL	CONDITIONS	GROUP A SUBGROUPS	TEMP (°C)	MIN	MAX	UNITS
Supply Current	+I _{CC}	V _{OUT} = 0V	1	+25	-	6	mA
			2, 3	+125, -55	-	7	mA
	-I _{CC}	V _{OUT} = 0V	1	+25	-6	-	mA
			2, 3	+125, -55	-7	-	mA
Power Supply Rejection Ratio	+PSRR	$\Delta V_{SUP} = \pm 5V$ $V_+ = +20V, V_- = -15V$ $V_+ = +10V, V_- = -15V$	1	+25	74	-	dB
			2, 3	+125, -55	74	-	dB
	-PSRR	$\Delta V_{SUP} = \pm 5V$ $V_+ = +15V, V_- = -20V$ $V_+ = +15V, V_- = -10V$	1	+25	74	-	dB
			2, 3	+125, -55	74	-	dB
Crosstalk	C _T	V _{IN} = ±10V	1	+25	-80	-	dB
Digital Logic Current	I _{IL}	V _{IL} = 0V	1	+25	-	1.5	mA
			2, 3	+125, -55	-	1.5	mA
	I _{IH}	V _{IH} = 5.0V	1	+25	-	1	μA
			2, 3	+125, -55	-	1	μA

TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: $V_+ = +15V$, $V_- = -15V$, $R_L = 2k\Omega$, $C_{LOAD} = 50pF$, unless otherwise specified. Digital Inputs: $V_{IL} = +0.5V$, $V_{IH} = +2.4V$, limits apply to each of the four channels, when addressed.

PARAMETER	SYMBOL	CONDITIONS	GROUP A SUBGROUPS	TEMP (°C)	MIN	MAX	UNITS
Slew Rate (Note 2)	+SR ₁	V _{OUT} = -5V to +5V	7	+25	6	-	V/μs
	-SR ₁	V _{OUT} = +5V to -5V	7	+25	6	-	V/μs
Rise and Fall Time	t _{R1}	V _{OUT} = 0 to +200mV	7	+25	-	45	ns
	t _{F1}	V _{OUT} = 0 to -200mV	7	+25	-	45	ns
Overshoot	+OS ₁	V _{OUT} = 0 to +200mV	7	+25	-	40	%
	-OS ₁	V _{OUT} = 0 to -200mV	7	+25	-	40	%

NOTES:

- $A_V = +1$, $C_{COMP} = 15pF$.

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: $V_+ = +15V$, $V_- = -15V$, unless otherwise specified.

PARAMETER	SYMBOL	CONDITIONS	NOTES	TEMP (°C)	MIN	MAX	UNITS
Unity Gain Bandwidth	UGBW ₁	$A_V = +1V$, $C_{COMP} = 15pF$, $R_L = 2k\Omega$, $C_L = 50pF$	3	+25	4	-	MHz
Gain Bandwidth Product	GBWP ₂	$A_V = +10V$, $C_{COMP} = 0pF$, $R_L = 2k\Omega$, $C_L = 50pF$	3	+25	20	-	MHz
Full Power Bandwidth ₁	FPBW ₁	$R_L = 2k\Omega$, $A_V = +1V$, $V_O = \pm 10V$, $C_L = 50pF$, $C_{COMP} = 15pF$	3, 4	+25	95	-	kHz
Full Power Bandwidth ₂	FPBW ₂	$R_L = 2k\Omega$, $A_V = +10V$, $V_O = \pm 10V$, $C_L = 50pF$, $C_{COMP} = 0pF$	3, 4	+25	300	-	kHz
Settling Time	T _{SET1}	$A_V = +1V$, $C_{COMP} = 15pF$, $R_L = 2k\Omega$, $C_L = 50pF$, $V_O = 10V_{P-P}$, to 0.1% F.V., Logic Control = +5.0V	3	+25	-	2.5	μs

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TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)

Device Characterized at: $V_+ = +15V$, $V_- = -15V$, unless otherwise specified.

PARAMETER	SYMBOL	CONDITIONS	NOTES	TEMP (°C)	MIN	MAX	UNITS
Slew Rate (Note 5)	+SR ₂	V _{OUT} = -5V to +5V, R _L = 2kΩ, C _L = 50pF, A _V = +10V, C _{COMP} = 0pF	3	+25	20	-	V/μs
	-SR ₂	V _{OUT} = +5V to -5V, R _L = 2kΩ, C _L = 50pF, A _V = +10V, C _{COMP} = 0pF	3	+25	20	-	V/μs
Output Delay	T _{DEL}	R _L = 2kΩ, C _L = 50pF, C _{COMP} = 15pF, V _{IN} = +5V	3	+25	-	250	ns
Minimum Closed Loop Stability	CLS ₁	R _L = 2kΩ, C _L = 50pF, C _{COMP} = 15pF	3	+25	1	-	V/V
	CLS ₂	R _L = 2kΩ, C _L = 50pF, C _{COMP} = 0pF	3	+25	10	-	V/V

NOTES:

- Parameters listed in Table 3 are controlled via design or process parameters and are not directly tested at final production. These parameters are lab characterized upon initial design release, or upon design changes. These parameters are guaranteed by characterization based upon data from multiple production runs which reflect lot to lot and within lot variation.
- FPBW = Slew Rate/(2πV_{PEAK}).
- A_V = +10, C_{COMP} = 0pF.

