

# 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.

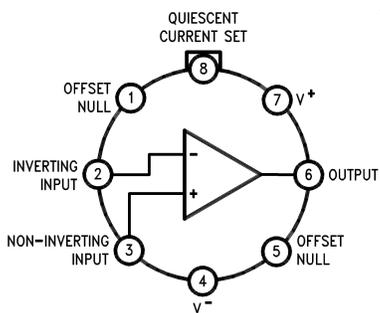
The LM4250C is identical to the LM4250 except that the LM4250C has its performance guaranteed over a 0°C to +70°C temperature range instead of the -55°C to +125°C temperature range of the LM4250.

## 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

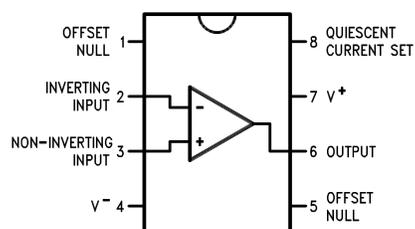
**Metal Can Package**



**Top View**

DS009300-2

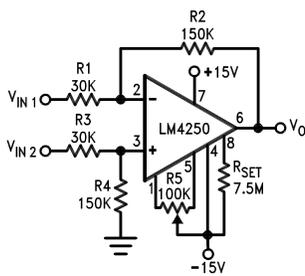
**Dual-In-Line Package**



**Top View**

DS009300-5

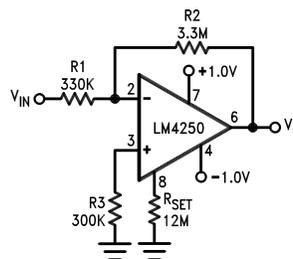
**X5 Difference Amplifier**



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 $\mu W$

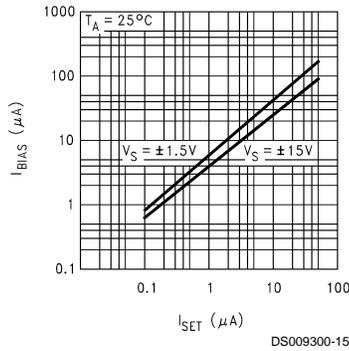
Parameter	Conditions	$V_S = \pm 15V$			
		$I_{SET} = 1 \mu A$		$I_{SET} = 10 \mu A$	
		Min	Max	Min	Max
$V_{OS}$	$R_S \leq 100 k\Omega, T_A = 25^\circ C$		5 mV		6 mV
$I_{OS}$	$T_A = 25^\circ C$		6 nA		20 nA
$I_{bias}$	$T_A = 25^\circ C$		10 nA		75 nA
Large Signal Voltage Gain	$R_L = 100 k\Omega, T_A = 25^\circ C$ $V_O = \pm 10V, R_L = 10 k\Omega$	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)

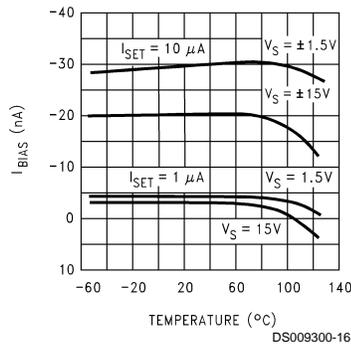
Parameter	Conditions	$V_S = \pm 15V$			
		$I_{SET} = 1 \mu A$		$I_{SET} = 10 \mu A$	
		Min	Max	Min	Max
Input Voltage Range		$\pm 13.5V$		$\pm 13.5V$	
Large Signal Voltage Gain	$V_O = \pm 10V, R_L = 100 k\Omega$ $R_L = 10 k\Omega$	50k		50k	
Output Voltage Swing	$R_L = 100 k\Omega$ $R_L = 10 k\Omega$	$\pm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

