National Semiconductor

May 1998

LM4250
Programmable Operational Amplifier

General Description

The LM4250 and LM4250C are extremely versatile programmable monolithic operational amplifiers. A single external master bias current setting resistor programs the input bias current, input offset current, quiescent power consumption, slew rate, input noise, and the gain-bandwidth product. The device is a truly general purpose operational amplifier.

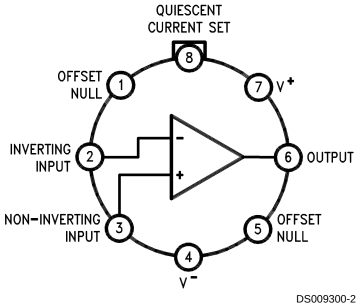
The LM4250C is identical to the LM4250 except that the LM4250C has its performance guaranteed over a 0˚C to +70˚C temperature range instead of the −55˚C to +125˚C temperature range of the LM4250.

Features

- ±1V to ±18V power supply operation
- 3 nA input offset current
- Standby power consumption as low as 500 nW
- No frequency compensation required
- Programmable electrical characteristics
- Offset voltage nulling capability
- Can be powered by two flashlight batteries
- Short circuit protection

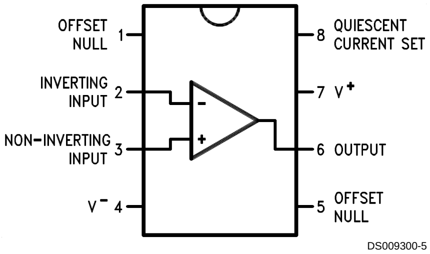
Connection Diagrams

Metal Can Package



Top View

Dual-In-Line Package



Top View

Ordering Information

Temperature Range		Package	NSC Package Number
Military $-55^\circ C \leq T_A \leq +125^\circ C$	Commercial $0^\circ C \leq T_A \leq +70^\circ C$		
	LM4250CN	8-Pin Molded DIP	N08E
	LM4250CM	8-Pin Surface Mount	M08A
LM4250J LM4250J-MIL		8-Pin Ceramic DIP	J08E
LM4250H LM4250H-MIL	LM4250CH	8-Pin Metal Can	H08C

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

(Note 3)

	LM4250	**LM4250C**
Supply Voltage	±18V	±18V
Operating Temp. Range	$-55^\circ C \le T_A \le +125^\circ C$	$0^\circ C \le T_A \le +70^\circ C$
Differential Input Voltage	±30V	±30V
Input Voltage (Note 2)	±15V	±15V
I_{SET} Current	150 nA	150 nA
Output Short Circuit Duration	Continuous	Continuous
T_{JMAX}		
H-Package	150˚C	100˚C
N-Package		100˚C
J-Package	150˚C	100˚C
M-Package		100˚C
Power Dissipation at T_A = 25˚C		
H-Package (Still Air)	500 mW	300 mW
(400 LF/Min Air Flow)	1200 mW	1200 mW
N-Package		500 mW
J-Package	1000 mW	600 mW
M-Package		350 mW
Thermal Resistance (Typical) θ_{JA}		
H-Package (Still Air)	165˚C/W	165˚C/W
(400 LF/Min Air Flow)	65˚C/W	65˚C/W
N-Package		130˚C/W
J-Package	108˚C/W	108˚C/W
M-Package		190˚C/W
(Typical) θ_{JC}		
H-Package	21˚C/W	21˚C/W
Storage Temperature Range	−65˚C to +150˚C	−65˚C to +150˚C

Soldering Information	
Dual-In-Line Package	
Soldering (10 seconds)	260˚C
Small Outline Package	
Vapor Phase (60 seconds)	215˚C
Infrared (15 seconds)	220˚C

See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface mount devices.

ESD tolerance (Note 4)	800V

Note 1: “Absolute Maximum Ratings” indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 3: Refer to RETS4250X for military specifications.

Note 4: Human body model, 1.5 kΩ in series with 100 pF.