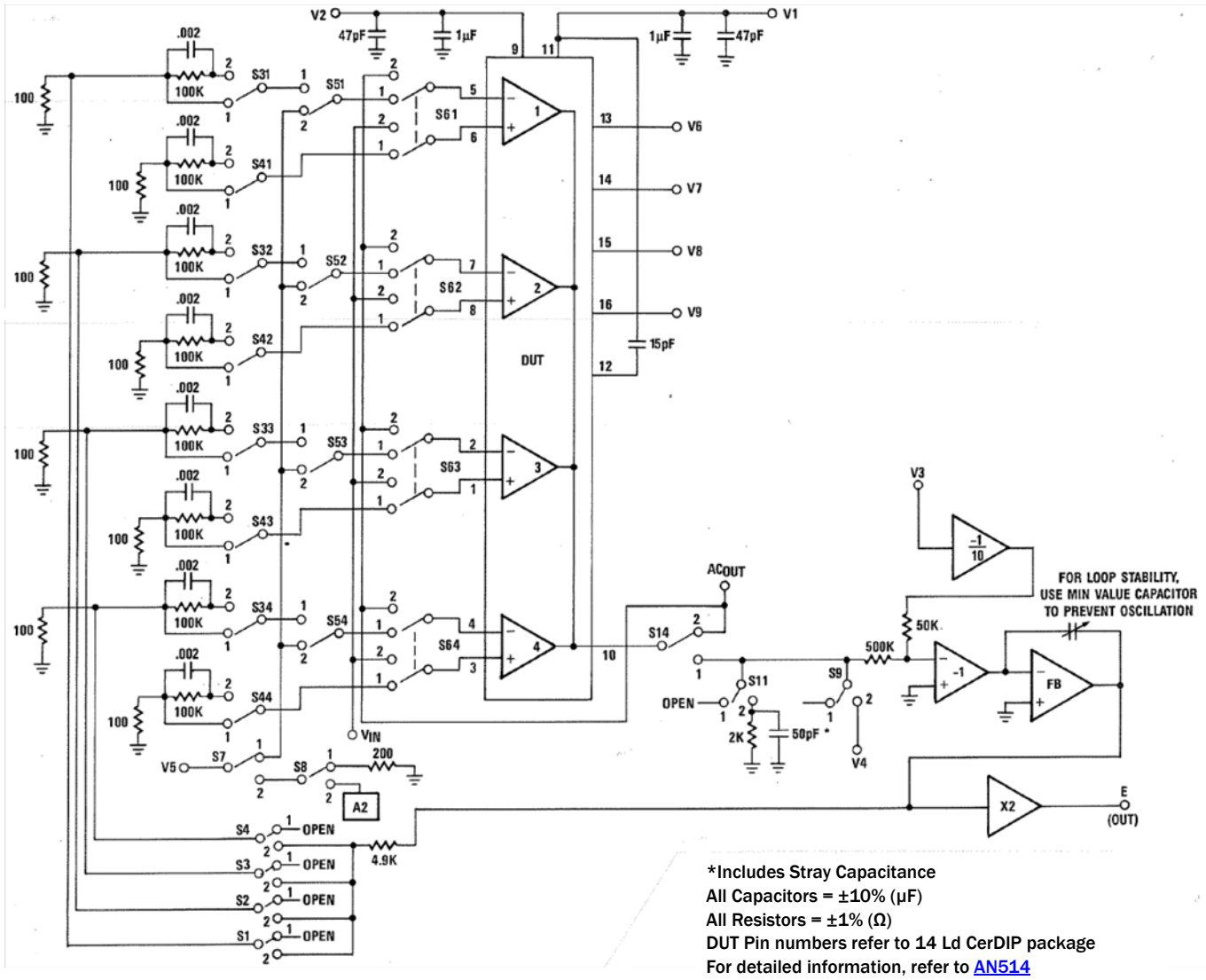
TABLE 4. ELECTRICAL TEST REQUIREMENTS

MIL-STD-883 TEST REQUIREMENTS	SUBGROUPS (SEE TABLES 1 AND 2)
Interim Electrical Parameters (Pre Burn-In)	1
Final Electrical Test Parameters	1 (Note 6), 2, 3, 4, 5, 6, 7
Group A Test Requirements	1, 2, 3, 4, 5, 6, 7
Groups C and D Endpoints	1

