

# LM4250

*LM4250 Programmable Operational Amplifier*



Literature Number: SNOSC17A

# 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.

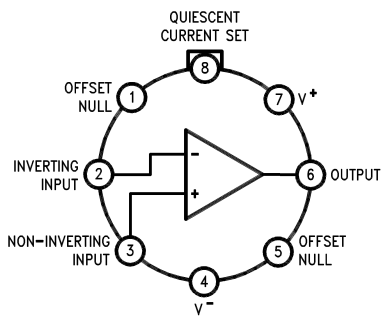
The LM4250C is identical to the LM4250 except that the LM4250C has its performance guaranteed over a 0°C to +70°C temperature range instead of the -55°C to +125°C temperature range of the LM4250.

## 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

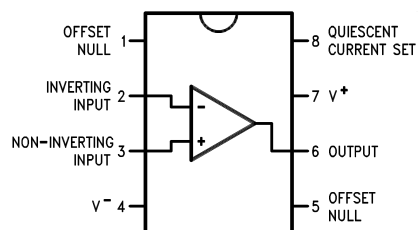
**Metal Can Package**



**Top View**

DS009300-2

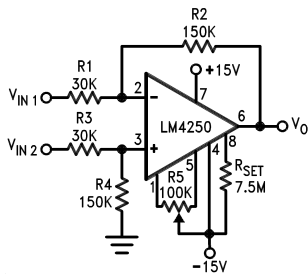
**Dual-In-Line Package**



**Top View**

DS009300-5

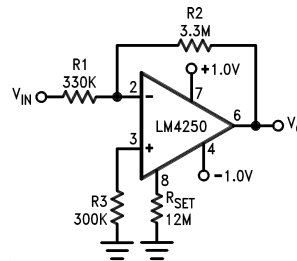
**X5 Difference Amplifier**



DS009300-3

Quiescent  $P_D = 0.6 \text{ mW}$

**500 Nano-Watt X10 Amplifier**



DS009300-4

Quiescent  $P_D = 500 \text{ nW}$

## 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°C ≤ T <sub>A</sub> ≤ +125°C	0°C ≤ T <sub>A</sub> ≤ +70°C
Differential Input Voltage	±30V	±30V
Input Voltage (Note 2)	±15V	±15V
I <sub>SET</sub> Current	150 nA	150 nA
Output Short Circuit Duration	Continuous	Continuous
T <sub>JMAX</sub>		
H-Package	150°C	100°C
N-Package		100°C
J-Package	150°C	100°C
M-Package		100°C
Power Dissipation at T <sub>A</sub> = 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 <sub>JA</sub>		
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 <sub>JC</sub>		
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 $V^-$

$V_S$	$I_{SET}$				
	0.1 $\mu A$	0.5 $\mu A$	1.0 $\mu A$	5 $\mu A$	10 $\mu A$
$\pm 1.5V$	25.6 M $\Omega$	5.04 M $\Omega$	2.5 M $\Omega$	492 k $\Omega$	244 k $\Omega$
$\pm 3.0V$	55.6 M $\Omega$	11.0 M $\Omega$	5.5 M $\Omega$	1.09 M $\Omega$	544 k $\Omega$
$\pm 6.0V$	116 M $\Omega$	23.0 M $\Omega$	11.5 M $\Omega$	2.29 M $\Omega$	1.14 M $\Omega$
$\pm 9.0V$	176 M $\Omega$	35.0 M $\Omega$	17.5 M $\Omega$	3.49 M $\Omega$	1.74 M $\Omega$
$\pm 12.0V$	236 M $\Omega$	47.0 M $\Omega$	23.5 M $\Omega$	4.69 M $\Omega$	2.34 M $\Omega$
$\pm 15.0V$	296 M $\Omega$	59.0 M $\Omega$	29.5 M $\Omega$	5.89 M $\Omega$	2.94 M $\Omega$