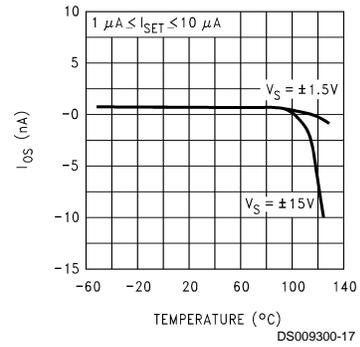
Input Bias Current vs  $I_{SET}$



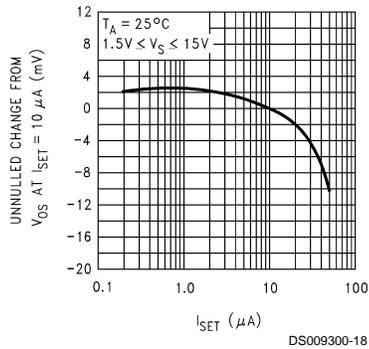
Input Bias Current vs Temperature



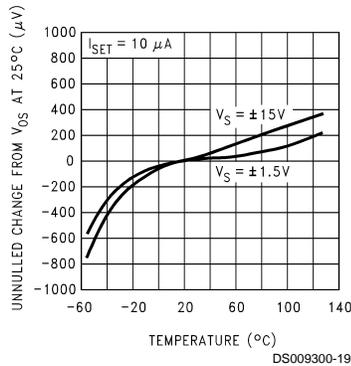
Input Offset Current vs Temperature



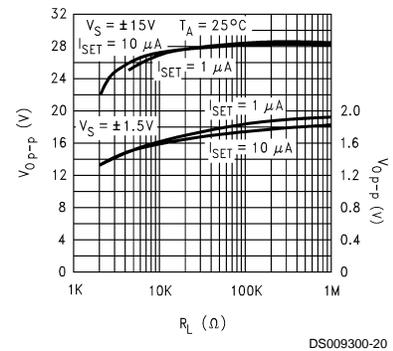
Unnull'd Input Offset Voltage Change vs  $I_{SET}$



Unnull'd Input Offset Voltage Change vs Temperature

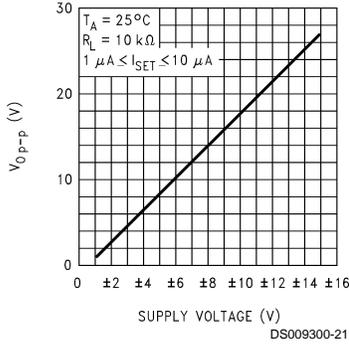


Peak to Peak Output Voltage Swing vs Load Resistance

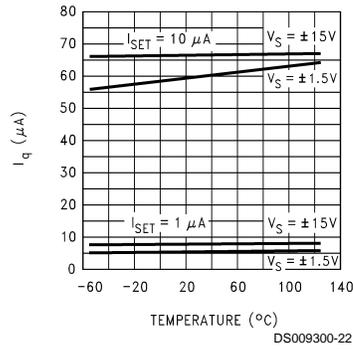


# Typical Performance Characteristics (Continued)

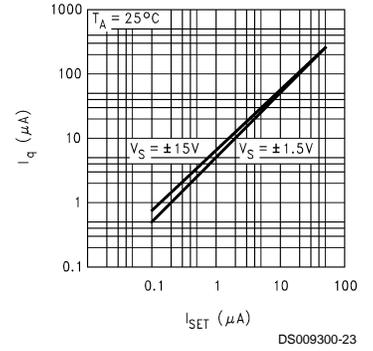
**Peak to Peak Output Voltage Swing vs Supply Voltage**



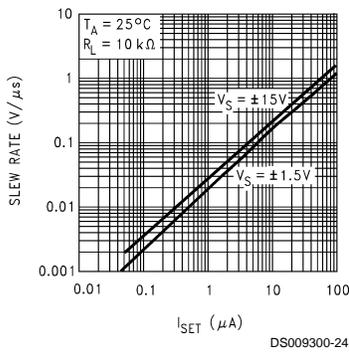
**Quiescent Current ( $I_q$ ) vs Temperature**



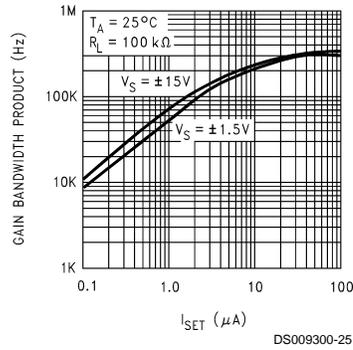
**Quiescent Current ( $I_q$ ) vs  $I_{SET}$**