Resistor Biasing

Set Current Setting Resistor to V^-

	I_{SET}				
V_S	0.1 µA	0.5 µA	1.0 µA	5 µA	10 µA
±1.5V	25.6 MΩ	5.04 MΩ	2.5 MΩ	492 kΩ	244 kΩ
±3.0V	55.6 MΩ	11.0 MΩ	5.5 MΩ	1.09 MΩ	544 kΩ
±6.0V	116 MΩ	23.0 MΩ	11.5 MΩ	2.29 MΩ	1.14 MΩ
±9.0V	176 MΩ	35.0 MΩ	17.5 MΩ	3.49 MΩ	1.74 MΩ
±12.0V	236 MΩ	47.0 MΩ	23.5 MΩ	4.69 MΩ	2.34 MΩ
±15.0V	296 MΩ	59.0 MΩ	29.5 MΩ	5.89 MΩ	2.94 MΩ

Electrical Characteristics

LM4250 ($-55^\circ C \le T_A \le +125^\circ C$ unless otherwise specified.) $T_A = T_J$

Parameter	Conditions	V_S = ±1.5V			
		I_{SET} = 1 µA		I_{SET} = 10 µA	
		Min	Max	Min	Max
V_{OS}	$R_S \le 100$ kΩ, $T_A = 25^\circ C$		3 mV		5 mV
I_{OS}	$T_A = 25^\circ C$		3 nA		10 nA
I_{bias}	$T_A = 25^\circ C$		7.5 nA		50 nA
Large Signal Voltage Gain	R_L = 100 kΩ, $T_A = 25^\circ C$	40k			
	V_O = ±0.6V, R_L = 10 kΩ			50k	
Supply Current	$T_A = 25^\circ C$		7.5 µA		80 µA
Power Consumption	$T_A = 25^\circ C$		23 µW		240 µW
V_{OS}	$R_S \le 100$ kΩ		4 mV		6 mV
I_{OS}	$T_A = +125^\circ C$		5 nA		10 nA
	$T_A = -55^\circ C$		3 nA		10 nA
I_{bias}			7.5 nA		50 nA
Input Voltage Range		±0.6V		±0.6V	
Large Signal Voltage Gain	V_O = ±0.5V, R_L = 100 kΩ	30k			
	R_L = 10 kΩ			30k	
Output Voltage Swing	R_L = 100 kΩ	±0.6V			
	R_L = 10 kΩ			±0.6V	
Common Mode Rejection Ratio	$R_S \le 10$ kΩ	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \le 10$ kΩ	76 dB		76 dB	
Supply Current			8 µA		90 µA

Parameter	Conditions	V_S = ±15V			
		I_{SET} = 1 µA		I_{SET} = 10 µA	
		Min	Max	Min	Max
V_{OS}	$R_S \le 100$ kΩ, $T_A = 25^\circ C$		3 mV		5 mV
I_{OS}	$T_A = 25^\circ C$		3 nA		10 nA
I_{bias}	$T_A = 25^\circ C$		7.5 nA		50 nA
Large Signal Voltage Gain	R_L = 100 kΩ, $T_A = 25^\circ C$	100k			
	V_O = ±10V, R_L = 10 kΩ			100k	
Supply Current	$T_A = 25^\circ C$		10 µA		90 µA
Power Consumption	$T_A = 25^\circ C$		300 µW		2.7 mW
V_{OS}	$R_S \le 100$ kΩ		4 mV		6 mV
I_{OS}	$T_A = +125^\circ C$		25 nA		25 nA
	$T_A = -55^\circ C$		3 nA		10 nA
I_{bias}			7.5 nA		50 nA
Input Voltage Range		±13.5V		±13.5V	

Electrical Characteristics (Continued)

Parameter	Conditions	V_S = ±15V			
		I_{SET} = 1 µA		I_{SET} = 10 µA	
		Min	Max	Min	Max
Large Signal Voltage Gain	V_O = ±10V, R_L = 100 kΩ	50k			
	R_L = 10 kΩ			50k	
Output Voltage Swing	R_L = 100 kΩ	±12V			
	R_L = 10 kΩ			±12V	
Common Mode Rejection Ratio	$R_S \le 10$ kΩ	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \le 10$ kΩ	76 dB		76 dB	
Supply Current			11 µA		100 µA
Power Consumption			330 µW		3 mW

Electrical Characteristics

LM4250C (0˚C ≤ T_A ≤ +70˚C unless otherwise specified.) T_A = T_J

Parameter	Conditions	V_S = ±1.5V			
		I_{SET} = 1 µA		I_{SET} = 10 µA	
		Min	Max	Min	Max
V_{OS}	$R_S \le 100$ kΩ, T_A = 25˚C		5 mV		6 mV
I_{OS}	T_A = 25˚C		6 nA		20 nA
I_{bias}	T_A = 25˚C		10 nA		75 nA
Large Signal Voltage Gain	R_L = 100 kΩ, T_A = 25˚C	25k			
	V_O = ±0.6V, R_L = 10 kΩ			25k	
Supply Current	T_A = 25˚C		8 µA		90 µA
Power Consumption	T_A = 25˚C		24 µW		270 µW
V_{OS}	$R_S \le 10$ kΩ		6.5 mV		7.5 mV
I_{OS}			8 nA		25 nA
I_{bias}			10 nA		80 nA
Input Voltage Range		±0.6V		±0.6V	
Large Signal Voltage Gain	V_O = ±0.5V, R_L = 100 kΩ	25k			
	R_L = 10 kΩ			25k	
Output Voltage Swing	R_L = 100 kΩ	±0.6V			
	R_L = 10 kΩ			±0.6V	
Common Mode Rejection Ratio	$R_S \le 10$ kΩ	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \le 10$ kΩ	74 dB		74 dB	
Supply Current			8 µA		90 µA
Power Consumption			24 µW		270 µW

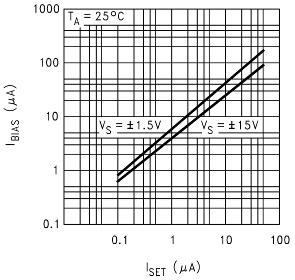
Parameter	Conditions	V_S = ±15V			
		I_{SET} = 1 µA		I_{SET} = 10 µA	
		Min	Max	Min	Max
V_{OS}	$R_S \le 100$ kΩ, T_A = 25˚C		5 mV		6 mV
I_{OS}	T_A = 25˚C		6 nA		20 nA
I_{bias}	T_A = 25˚C		10 nA		75 nA
Large Signal Voltage Gain	R_L = 100 kΩ, T_A = 25˚C	60k			
	V_O = ±10V, R_L = 10 kΩ			60k	
Supply Current	T_A = 25˚C		11 µA		100 µA
Power Consumption	T_A = 25˚C		330 µW		3 mW
V_{OS}	$R_S \le 100$ kΩ		6.5 mV		7.5 mV
I_{OS}			8 nA		25 nA
I_{bias}			10 nA		80 nA

Electrical Characteristics (Continued)

Parameter	Conditions	$V_S = \pm 15V$			
		$I_{SET} = 1\ \mu A$		$I_{SET} = 10\ \mu A$	
		Min	Max	Min	Max
Input Voltage Range		±13.5V		±13.5V	
Large Signal Voltage	$V_O = \pm 10V$, $R_L = 100\ k\Omega$	50k			
Gain	$R_L = 10\ k\Omega$			50k	
Output Voltage Swing	$R_L = 100\ k\Omega$	±12V			
	$R_L = 10\ k\Omega$			±12V	
Common Mode Rejection Ratio	$R_S \leq 10\ k\Omega$	70 dB		70 dB	
Supply Voltage Rejection Ratio	$R_S \leq 10\ k\Omega$	74 dB		74 dB	
Supply Current			11 µA		100 µA
Power Consumption			330 µW		3 mW

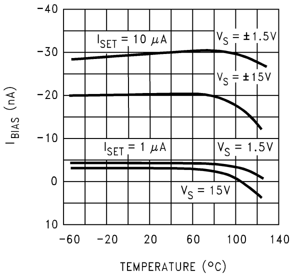
Typical Performance Characteristics

Input Bias Current vs I_{SET}



DS009300-15

Input Bias Current vs Temperature



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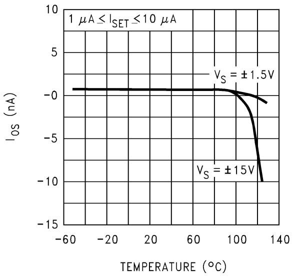
Input Offset Current vs Temperature



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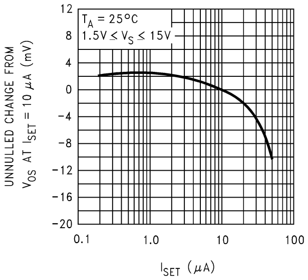
Unnulled Input Offset Voltage Change vs I_{SET}



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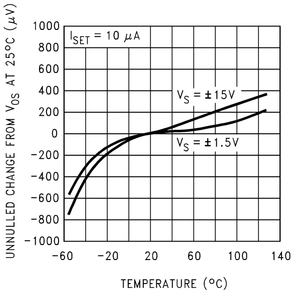
Unnulled Input Offset Voltage Change vs Temperature



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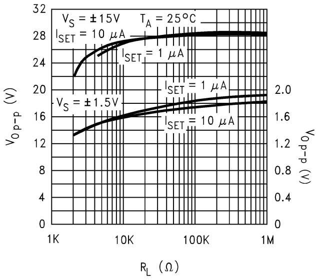
Peak to Peak Output Voltage Swing vs Load Resistance



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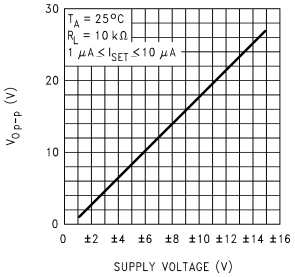
Typical Performance Characteristics (Continued)

Peak to Peak Output Voltage Swing vs Supply Voltage



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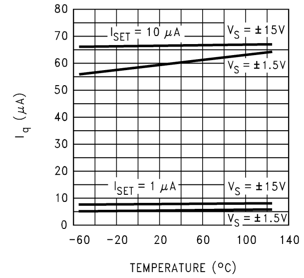
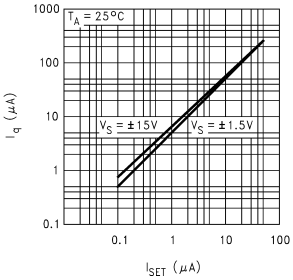
Quiescent Current (I_q) vs Temperature



DS009300-22

Quiescent Current (I_q) vs I_{SET}



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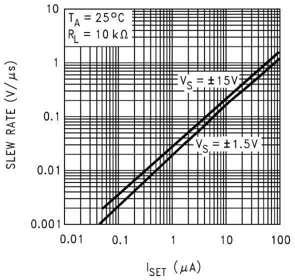
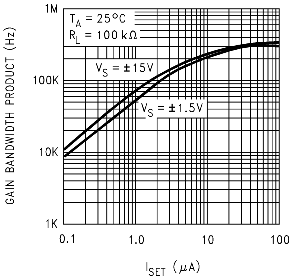
Slew Rate vs I_{SET}



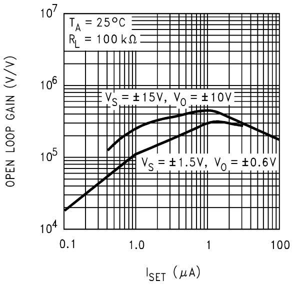
DS009300-24

Gain Bandwidth Product vs I_{SET}



DS009300-25

Open Loop Voltage Gain vs I_{SET}



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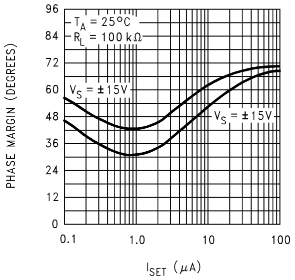
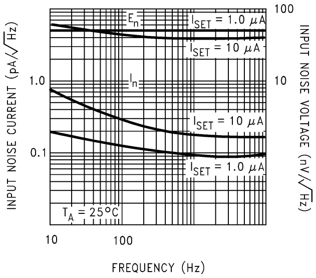
Phase Margin vs I_{SET}



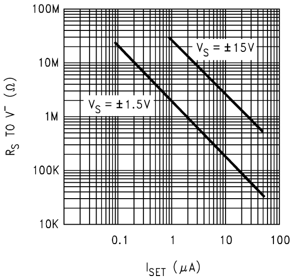
DS009300-27

Input Noise Current (I_n) and Voltage (E_n) vs Frequency



DS009300-28

R_{SET} vs I_{SET}



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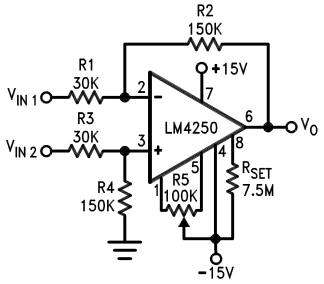
Typical Applications

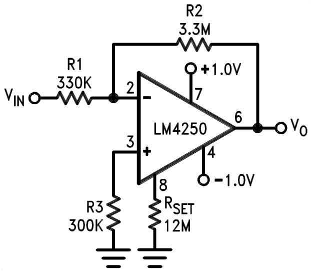
X5 Difference Amplifier



DS009300-3

Quiescent P_D = 0.6 mW

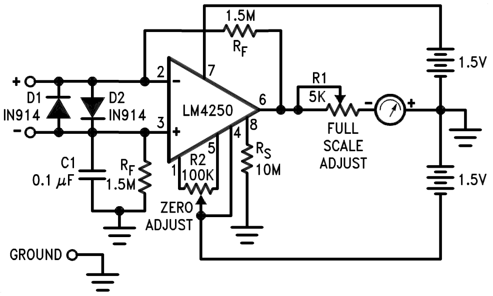
500 Nano-Watt X10 Amplifier



DS009300-4

Quiescent P_D = 500 nW

Floating Input Meter Amplifier
100 nA full Scale



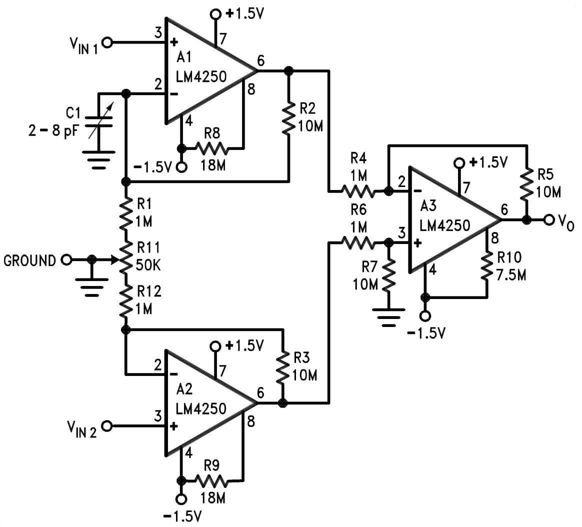
DS009300-8

Quiescent P_D = 1.8 µW

*Meter movement (0–100 µA, 2 kΩ) marked for 0–100 nA full scale.

Typical Applications (Continued)

X100 Instrumentation Amplifier 10 µW



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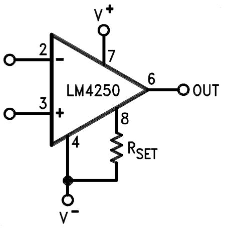
Note 5: Quiescent P_D = 10 µW.

Note 6: R2, R3, R4, R5, R6 and R7 are 1% resistors.

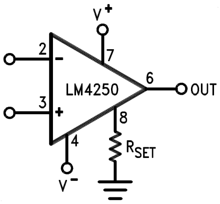
Note 7: R11 and C1 are for DC and AC common mode rejection adjustments.

R_{SET} Connected to V^-



DS009300-10

R_{SET} Connected to Ground



DS009300-11

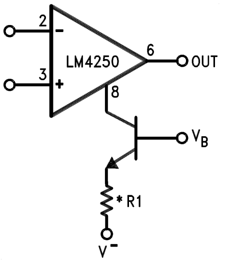
I_{SET} Equations:

$$I_{SET} \approx \frac{V^+ + |V^-| - 0.5}{R_{SET}}$$ where R_{SET} is connected to V^-.

$$I_{SET} \approx \frac{V^+ - 0.5}{R_{SET}}$$ where R_{SET} is connected to ground.

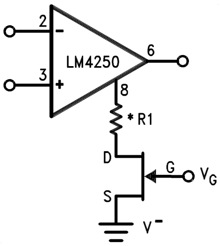
DS009300-30

Transistor Current Sourcing Biasing



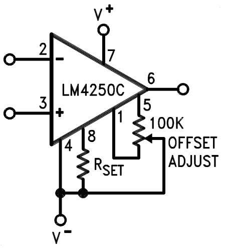
DS009300-12

FET Current Sourcing Biasing



DS009300-13

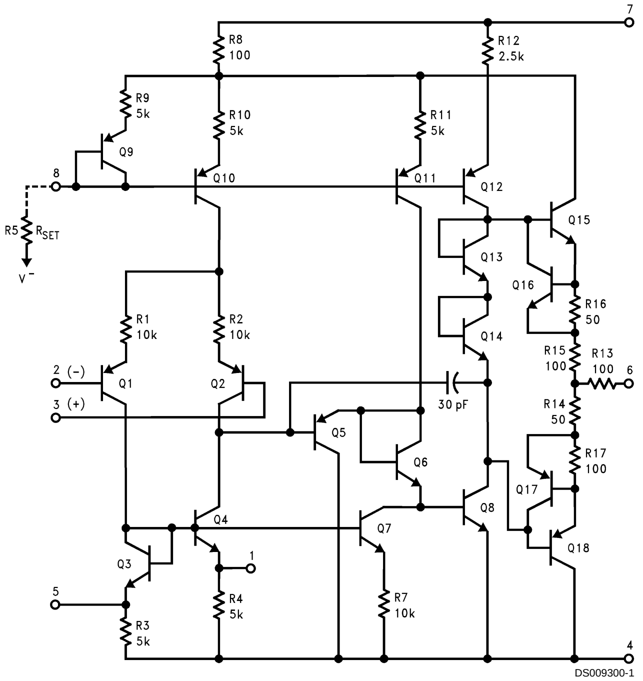
Offset Null Circuit



DS009300-14

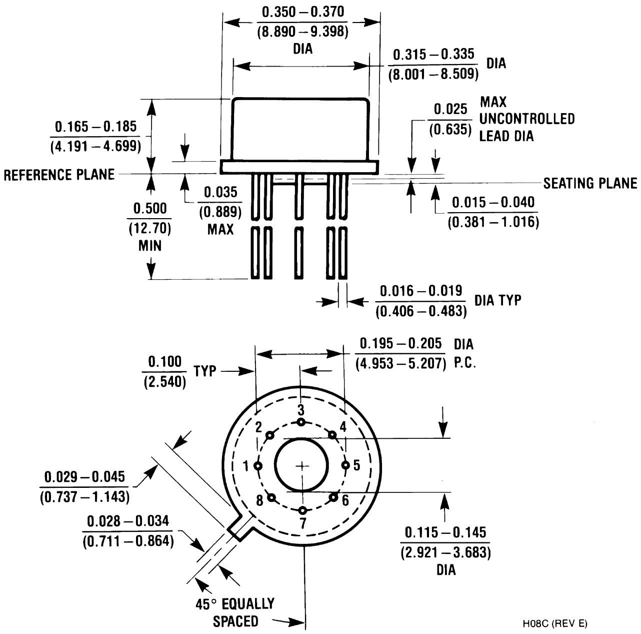
*R1 limits I_{SET} maximum

Schematic Diagram

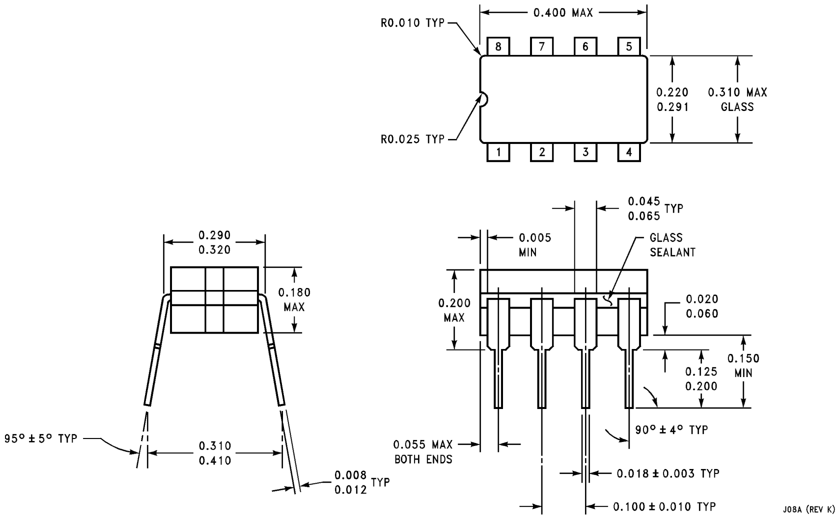


DS009300-1

Physical Dimensions inches (millimeters) unless otherwise noted

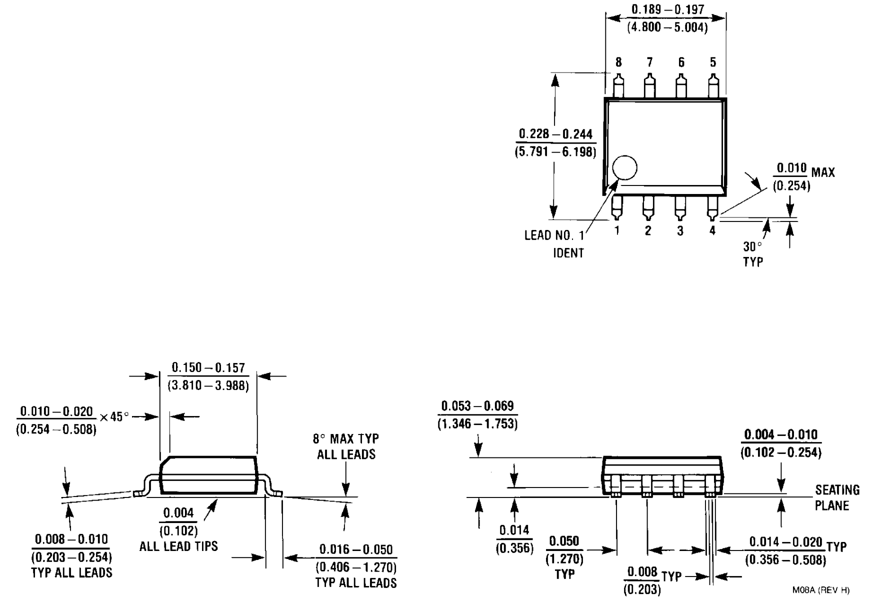


Metal Can Package (H)
Order Number LM4250H, LM4250CH or LM4250H-MIL
NS Package Number H08C

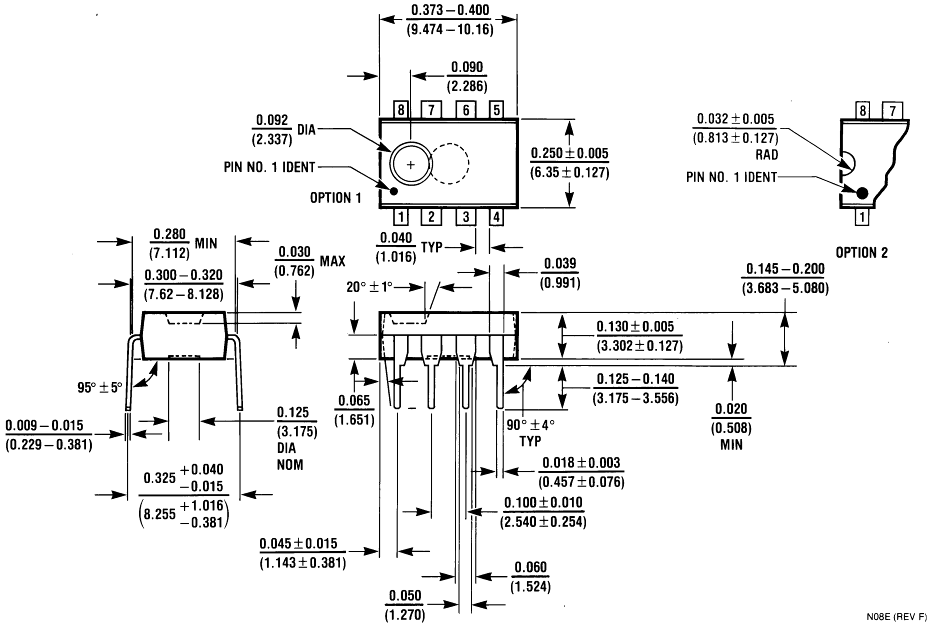


Ceramic Dual-In-Line Package (J)
Order Number LM4250J, or LM4250J-MIL
NS Package Number J08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Small Outline Package (M)
Order Number LM4250M
NS Package Number M08A



Molded Dual-In-Line Package (N)
Order Number LM4250CN
NS Package Number N08E

Notes

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