## Electrical Characteristics

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

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

Parameter	Conditions	$V_S = \pm 15V$			
		$I_{SET} = 1 \mu A$		$I_{SET} = 10 \mu A$	
		Min	Max	Min	Max
$V_{OS}$	$R_S \leq 100 k\Omega$ , $T_A = 25^\circ C$		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	$R_L = 100 k\Omega$ , $T_A = 25^\circ C$ $V_O = \pm 10V$ , $R_L = 10 k\Omega$	100k		100k	
Supply Current	$T_A = 25^\circ C$		10 $\mu A$		90 $\mu A$
Power Consumption	$T_A = 25^\circ C$		300 $\mu W$		2.7 mW
$V_{OS}$	$R_S \leq 100 k\Omega$		4 mV		6 mV
$I_{OS}$	$T_A = +125^\circ C$ $T_A = -55^\circ C$		25 nA 3 nA		25 nA 10 nA
$I_{bias}$			7.5 nA		50 nA
Input Voltage Range		$\pm 13.5V$		$\pm 13.5V$	

## Electrical Characteristics (Continued)

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

## Electrical Characteristics

LM4250C ( $0^\circ C \leq T_A \leq +70^\circ C$  unless otherwise specified.)  $T_A = T_J$

Parameter	Conditions	$V_S = \pm 1.5V$			
		$I_{SET} = 1 \mu A$		$I_{SET} = 10 \mu A$	
		Min	Max	Min	Max
$V_{OS}$	$R_S \leq 100 k\Omega, T_A = 25^\circ C$		5 mV		6 mV
$I_{OS}$	$T_A = 25^\circ C$		6 nA		20 nA
$I_{bias}$	$T_A = 25^\circ C$		10 nA		75 nA
Large Signal Voltage Gain	$R_L = 100 k\Omega, T_A = 25^\circ C$ $V_O = \pm 0.6V, R_L = 10 k\Omega$	25k		25k	
Supply Current	$T_A = 25^\circ C$		8 $\mu A$		90 $\mu A$
Power Consumption	$T_A = 25^\circ C$		24 $\mu W$		270 $\mu W$
$V_{OS}$	$R_S \leq 10 k\Omega$		6.5 mV		7.5 mV
$I_{OS}$			8 nA		25 nA
$I_{bias}$			10 nA		80 nA
Input Voltage Range		$\pm 0.6V$		$\pm 0.6V$	
Large Signal Voltage Gain	$V_O = \pm 0.5V, R_L = 100 k\Omega$ $R_L = 10 k\Omega$	25k		25k	
Output Voltage Swing	$R_L = 100 k\Omega$ $R_L = 10 k\Omega$	$\pm 0.6V$		$\pm 0.6V$	
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			8 $\mu A$		90 $\mu A$
Power Consumption			24 $\mu W$		270 $\mu W$

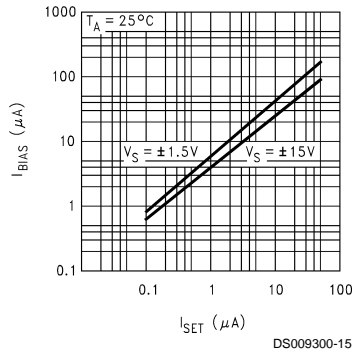
Parameter	Conditions	$V_S = \pm 15V$			
		$I_{SET} = 1 \mu A$		$I_{SET} = 10 \mu A$	
		Min	Max	Min	Max
$V_{OS}$	$R_S \leq 100 k\Omega, T_A = 25^\circ C$		5 mV		6 mV
$I_{OS}$	$T_A = 25^\circ C$		6 nA		20 nA
$I_{bias}$	$T_A = 25^\circ C$		10 nA		75 nA
Large Signal Voltage Gain	$R_L = 100 k\Omega, T_A = 25^\circ C$ $V_O = \pm 10V, R_L = 10 k\Omega$	60k		60k	
Supply Current	$T_A = 25^\circ C$		11 $\mu A$		100 $\mu A$
Power Consumption	$T_A = 25^\circ C$		330 $\mu W$		3 mW
$V_{OS}$	$R_S \leq 100 k\Omega$		6.5 mV		7.5 mV
$I_{OS}$			8 nA		25 nA
$I_{bias}$			10 nA		80 nA