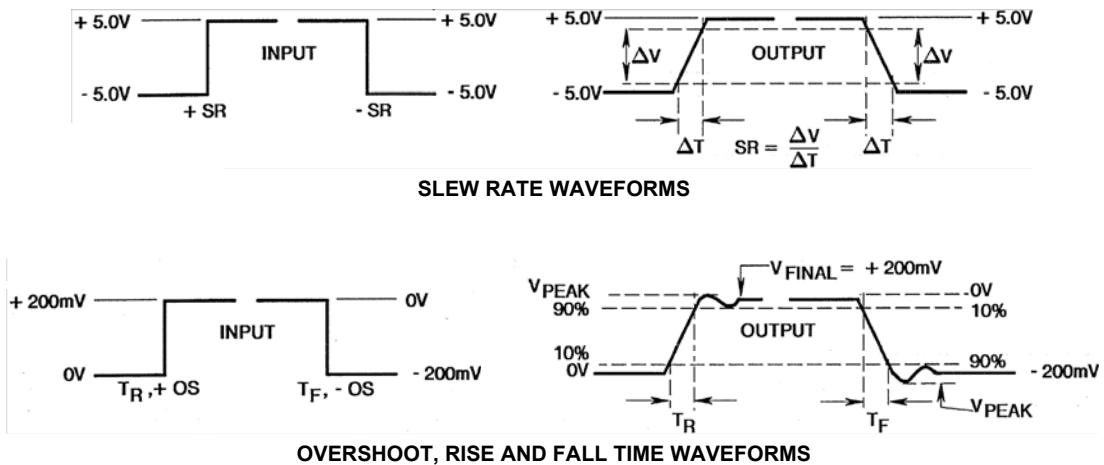
NOTES:

- PDA applies to Subgroup 1 only.
- The subgroup assignments of the parameters in these tables were patterned after DESC SMD #5962-87783.

Test Circuit

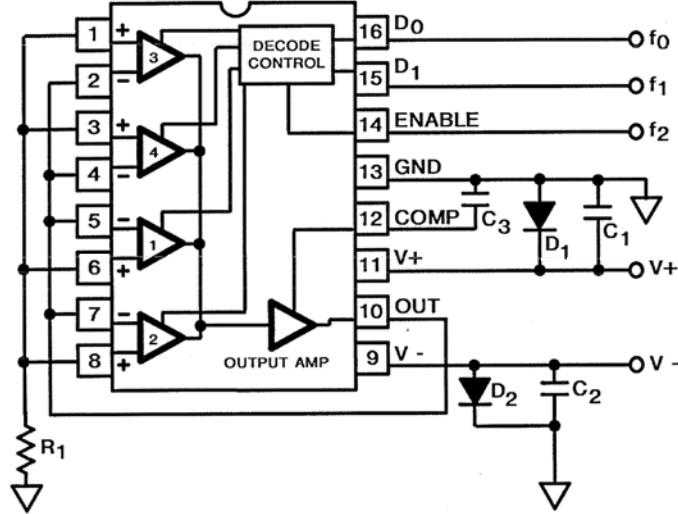


Test Waveforms



Burn-In Circuit

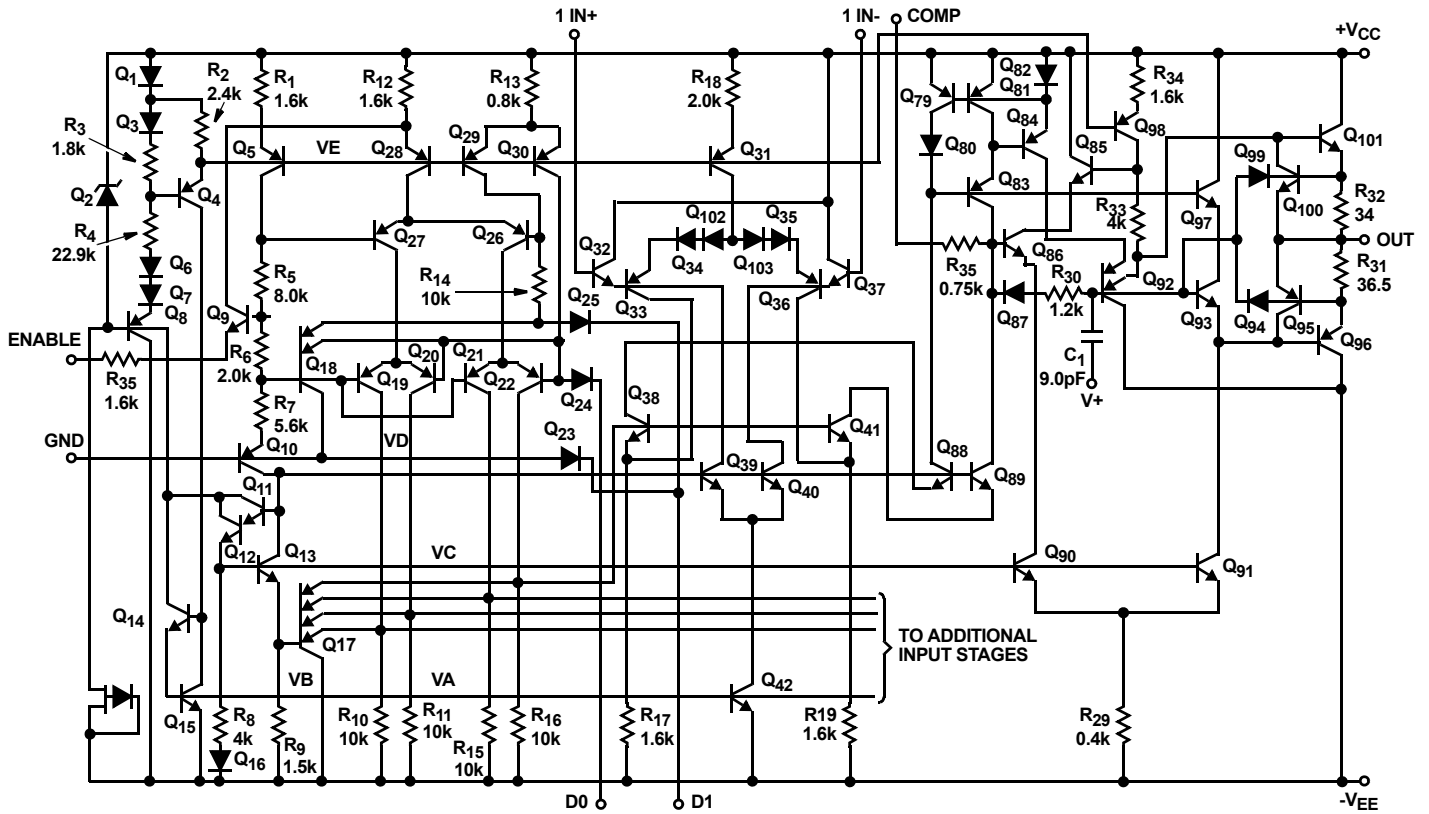
HA-2400/883 CERAMIC DIP



NOTES:

- $R_1 = 100k\Omega/\text{socket}$, 5% 1/4W (min)
 - $C_1 = C_2 = 0.01\mu\text{F}$ per socket (min) or $0.1\mu\text{F}$ per row (min)
 - $C_3 = 0.001\mu\text{F}$ per socket, 10%
 - $D_1, D_2 = 1N4002$ or equivalent per board
 - $|V^+ - V^-| = 30V$
 - $f_0 = 100\text{kHz}$
 - $f_1 = 50\text{kHz}$
 - $f_2 = 25\text{kHz}$
- } 50% Duty Cycle

Schematic Diagram



HA-2400/883

Die Characteristics

DIE DIMENSIONS:

88mils x 67mils x 19mils ± 1mil
2240µm x 1710µm x 483µm ± 25.4µm

METALLIZATION:

Type: Al, 1% Cu
Thickness: 16kÅ ± 2kÅ

GLASSIVATION:

Type: Nitride (Si₃N₄) over Silox (SiO₂, 5% Phos.)
Silox Thickness: 12kÅ ± 2kÅ
Nitride Thickness: 3.5kÅ ± 1.5kÅ

WORST CASE CURRENT DENSITY:

0.7 x 10⁵A/cm²

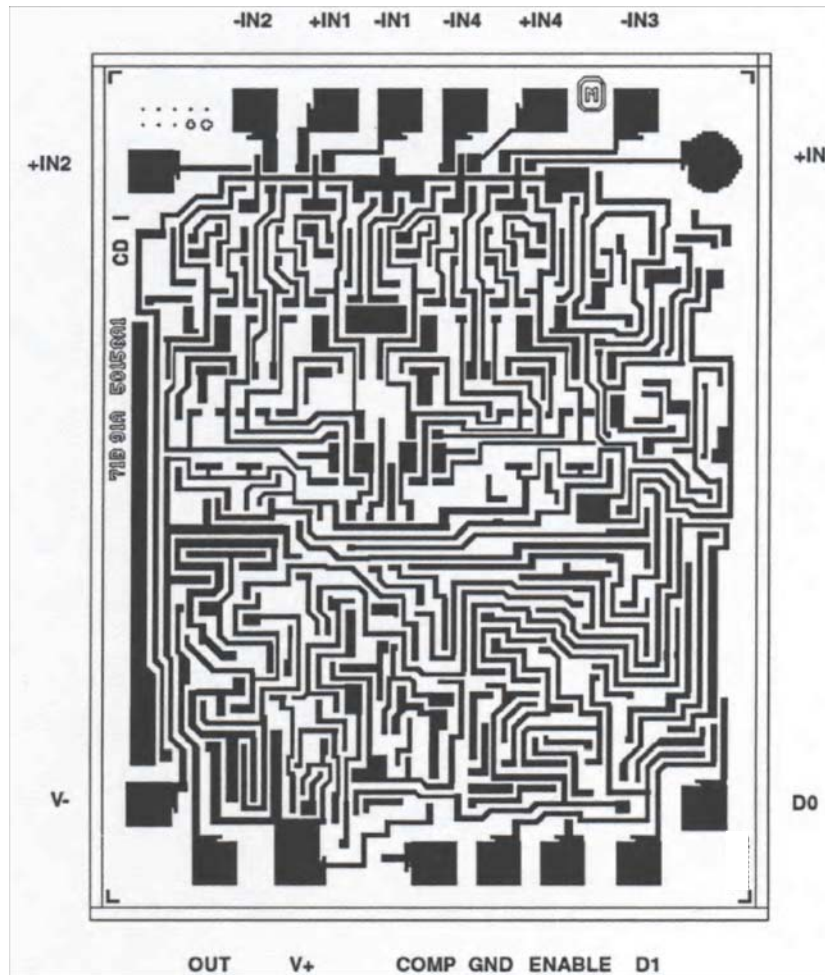
SUBSTRATE POTENTIAL (Powered Up): Unbiased