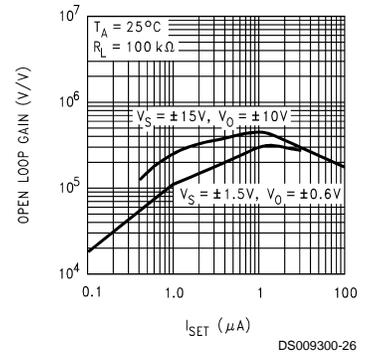
**Slew Rate vs  $I_{SET}$**



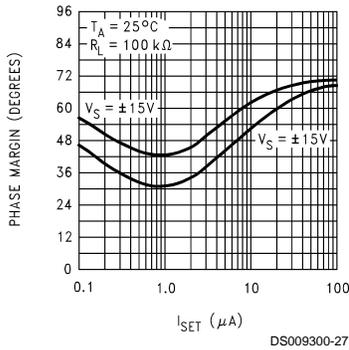
**Gain Bandwidth Product vs  $I_{SET}$**



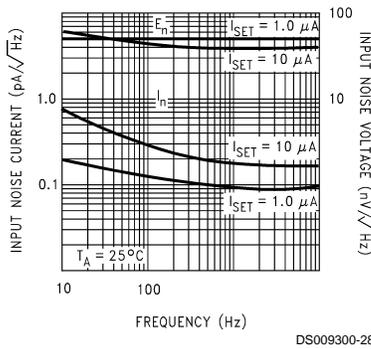
**Open Loop Voltage Gain vs  $I_{SET}$**