# Electrical Characteristics (Continued)

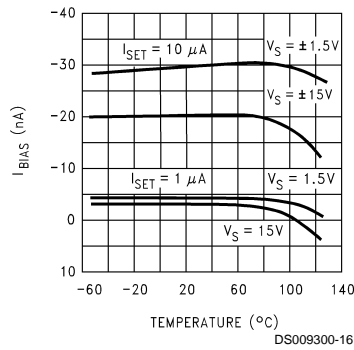
Parameter	Conditions	$V_S = \pm 15V$			
		$I_{SET} = 1 \mu A$		$I_{SET} = 10 \mu A$	
		Min	Max	Min	Max
Input Voltage Range		$\pm 13.5V$		$\pm 13.5V$	
Large Signal Voltage Gain	$V_O = \pm 10V, R_L = 100 k\Omega$ $R_L = 10 k\Omega$	50k		50k	
Output Voltage Swing	$R_L = 100 k\Omega$ $R_L = 10 k\Omega$	$\pm 12V$		$\pm 12V$	
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 $\mu A$		100 $\mu A$	
Power Consumption		330 $\mu W$		3 mW	

## Typical Performance Characteristics

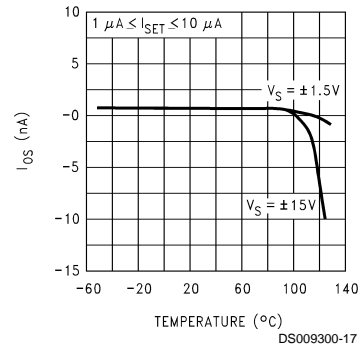
Input Bias Current vs  $I_{SET}$



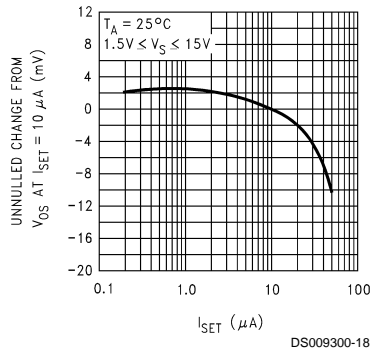
Input Bias Current vs Temperature



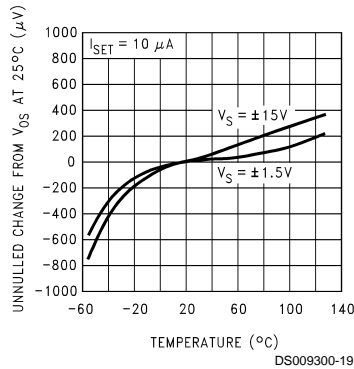
Input Offset Current vs Temperature



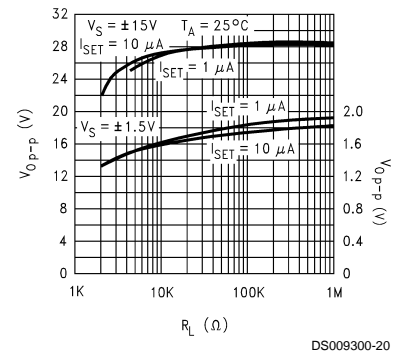
Unnull'd Input Offset Voltage Change vs  $I_{SET}$



Unnull'd Input Offset Voltage Change vs Temperature

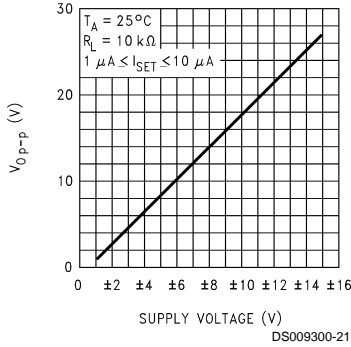


Peak to Peak Output Voltage Swing vs Load Resistance

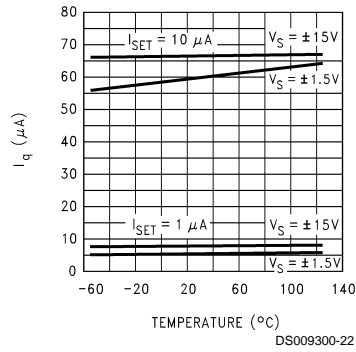


# Typical Performance Characteristics (Continued)

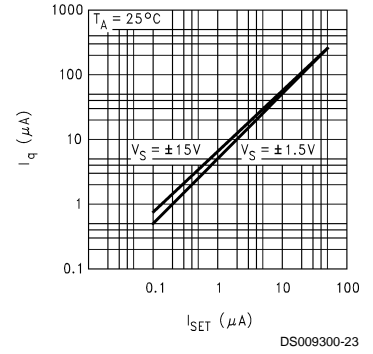
**Peak to Peak Output Voltage Swing vs Supply Voltage**



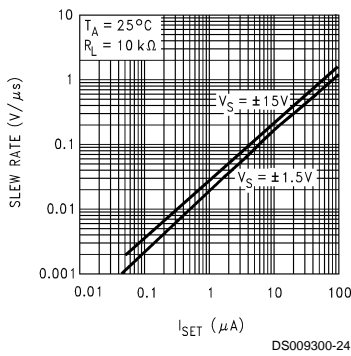
**Quiescent Current ( $I_q$ ) vs Temperature**



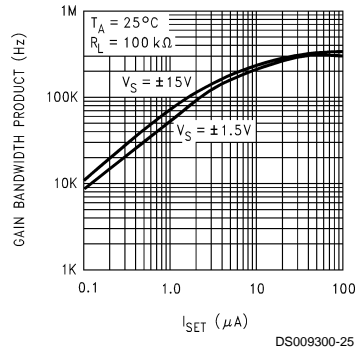
**Quiescent Current ( $I_q$ ) vs  $I_{SET}$**



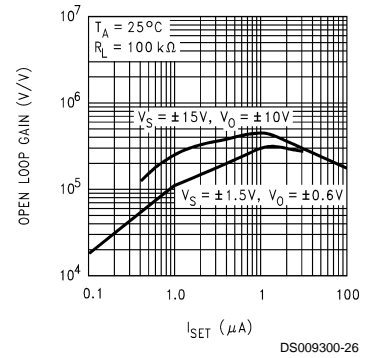
**Slew Rate vs  $I_{SET}$**



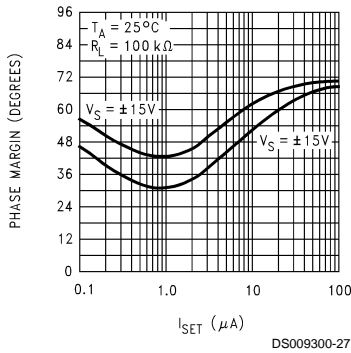
**Gain Bandwidth Product vs  $I_{SET}$**



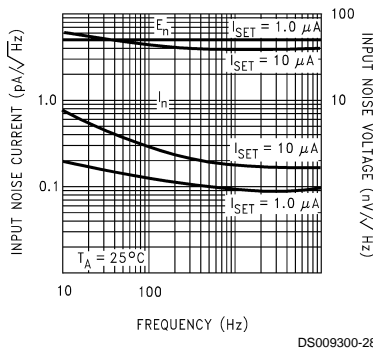
**Open Loop Voltage Gain vs  $I_{SET}$**



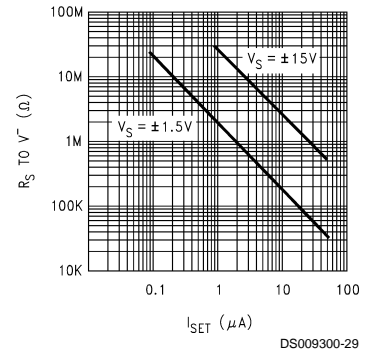
**Phase Margin vs  $I_{SET}$**



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

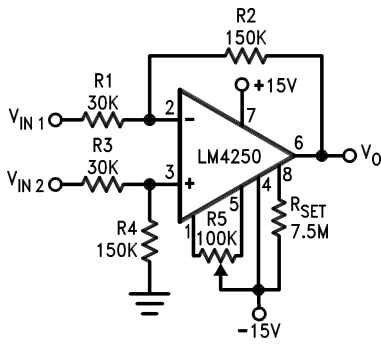


**$R_S$  TO  $V^-$  vs  $I_{SET}$**



# Typical Applications

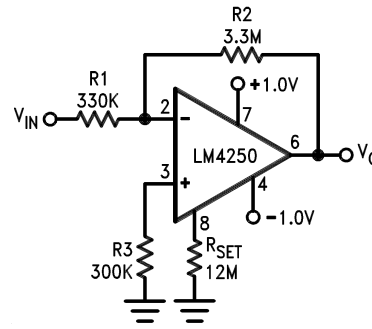
**X5 Difference Amplifier**



DS009300-3

Quiescent  $P_D = 0.6 \text{ mW}$

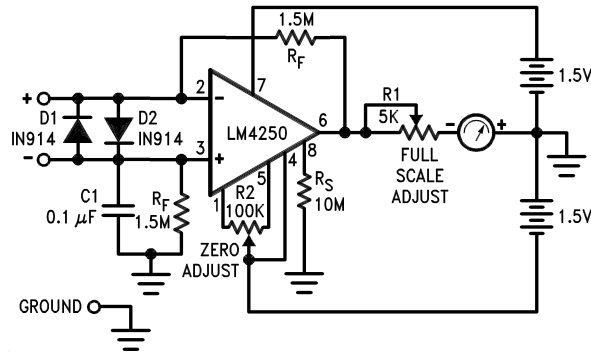
**500 Nano-Watt X10 Amplifier**



DS009300-4

Quiescent  $P_D = 500 \text{ nW}$

**Floating Input Meter Amplifier  
100 nA full Scale**



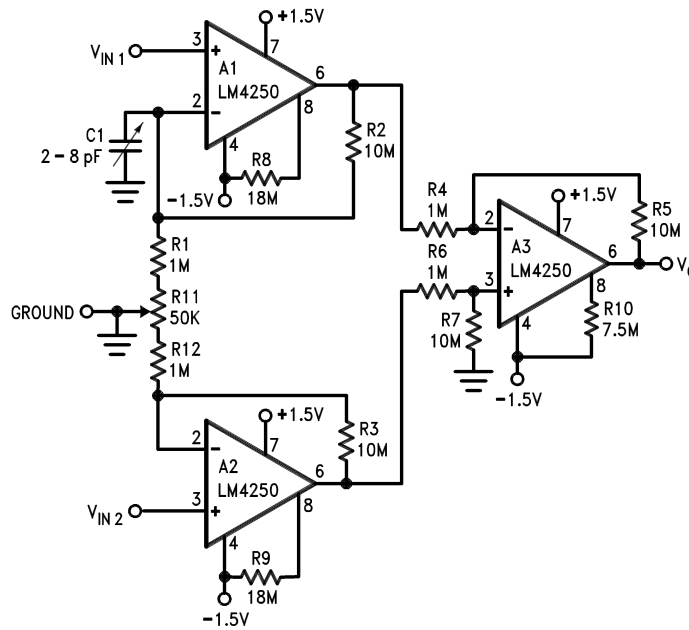
DS009300-8

Quiescent  $P_D = 1.8 \text{ μW}$

\*Meter movement (0–100  $\mu\text{A}$ , 2 k $\Omega$ ) marked for 0–100 nA full scale.

# Typical Applications (Continued)

## X100 Instrumentation Amplifier 10 μW



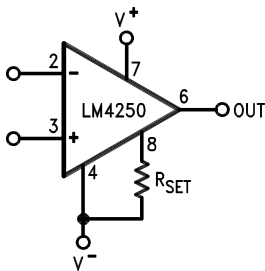
DS009300-9

**Note 5:** Quiescent  $P_D = 10 \mu W$ .

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

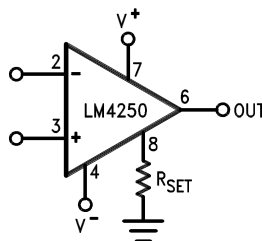
**Note 7:** R11 and C1 are for DC and AC common mode rejection adjustments.

### R<sub>SET</sub> Connected to V<sup>-</sup>



DS009300-10

### R<sub>SET</sub> Connected to Ground



DS009300-11

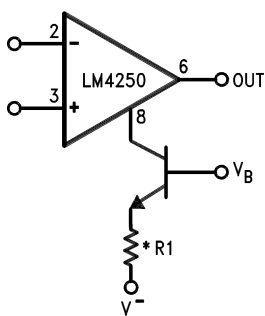
I<sub>SET</sub> Equations:

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

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

DS009300-30

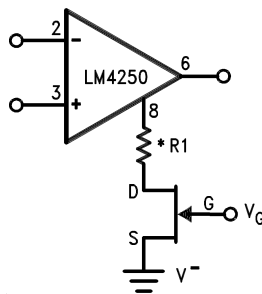
### Transistor Current Sourcing Biasing



DS009300-12

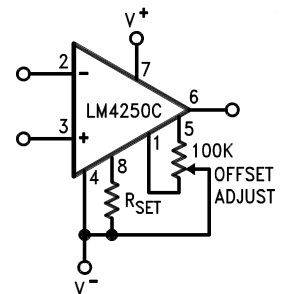
\*R1 limits I<sub>SET</sub> maximum

### FET Current Sourcing Biasing



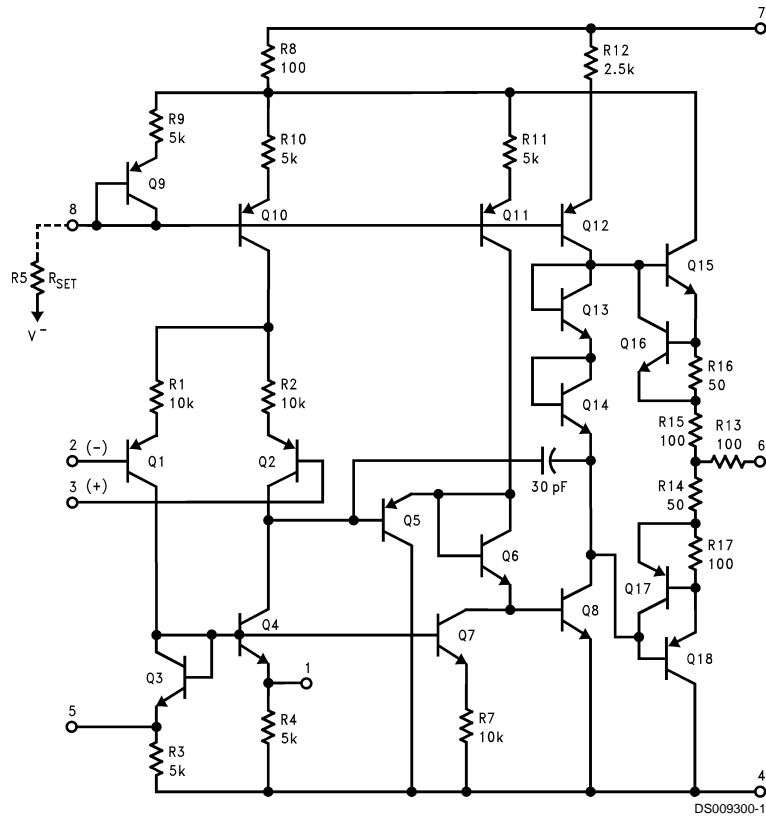
DS009300-13

### Offset Null Circuit



DS009300-14

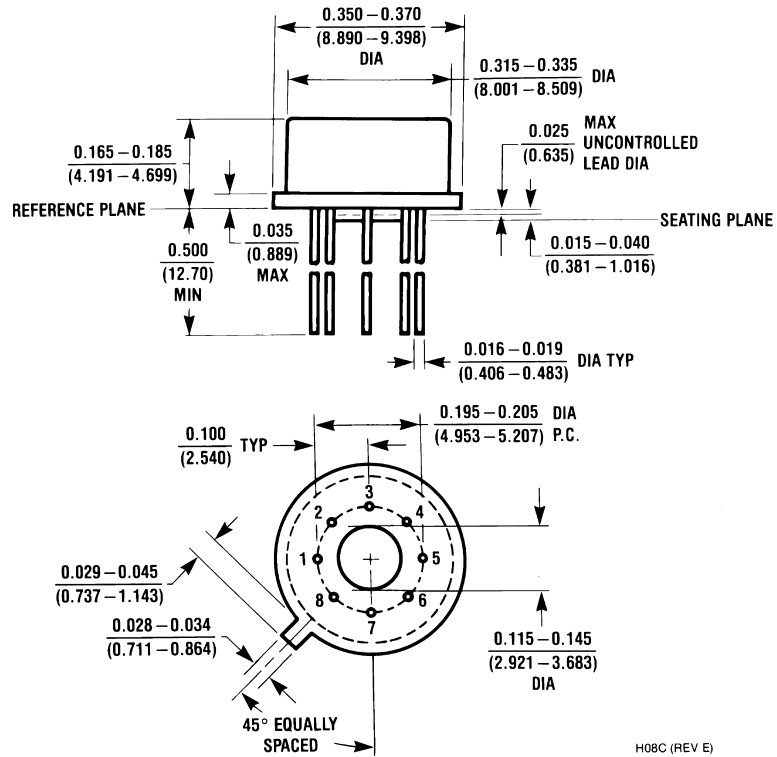
## Schematic Diagram



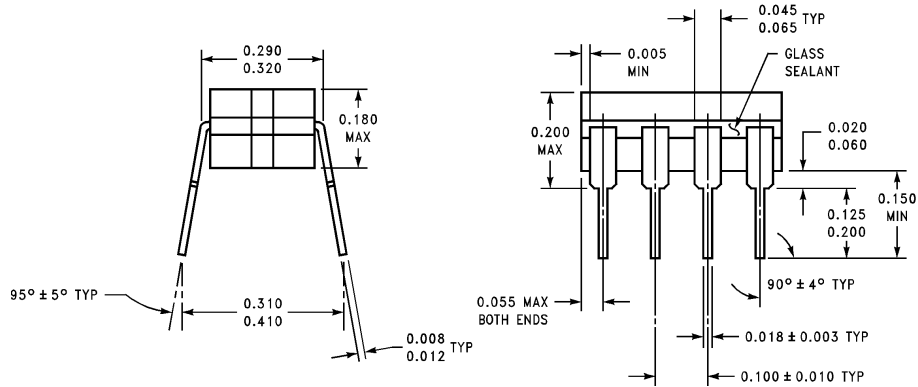
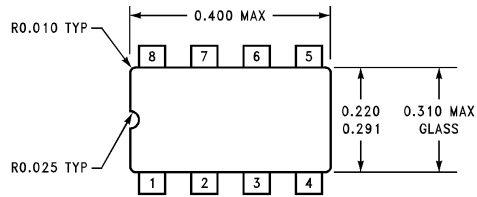
## Ordering Information

Temperature Range		Package	NSC Package Number
Military $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$	Commercial $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$		
	LM4250CN	8-Pin Molded DIP	N08E
	LM4250CM LM4250CMX	8-Pin Surface Mount	M08A
LM4250J-MIL		8-Pin Ceramic DIP	J08E
	LM4250CH	8-Pin Metal Can	H08C

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



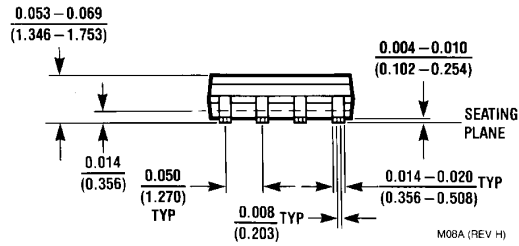
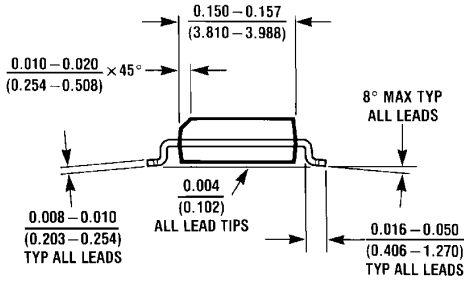
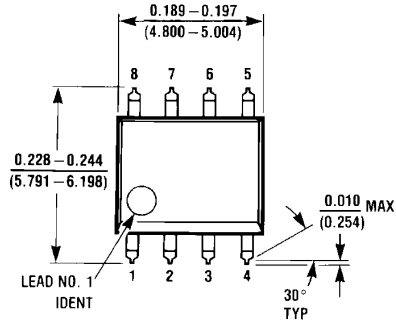
**Metal Can Package (H)**  
**Order Number LM4250CH**  
**NS Package Number H08C**



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

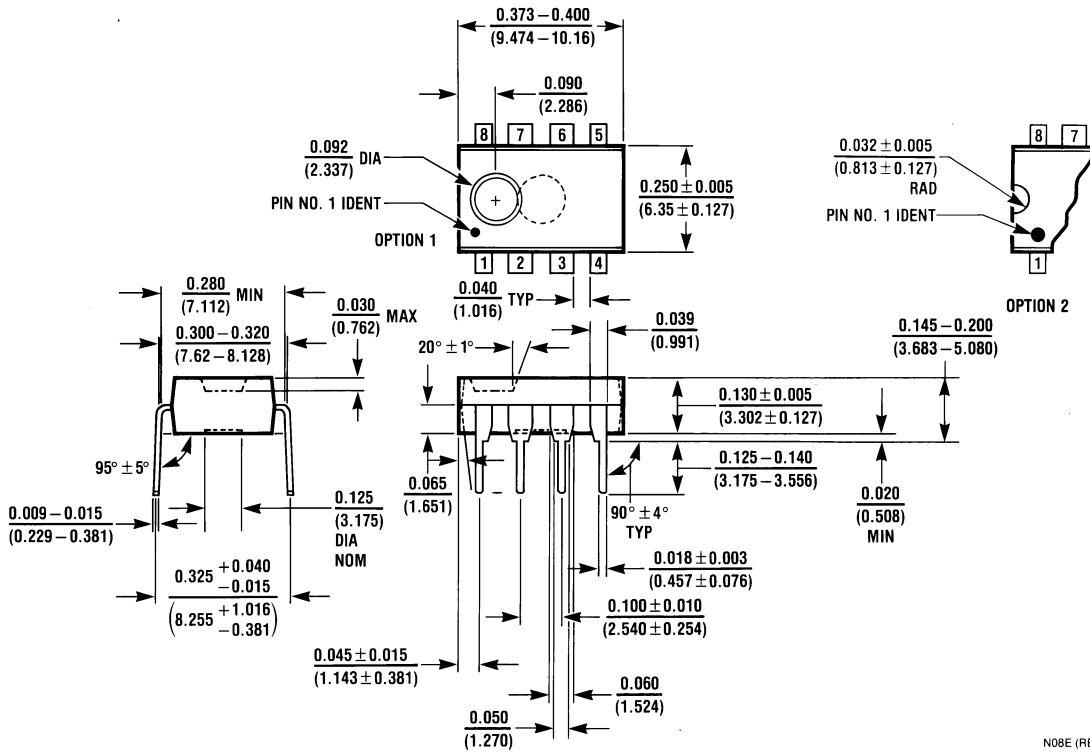
J08A (REV K)

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



M08A (REV H)

**Small Outline Package (M)**  
**Order Number LM4250CM or LM4250CMX**  
**NS Package Number M08A**



N08E (REV F)

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

## Notes

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