TRANSISTOR COUNT: 251

PROCESS: Bipolar Dielectric Isolation

Metallization Mask Layout

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HA-2400/883

The information contained in this section has been developed through characterization and is for use as application and design aid only. These characteristics are not 100% tested and no product guarantee is implied.

Typical Performance Characteristics

Devices Characterized at: $V_S = \pm 15V$, $V_{IL} = +0.5V$, $V_{IH} = +2.4V$. Values apply to each of the four channels, when addressed

PARAMETER	TEST CONDITIONS	TEMP. (°C)	TYP	UNITS
Offset Voltage	$V_{CM} = 0V$	+25	4	mV
Bias Current	$V_{CM} = 0V$	+25	50	nA
Offset Current	$V_{CM} = 0V$	+25	5	nA
Input Resistance		+25	30	MΩ
Large Signal Voltage Gain	$R_L = 2k\Omega$, $V_O = 20V_{P-P}$	+25	150	kV/V
Common Mode Rejection Ratio	$V_{CM} = \pm 5V_{DC}$	Full	100	dB
Gain Bandwidth Product	$R_L = 2k\Omega$, $C_L = 50pF$, $C_{COMP} = 0pF$, $A_V = +10V$	+25	40	MHz
Unity Gain Bandwidth	$R_L = 2k\Omega$, $C_L = 50pF$, $C_{COMP} = 15pF$, $A_V = +1V$	+25	8	MHz
Output Voltage Swing	$R_L = 2k\Omega$	Full	± 12	V
Output Current	$V_{OUT} = \pm 10V$	+25	20	mA
FPBW ₁	$V_P = 10V$ (Note 8)	+25	475	kHz
FPBW ₂	$V_P = 10V$ (Note 8)	+25	125	kHz
Rise Time	$R_L = 2k\Omega$, $C_L = 50pF$, $C_{COMP} = 15pF$, $A_V = +1V$	+25	20	ns
Overshoot	$R_L = 2k\Omega$, $C_L = 50pF$, $C_{COMP} = 15pF$, $A_V = +1V$	+25	25	%
Slew Rate ₁	$A_V = +1V/V$	+25	8	V/μs
Slew Rate ₂	$A_V = +10V/V$	+25	30	V/μs
Settling Time ₁	$V_O = 10V_{P-P}$ to 0.1%	+25	1.5	μs
Digital Logic Current	$V_{IN} = +5.0V$	Full	5	nA
	$V_{IN} = 0V$	Full	1	mA
Output Delay	To 10% of Final Value	+25	100	ns
Crosstalk	Unselected Input to Output, $V_{IN} = \pm 10V_{DC}$	+25	-110	dB
Supply Current	Not Loaded	+25	4.8	mA
PSRR	$\Delta V_S = \pm 10V$	Full	90	dB

NOTE:

8. $FPBW = \text{Slew Rate} / (2\pi V_{PEAK})$.

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Typical Performance Curves $V_{\pm} = \pm 15V, T_A = +25^{\circ}C$, unless otherwise specified.

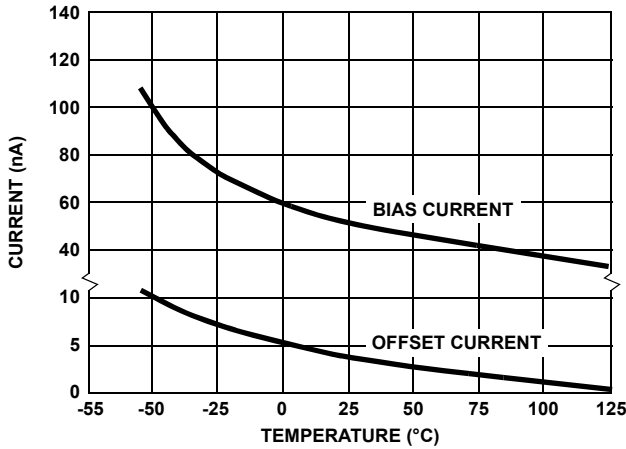


FIGURE 1. INPUT BIAS CURRENT AND OFFSET CURRENT AS A FUNCTION OF TEMPERATURE

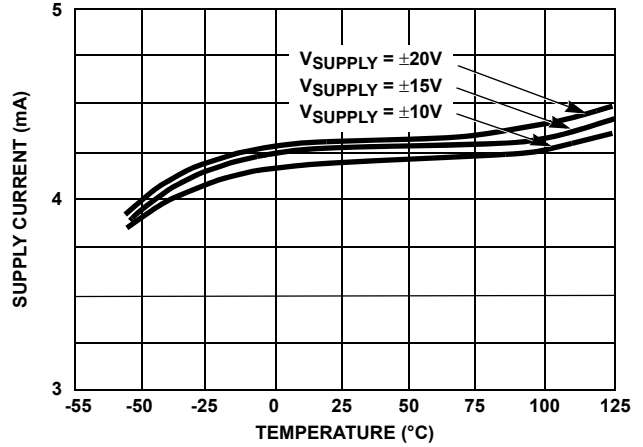


FIGURE 2. POWER SUPPLY CURRENT DRAIN AS A FUNCTION OF TEMPERATURE

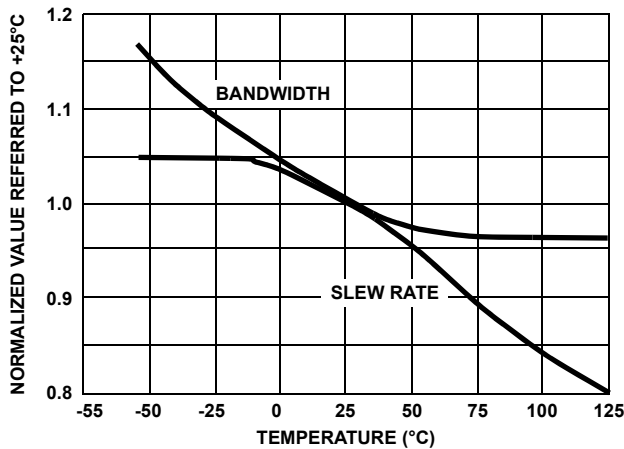


FIGURE 3. NORMALIZED AC PARAMETERS vs TEMPERATURE

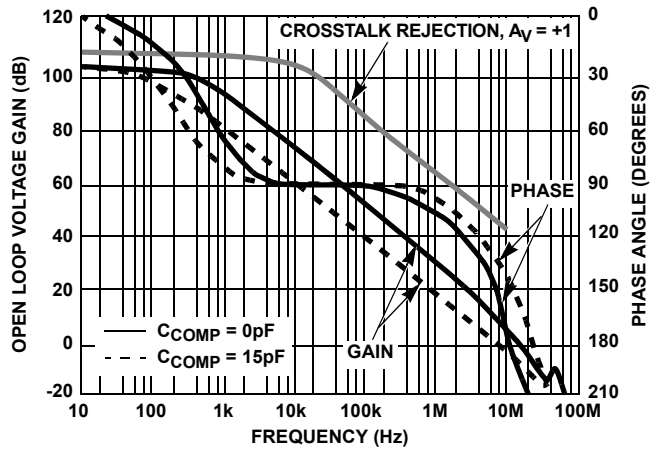


FIGURE 4. OPEN LOOP FREQUENCY AND PHASE RESPONSE

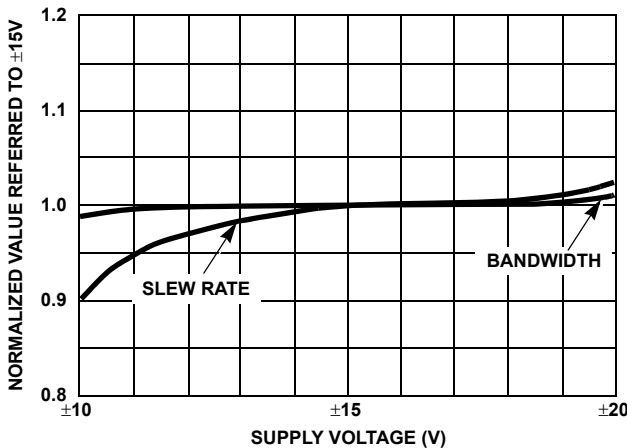


FIGURE 5. NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE

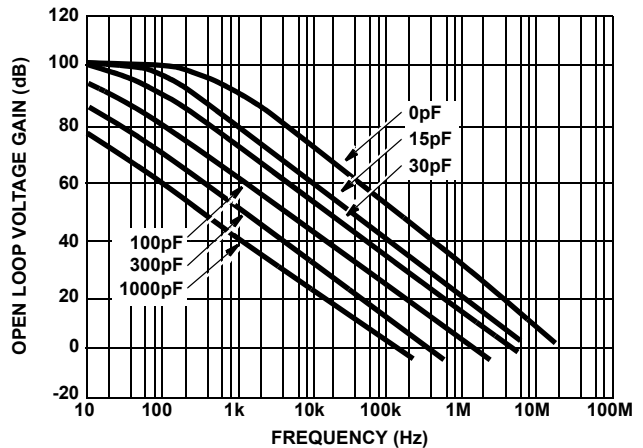


FIGURE 6. FREQUENCY RESPONSE vs C_{COMP}

The information contained in this section has been developed through characterization and is for use as application and design information only. No guarantee is implied.

Typical Performance Curves $V_{\pm} = \pm 15V$, $T_A = +25^{\circ}C$, unless otherwise specified. (Continued)

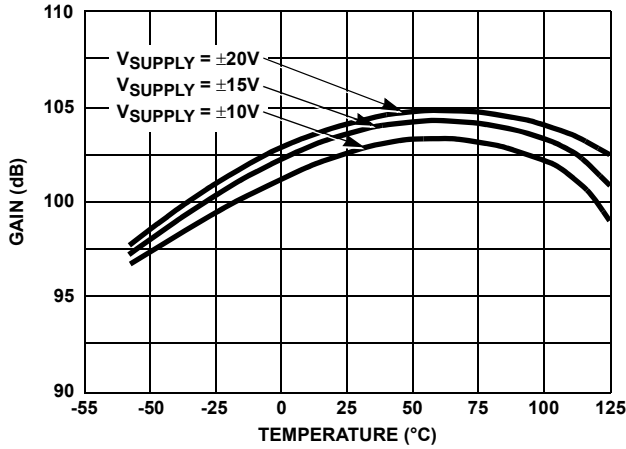


FIGURE 7. OPEN LOOP VOLTAGE GAIN vs TEMPERATURE

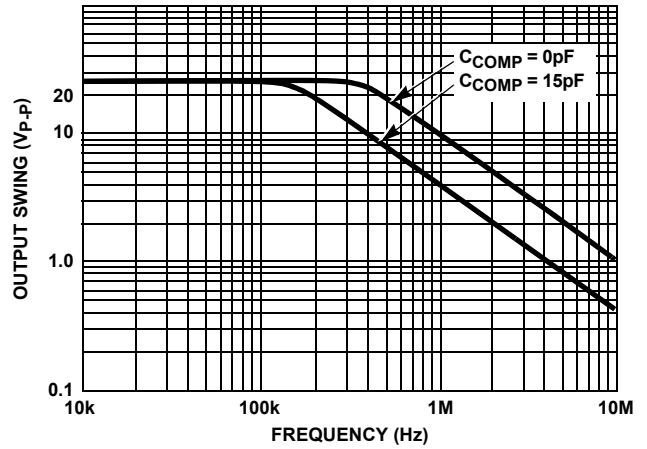


FIGURE 8. OUTPUT VOLTAGE SWING

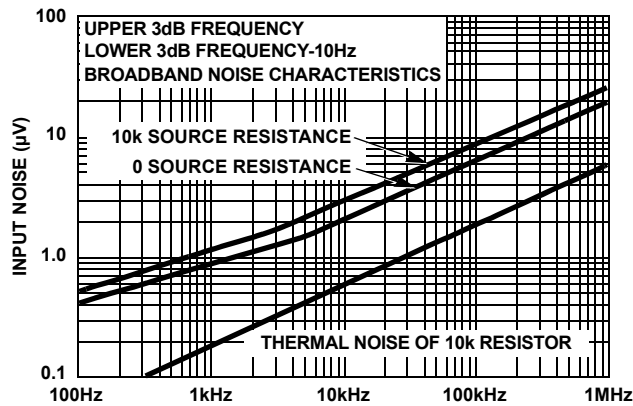


FIGURE 9. EQUIVALENT INPUT NOISE vs BANDWIDTH

Typical Applications (See Application Note [AN514](#))

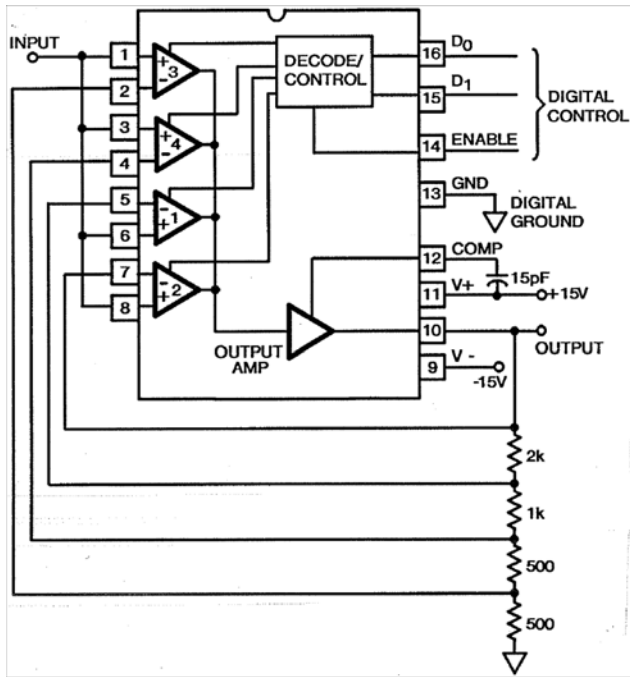
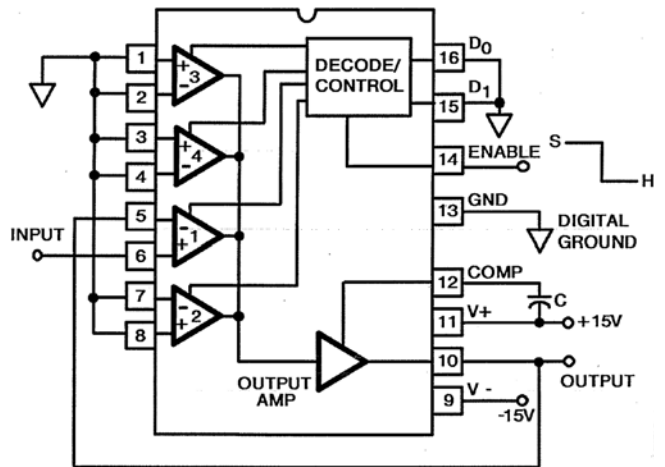


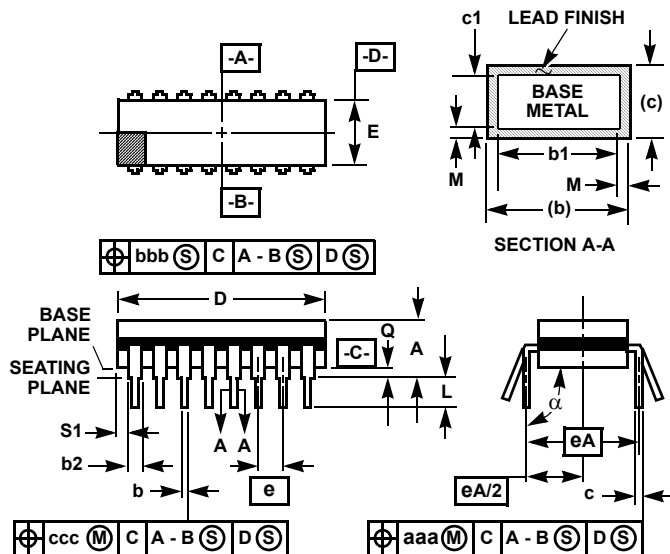
FIGURE 10. AMPLIFIER, NON-INVERTING PROGRAMMABLE GAIN



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

FIGURE 11. SAMPLE AND HOLD

Ceramic Dual-In-Line Frit Seal Packages (CERDIP)



NOTES:

1. Index area: A notch or a pin one identification mark shall be located adjacent to pin one and shall be located within the shaded area shown. The manufacturer's identification shall not be used as a pin one identification mark.
2. The maximum limits of lead dimensions b and c or M shall be measured at the centroid of the finished lead surfaces, when solder dip or tin plate lead finish is applied.
3. Dimensions b1 and c1 apply to lead base metal only. Dimension M applies to lead plating and finish thickness.
4. Corner leads (1, N, N/2, and N/2+1) may be configured with a partial lead paddle. For this configuration dimension b3 replaces dimension b2.
5. This dimension allows for off-center lid, meniscus, and glass overrun.
6. Dimension Q shall be measured from the seating plane to the base plane.
7. Measure dimension S1 at all four corners.
8. N is the maximum number of terminal positions.
9. Dimensioning and tolerancing per ANSI Y14.5M - 1982.
10. Controlling dimension: INCH.

**F16.3 MIL-STD-1835 GDIP1-T16 (D-2, CONFIGURATION A)
16 LEAD CERAMIC DUAL-IN-LINE FRIT SEAL PACKAGE**

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.200	-	5.08	-
b	0.014	0.026	0.36	0.66	2
b1	0.014	0.023	0.36	0.58	3
b2	0.045	0.065	1.14	1.65	-
b3	0.023	0.045	0.58	1.14	4
c	0.008	0.018	0.20	0.46	2
c1	0.008	0.015	0.20	0.38	3
D	-	0.840	-	21.34	5
E	0.220	0.310	5.59	7.87	5
e	0.100 BSC		2.54 BSC		-
eA	0.300 BSC		7.62 BSC		-
eA/2	0.150 BSC		3.81 BSC		-
L	0.125	0.200	3.18	5.08	-
Q	0.015	0.060	0.38	1.52	6
S1	0.005	-	0.13	-	7
α	90°	105°	90°	105°	-
aaa	-	0.015	-	0.38	-
bbb	-	0.030	-	0.76	-
ccc	-	0.010	-	0.25	-
M	-	0.0015	-	0.038	2, 3
N	16		16		8

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