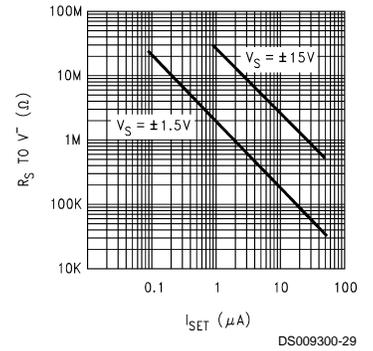
**Phase Margin vs  $I_{SET}$**



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

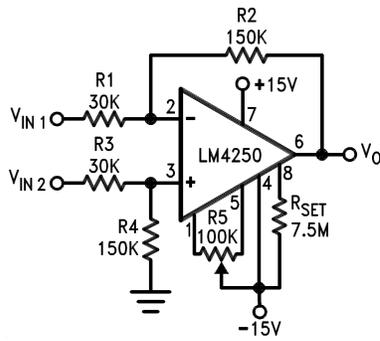


**$R_{SET}$  vs  $I_{SET}$**



# Typical Applications

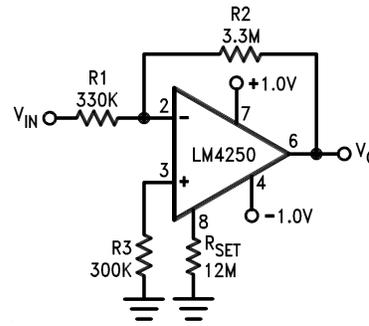
**X5 Difference Amplifier**



DS009300-3

Quiescent  $P_D = 0.6 \text{ mW}$

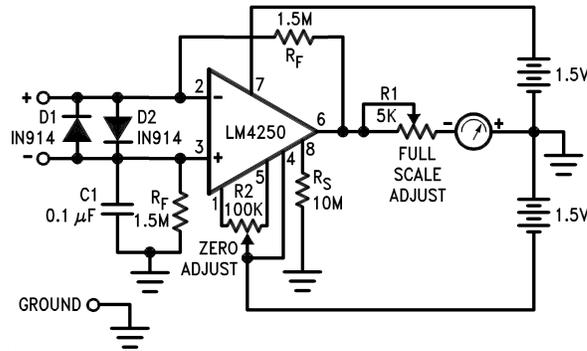
**500 Nano-Watt X10 Amplifier**



DS009300-4

Quiescent  $P_D = 500 \text{ nW}$

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



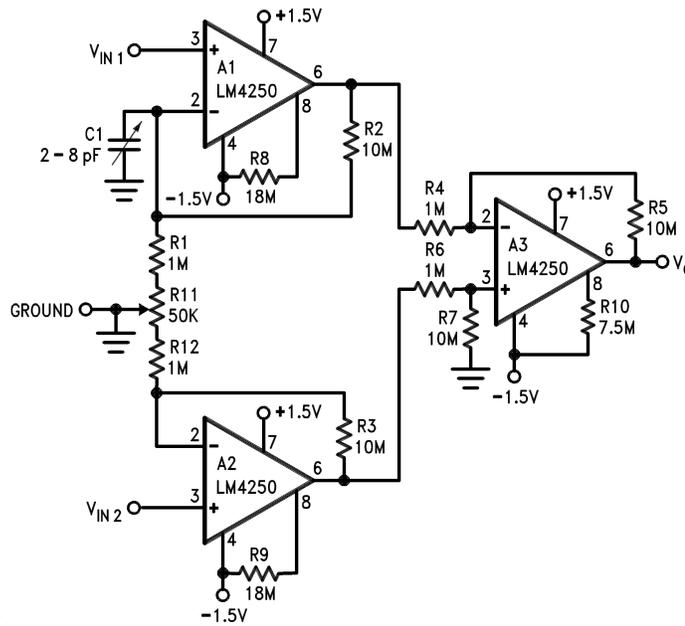
DS009300-8

Quiescent  $P_D = 1.8 \text{ } \mu\text{W}$

\*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



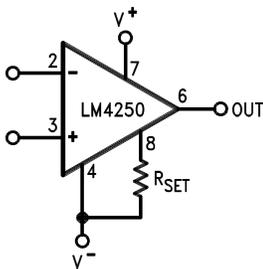
DS009300-9

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

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

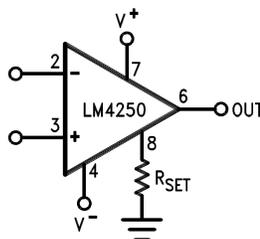
**Note 7:** R11 and C1 are for DC and AC common mode rejection adjustments.

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



DS009300-10

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



DS009300-11

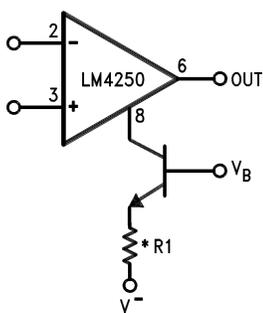
I<sub>SET</sub> Equations:

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

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

DS009300-30

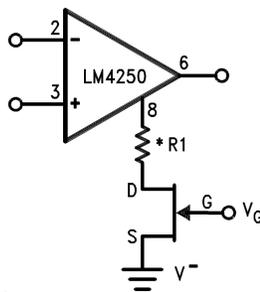
### Transistor Current Sourcing Biasing



DS009300-12

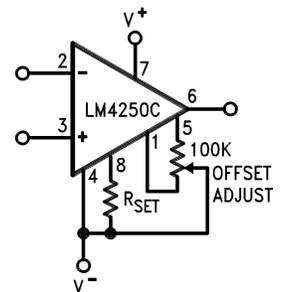
\*R1 limits I<sub>SET</sub> maximum

### FET Current Sourcing Biasing



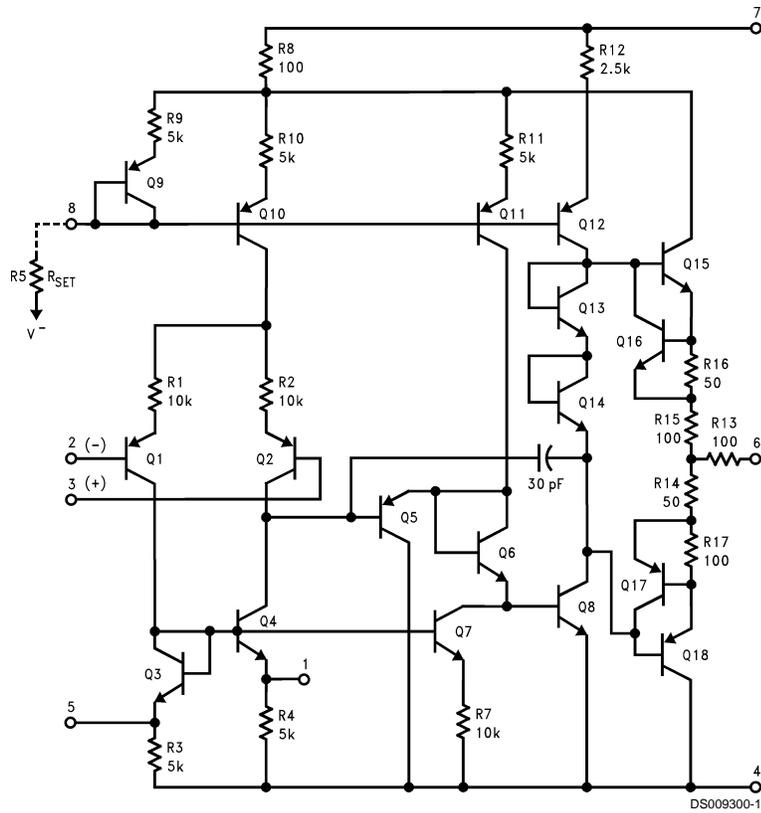
DS009300-13

### Offset Null Circuit



DS009300-14

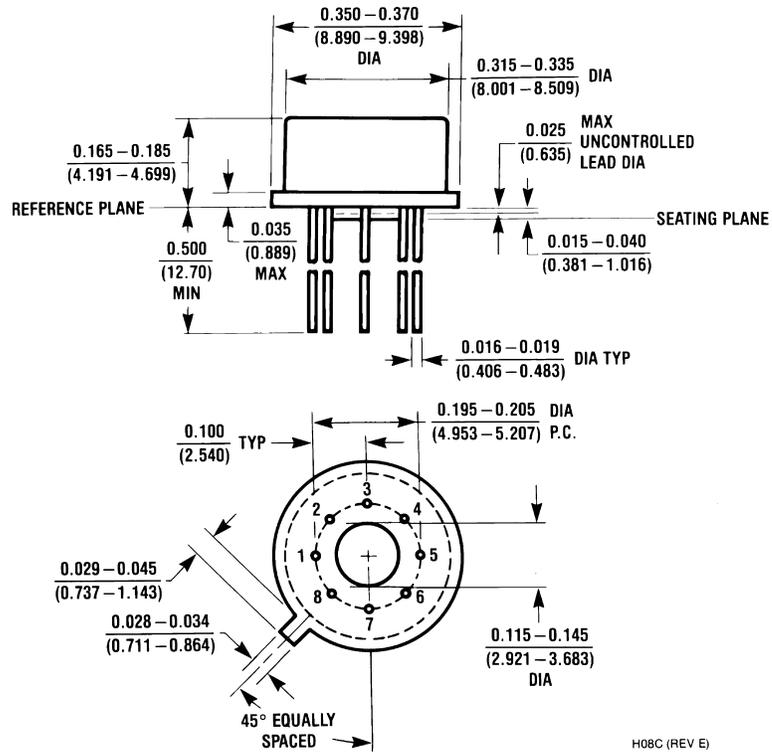
### Schematic Diagram



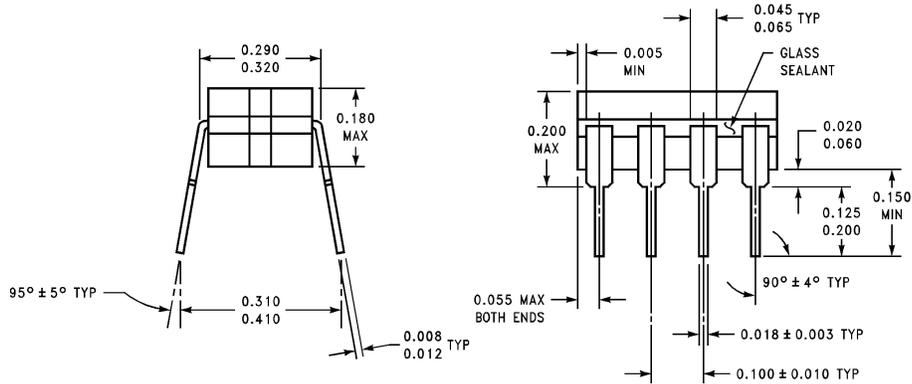
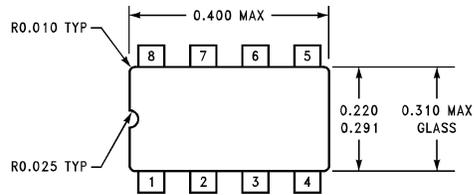
### Ordering Information

Temperature Range		Package	NSC Package Number
Military -55°C ≤ T <sub>A</sub> ≤ +125°C	Commercial 0°C ≤ T <sub>A</sub> ≤ +70°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



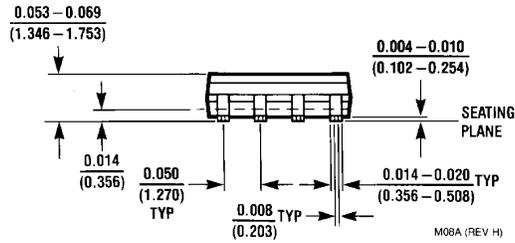
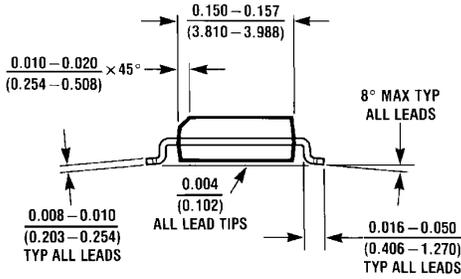
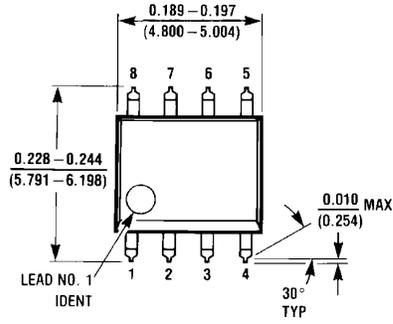
**Metal Can Package (H)**  
**Order Number LM4250CH**  
**NS Package Number H08C**



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

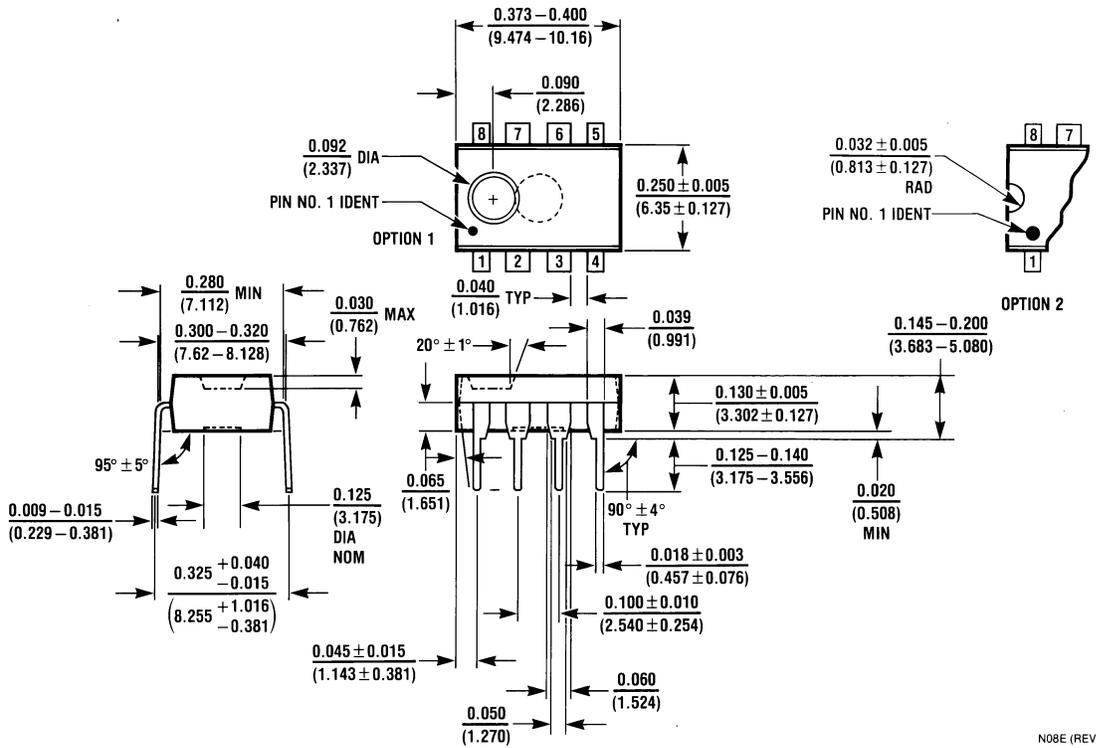
J08A (REV K)

**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

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

 <p><b>National Semiconductor Corporation</b> Americas Tel: 1-800-272-9959 Fax: 1-800-737-7018 Email: support@nsc.com www.national.com</p>	<p><b>National Semiconductor Europe</b> Fax: +49 (0) 180-530 85 86 Email: europe.support@nsc.com Deutsch Tel: +49 (0) 69 9508 6208 English Tel: +44 (0) 870 24 0 2171 Français Tel: +33 (0) 1 41 91 8790</p>	<p><b>National Semiconductor Asia Pacific Customer Response Group</b> Tel: 65-2544466 Fax: 65-2504466 Email: ap.support@nsc.com</p>	<p><b>National Semiconductor Japan Ltd.</b> Tel: 81-3-5639-7560 Fax: 81-3-5639-7507</p>
---	--	---	---

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Transportation and Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated