

## LM134/LM234/LM334 3-Terminal Adjustable Current Sources

 Check for Samples: [LM134](#), [LM234](#), [LM334](#)

### FEATURES

- Operates From 1V to 40V
- 0.02%/V Current Regulation
- Programmable From 1 $\mu$ A to 10mA
- True 2-Terminal Operation
- Available as Fully Specified Temperature Sensor
- $\pm 3\%$  Initial Accuracy

### DESCRIPTION

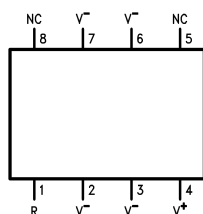
The LM134/LM234/LM334 are 3-terminal adjustable current sources featuring 10,000:1 range in operating current, excellent current regulation and a wide dynamic voltage range of 1V to 40V. Current is established with one external resistor and no other parts are required. Initial current accuracy is  $\pm 3\%$ . The LM134/LM234/LM334 are true floating current sources with no separate power supply connections. In addition, reverse applied voltages of up to 20V will draw only a few dozen microamperes of current, allowing the devices to act as both a rectifier and current source in AC applications.

The sense voltage used to establish operating current in the LM134 is 64mV at 25°C and is directly proportional to absolute temperature ( $^{\circ}$ K). The simplest one external resistor connection, then, generates a current with  $\approx +0.33\%/^{\circ}$ C temperature dependence. Zero drift operation can be obtained by adding one extra resistor and a diode.

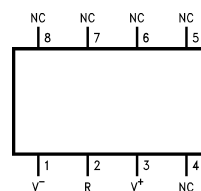
Applications for the current sources include bias networks, surge protection, low power reference, ramp generation, LED driver, and temperature sensing. The LM234-3 and LM234-6 are specified as true temperature sensors with ensured initial accuracy of  $\pm 3^{\circ}$ C and  $\pm 6^{\circ}$ C, respectively. These devices are ideal in remote sense applications because series resistance in long wire runs does not affect accuracy. In addition, only 2 wires are required.

The LM134 is specified over a temperature range of  $-55^{\circ}$ C to  $+125^{\circ}$ C, the LM234 from  $-25^{\circ}$ C to  $+100^{\circ}$ C and the LM334 from  $0^{\circ}$ C to  $+70^{\circ}$ C. These devices are available in TO hermetic, TO-92 and SOIC-8 plastic packages.

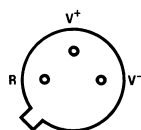
### Connection Diagrams



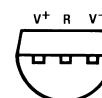
**Figure 1. SOIC-8 Surface Mount Package**  
(LM334M; LM334M/NOPB; LM334MX;  
LM334MX/NOPB)  
See Package Number D



**Figure 2. SOIC-8 Alternative Pinout Surface Mount Package**  
(LM334SM; LM334SM/NOPB; LM334SMX;  
LM334SMX/NOPB)  
See Package Number D



**Figure 3. TO Metal Can Package (Bottom View)**  
See Package Number NDV



**Figure 4. TO-92 Plastic Package (Bottom View)**  
See Package Number LP



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### Absolute Maximum Ratings<sup>(1)(2)</sup>

V <sup>+</sup> to V <sup>-</sup> Forward Voltage	LM134/LM234/LM334	40V	
	LM234-3/LM234-6	30V	
V <sup>+</sup> to V <sup>-</sup> Reverse Voltage		20V	
R Pin to V <sup>-</sup> Voltage		5V	
Set Current		10 mA	
Power Dissipation		400 mW	
ESD Susceptibility <sup>(3)</sup>		2000V	
Operating Temperature Range <sup>(4)</sup>	LM134	-55°C to +125°C	
	LM234/LM234-3/LM234-6	-25°C to +100°C	
	LM334	0°C to +70°C	
Soldering Information	TO-92 Package (10 sec.)	260°C	
	TO Package (10 sec.)	300°C	
	SOIC Package	Vapor Phase (60 sec.)	215°C
		Infrared (15 sec.)	220°C

- (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 ensure specific performance limits.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (3) Human body model, 100pF discharged through a 1.5kΩ resistor.
- (4) For elevated temperature operation, T<sub>J</sub> max is:

LM134	150°C
LM234	125°C
LM334	100°C

See [Thermal Characteristics](#).

### Thermal Characteristics

over operating free-air temperature range (unless otherwise noted)

Thermal Resistance	TO-92	TO	SOIC-8
θ <sub>ja</sub> (Junction to Ambient)	180°C/W (0.4" leads)	440°C/W	165°C/W
	160°C/W (0.125" leads)		
θ <sub>jc</sub> (Junction to Case)	N/A	32°C/W	80°C/W

**Electrical Characteristics<sup>(1)</sup>**

Parameter	Conditions	LM134/LM234			LM334			Units
		Min	Typ	Max	Min	Typ	Max	
Set Current Error, $V^+ = 2.5V$ <sup>(2)</sup>	$10\mu A \leq I_{SET} \leq 1mA$			3			6	%
	$1mA < I_{SET} \leq 5mA$			5			8	%
	$2\mu A \leq I_{SET} < 10\mu A$			8			12	%
Ratio of Set Current to Bias Current	$100\mu A \leq I_{SET} \leq 1mA$	14	18	23	14	18	26	
	$1mA \leq I_{SET} \leq 5mA$		14			14		
	$2\mu A \leq I_{SET} \leq 100\mu A$		18	23		18	26	
Minimum Operating Voltage	$2\mu A \leq I_{SET} \leq 100\mu A$		0.8			0.8		V
	$100\mu A < I_{SET} \leq 1mA$		0.9			0.9		V
	$1mA < I_{SET} \leq 5mA$		1.0			1.0		V
Average Change in Set Current with Input Voltage	$2\mu A \leq I_{SET} \leq 1mA$	$1.5 \leq V^+ \leq 5V$	0.02	0.05		0.02	0.1	%/V
		$5V \leq V^+ \leq 40V$	0.01	0.03		0.01	0.05	%/V
	$1mA < I_{SET} \leq 5mA$	$1.5V \leq V \leq 5V$	0.03			0.03		%/V
		$5V \leq V \leq 40V$	0.02			0.02		%/V
Temperature Dependence of Set Current <sup>(3)</sup>	$25\mu A \leq I_{SET} \leq 1mA$	0.96T	T	1.04T	0.96T	T	1.04T	
Effective Shunt Capacitance			15			15		pF

- (1) Unless otherwise specified, tests are performed at  $T_j = 25^\circ C$  with pulse testing so that junction temperature does not change during test
- (2) Set current is the current flowing into the  $V^+$  pin. For the Basic 2-Terminal Current Source circuit shown in Figure 13.  $I_{SET}$  is determined by the following formula:  $I_{SET} = 67.7 \text{ mV}/R_{SET}$  (@  $25^\circ C$ ). Set current error is expressed as a percent deviation from this amount.  $I_{SET}$  increases at  $0.336\%/^\circ C$  @  $T_j = 25^\circ C$  ( $227 \mu V/^\circ C$ ).
- (3)  $I_{SET}$  is directly proportional to absolute temperature ( $^\circ K$ ).  $I_{SET}$  at any temperature can be calculated from:  $I_{SET} = I_o (T/T_o)$  where  $I_o$  is  $I_{SET}$  measured at  $T_o$  ( $^\circ K$ ).

**Electrical Characteristics<sup>(1)</sup>**

Parameter	Conditions	LM234-3			LM234-6			Units
		Min	Typ	Max	Min	Typ	Max	
Set Current Error, $V^+ = 2.5V$ <sup>(2)</sup>	$100\mu A \leq I_{SET} \leq 1mA$			$\pm 1$			$\pm 2$	%
	$T_j = 25^\circ$							
Equivalent Temperature Error				$\pm 3$			$\pm 6$	$^\circ C$
Ratio of Set Current to Bias Current	$100\mu A \leq I_{SET} \leq 1mA$	14	18	26	14	18	26	
Minimum Operating Voltage	$100\mu A I_{SET} \leq 1mA$		0.9			0.9		V
Average Change in Set Current with Input Voltage	$100\mu A \leq I_{SET} \leq 1mA$	$1.5 \leq V^+ \leq 5V$	0.02	0.05		0.02	0.01	%/V
		$5V \leq V^+ \leq 30V$	0.01	0.03		0.01	0.05	%/V
Temperature Dependence of Set Current <sup>(3)</sup>	$100\mu A \leq I_{SET} \leq 1mA$	0.98T	T	1.02T	0.97T	T	1.03T	
Equivalent Slope Error				$\pm 2$			$\pm 3$	%
Effective Shunt Capacitance			15			15		pF

- (1) Unless otherwise specified, tests are performed at  $T_j = 25^\circ C$  with pulse testing so that junction temperature does not change during test
- (2) Set current is the current flowing into the  $V^+$  pin. For the Basic 2-Terminal Current Source circuit shown in Figure 13.  $I_{SET}$  is determined by the following formula:  $I_{SET} = 67.7 \text{ mV}/R_{SET}$  (@  $25^\circ C$ ). Set current error is expressed as a percent deviation from this amount.  $I_{SET}$  increases at  $0.336\%/^\circ C$  @  $T_j = 25^\circ C$  ( $227 \mu V/^\circ C$ ).
- (3)  $I_{SET}$  is directly proportional to absolute temperature ( $^\circ K$ ).  $I_{SET}$  at any temperature can be calculated from:  $I_{SET} = I_o (T/T_o)$  where  $I_o$  is  $I_{SET}$  measured at  $T_o$  ( $^\circ K$ ).

Typical Performance Characteristics

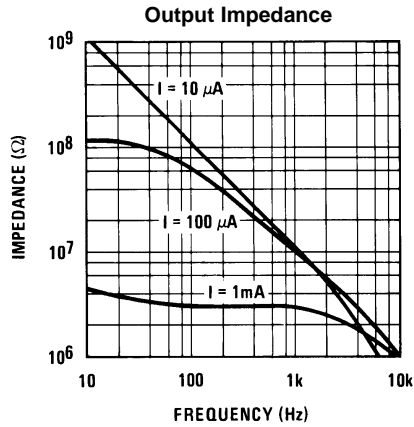


Figure 5.

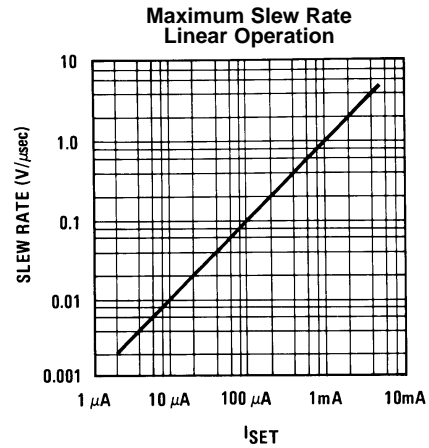
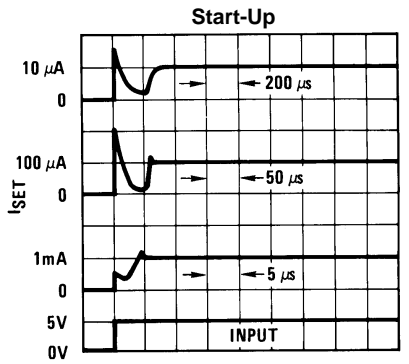
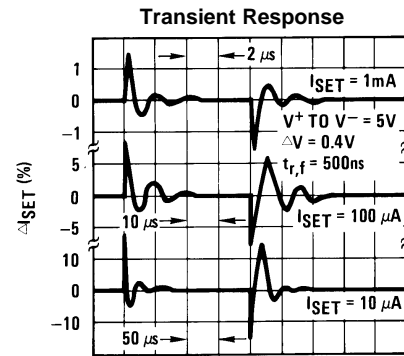


Figure 6.



TIME (Note scale changes at each current level)

Figure 7.



TIME (Note scale changes for each current)

Figure 8.

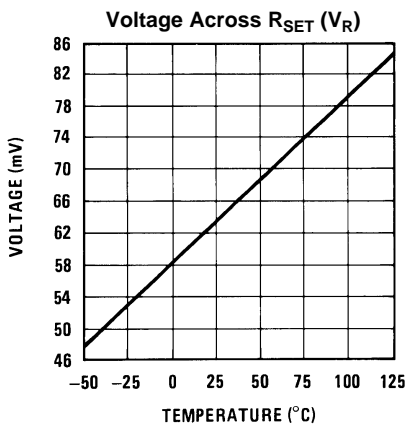


Figure 9.

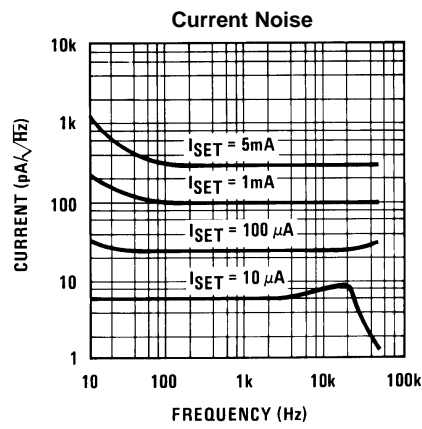
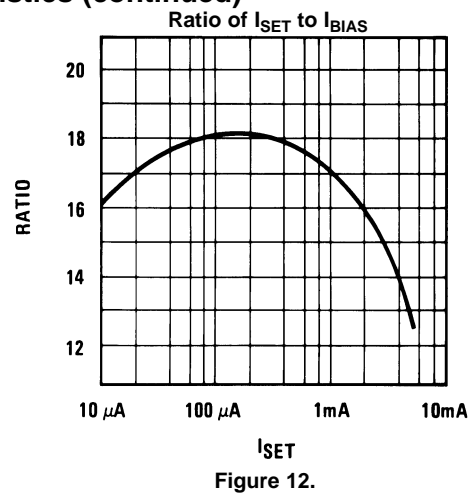
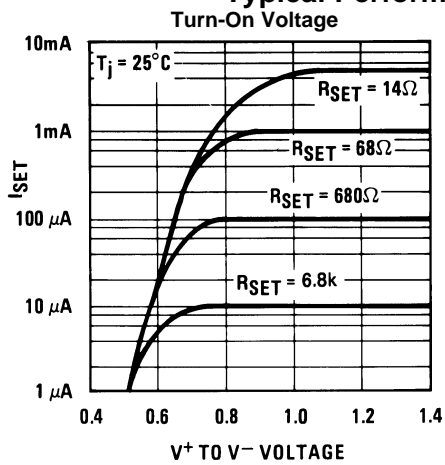


Figure 10.

Typical Performance Characteristics (continued)

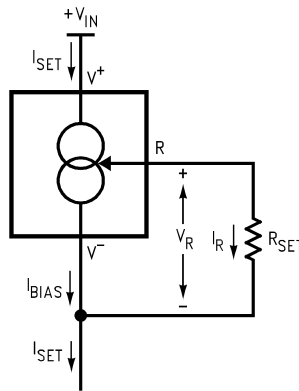


## APPLICATION HINTS

The LM134 has been designed for ease of application, but a general discussion of design features is presented here to familiarize the designer with device characteristics which may not be immediately obvious. These include the effects of slewing, power dissipation, capacitance, noise, and contact resistance.

### Calculating $R_{SET}$

The total current through the LM134 ( $I_{SET}$ ) is the sum of the current going through the SET resistor ( $I_R$ ) and the LM134's bias current ( $I_{BIAS}$ ), as shown in [Figure 13](#).



**Figure 13. Basic Current Source**

A graph showing the ratio of these two currents is supplied under **Ratio of  $I_{SET}$  to  $I_{BIAS}$**  in [Typical Performance Characteristics](#). The current flowing through  $R_{SET}$  is determined by  $V_R$ , which is approximately  $214\mu\text{V}/^\circ\text{K}$  ( $64\text{mV}/298^\circ\text{K} \sim 214\mu\text{V}/^\circ\text{K}$ ).

$$I_{SET} = I_R + I_{BIAS} = \frac{V_R}{R_{SET}} + I_{BIAS} \quad (1)$$

Since (for a given set current)  $I_{BIAS}$  is simply a percentage of  $I_{SET}$ , the equation can be rewritten

$$I_{SET} = \left( \frac{V_R}{R_{SET}} \right) \left( \frac{n}{n-1} \right)$$

where

- $n$  is the ratio of  $I_{SET}$  to  $I_{BIAS}$  as specified in [Electrical Characteristics](#) and shown in the graph (2)

Since  $n$  is typically 18 for  $2\mu\text{A} \leq I_{SET} \leq 1\text{mA}$ , the equation can be further simplified to

$$I_{SET} = \left( \frac{V_R}{R_{SET}} \right) (1.059) = \frac{227\mu\text{V}/^\circ\text{K}}{R_{SET}} \quad (3)$$

for most set currents.

### Slew Rate

At slew rates above a given threshold (see curve), the LM134 may exhibit non-linear current shifts. The slewing rate at which this occurs is directly proportional to  $I_{SET}$ . At  $I_{SET} = 10\mu\text{A}$ , maximum  $dV/dt$  is  $0.01\text{V}/\mu\text{s}$ ; at  $I_{SET} = 1\text{mA}$ , the limit is  $1\text{V}/\mu\text{s}$ . Slew rates above the limit do not harm the LM134, or cause large currents to flow.

### Thermal Effects

Internal heating can have a significant effect on current regulation for  $I_{SET}$  greater than  $100\mu\text{A}$ . For example, each  $1\text{V}$  increase across the LM134 at  $I_{SET} = 1\text{mA}$  will increase junction temperature by  $\approx 0.4^\circ\text{C}$  in still air. Output current ( $I_{SET}$ ) has a temperature coefficient of  $\approx 0.33\%/^\circ\text{C}$ , so the change in current due to temperature rise will be  $(0.4)(0.33) = 0.132\%$ . This is a 10:1 degradation in regulation compared to true electrical effects. Thermal effects, therefore, must be taken into account when DC regulation is critical and  $I_{SET}$  exceeds  $100\mu\text{A}$ . Heat sinking of the TO package or the TO-92 leads can reduce this effect by more than 3:1.

## Shunt Capacitance

In certain applications, the 15 pF shunt capacitance of the LM134 may have to be reduced, either because of loading problems or because it limits the AC output impedance of the current source. This can be easily accomplished by buffering the LM134 with an FET as shown in the applications. This can reduce capacitance to less than 3 pF and improve regulation by at least an order of magnitude. DC characteristics (with the exception of minimum input voltage), are not affected.

## Noise

Current noise generated by the LM134 is approximately 4 times the shot noise of a transistor. If the LM134 is used as an active load for a transistor amplifier, input referred noise will be increased by about 12dB. In many cases, this is acceptable and a single stage amplifier can be built with a voltage gain exceeding 2000.

## Lead Resistance

The sense voltage which determines operating current of the LM134 is less than 100mV. At this level, thermocouple or lead resistance effects should be minimized by locating the current setting resistor physically close to the device. Sockets should be avoided if possible. It takes only 0.7Ω contact resistance to reduce output current by 1% at the 1 mA level.

## Sensing Temperature

The LM134 makes an ideal remote temperature sensor because its current mode operation does not lose accuracy over long wire runs. Output current is directly proportional to absolute temperature in degrees Kelvin, according to the following formula:

$$I_{SET} = \frac{(227 \mu V/^{\circ}K) (T)}{R_{SET}} \quad (4)$$

Calibration of the LM134 is greatly simplified because of the fact that most of the initial inaccuracy is due to a gain term (slope error) and not an offset. This means that a calibration consisting of a gain adjustment only will trim both slope and zero at the same time. In addition, gain adjustment is a one point trim because the output of the LM134 extrapolates to zero at 0°K, independent of R<sub>SET</sub> or any initial inaccuracy.

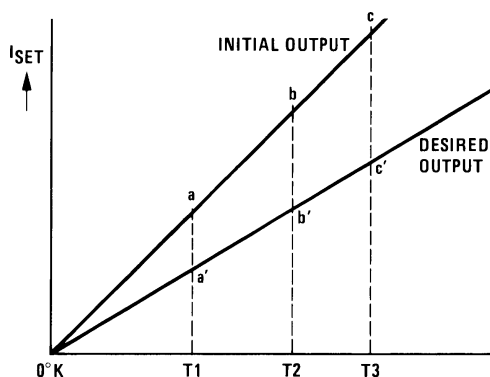


Figure 14. Gain Adjustment

This property of the LM134 is illustrated in the accompanying graph. Line abc is the sensor current before trimming. Line a'b'c' is the desired output. A gain trim done at T<sub>2</sub> will move the output from b to b' and will simultaneously correct the slope so that the output at T<sub>1</sub> and T<sub>3</sub> will be correct. This gain trim can be done on R<sub>SET</sub> or on the load resistor used to terminate the LM134. Slope error after trim will normally be less than ±1%. To maintain this accuracy, however, a low temperature coefficient resistor must be used for R<sub>SET</sub>.

A 33 ppm/°C drift of R<sub>SET</sub> will give a 1% slope error because the resistor will normally see about the same temperature variations as the LM134. Separating R<sub>SET</sub> from the LM134 requires 3 wires and has lead resistance problems, so is not normally recommended. Metal film resistors with less than 20 ppm/°C drift are readily available. Wire wound resistors may also be used where best stability is required.

### Application as a Zero Temperature Coefficient Current Source

Adding a diode and a resistor to the standard LM134 configuration can cancel the temperature-dependent characteristic of the LM134. The circuit shown in Figure 15 balances the positive tempco of the LM134 (about +0.23 mV/°C) with the negative tempco of a forward-biased silicon diode (about -2.5 mV/°C).

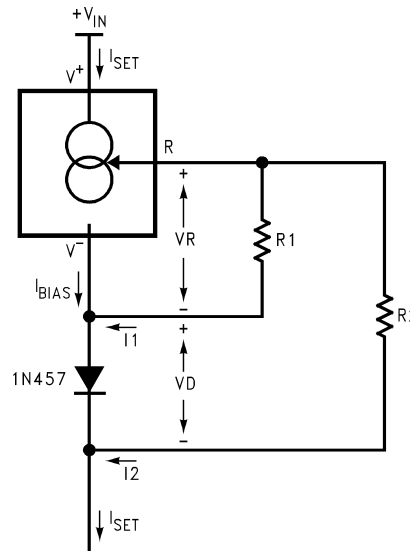


Figure 15. Zero Tempco Current Source

The set current ( $I_{SET}$ ) is the sum of  $I_1$  and  $I_2$ , each contributing approximately 50% of the set current, and  $I_{BIAS}$ .  $I_{BIAS}$  is usually included in the  $I_1$  term by increasing the  $V_R$  value used for calculations by 5.9%. (See **CALCULATING  $R_{SET}$** .)

$I_{SET} = I_1 + I_2 + I_{BIAS}$ , where

$$I_1 = \frac{V_R}{R_1} \quad \text{and} \quad I_2 = \frac{V_R + V_D}{R_2} \quad (5)$$

The first step is to minimize the tempco of the circuit, using the following equations. An example is given using a value of +227  $\mu\text{V}/^\circ\text{C}$  as the tempco of the LM134 (which includes the  $I_{BIAS}$  component), and -2.5 mV/°C as the tempco of the diode (for best results, this value should be directly measured or obtained from the manufacturer of the diode).

$$\begin{aligned} I_{SET} &= I_1 + I_2 \\ \frac{dI_{SET}}{dT} &= \frac{dI_1}{dT} + \frac{dI_2}{dT} \\ &\approx \frac{227 \mu\text{V}/^\circ\text{C}}{R_1} + \frac{227 \mu\text{V}/^\circ\text{C} - 2.5 \text{ mV}/^\circ\text{C}}{R_2} \\ &= 0 \quad (\text{solve for tempco} = 0) \end{aligned} \quad (6)$$

$$\frac{R_2}{R_1} \approx \frac{2.5 \text{ mV}/^\circ\text{C} - 227 \mu\text{V}/^\circ\text{C}}{227 \mu\text{V}/^\circ\text{C}} \approx 10.0 \quad (7)$$

With the  $R_1$  to  $R_2$  ratio determined, values for  $R_1$  and  $R_2$  should be determined to give the desired set current. The formula for calculating the set current at  $T = 25^\circ\text{C}$  is shown below, followed by an example that assumes the forward voltage drop across the diode ( $V_D$ ) is 0.6V, the voltage across  $R_1$  is 67.7mV (64 mV + 5.9% to account for  $I_{BIAS}$ ), and  $R_2/R_1 = 10$  (from the previous calculations).



$$\begin{aligned}
 I_{SET} &= I_1 + I_2 + I_{BIAS} \\
 &= \frac{V_R}{R_1} + \frac{V_R + V_D}{R_2} \\
 &\approx \frac{67.7 \text{ mV}}{R_1} + \frac{67.7 \text{ mV} + 0.6 \text{ V}}{10.0 R_1} \\
 I_{SET} &\approx \frac{0.134 \text{ V}}{R_1}
 \end{aligned} \tag{8}$$

This circuit will eliminate most of the LM134's temperature coefficient, and it does a good job even if the estimates of the diode's characteristics are not accurate (as the following example will show). For lowest tempco with a specific diode at the desired  $I_{SET}$ , however, the circuit should be built and tested over temperature. If the measured tempco of  $I_{SET}$  is positive,  $R_2$  should be reduced. If the resulting tempco is negative,  $R_2$  should be increased. The recommended diode for use in this circuit is the 1N457 because its tempco is centered at 11 times the tempco of the LM134, allowing  $R_2 = 10 R_1$ . You can also use this circuit to create a current source with non-zero tempcos by setting the tempco component of the tempco equation to the desired value instead of 0.

**EXAMPLE: A 1mA, Zero-Tempco Current Source**

First, solve for  $R_1$  and  $R_2$ :

$$\begin{aligned}
 I_{SET} \approx 1 \text{ mA} &= \frac{0.134 \text{ V}}{R_1} \\
 R_2 &= 134 \Omega = 10 R_1 \\
 R_2 &= 1340 \Omega
 \end{aligned} \tag{9}$$

The values of  $R_1$  and  $R_2$  can be changed to standard 1% resistor values ( $R_1 = 133\Omega$  and  $R_2 = 1.33\text{k}\Omega$ ) with less than a 0.75% error.

If the forward voltage drop of the diode was 0.65V instead of the estimate of 0.6V (an error of 8%), the actual set current will be

$$\begin{aligned}
 I_{SET} &= \frac{67.7 \text{ mV}}{R_1} + \frac{67.7 \text{ mV} + 0.65 \text{ V}}{R_2} \\
 &= \frac{67.7 \text{ mV}}{133} + \frac{67.7 \text{ mV} + 0.65 \text{ V}}{1330} \\
 &= 1.049 \text{ mA}
 \end{aligned} \tag{10}$$

an error of less than 5%.

If the estimate for the tempco of the diode's forward voltage drop was off, the tempco cancellation is still reasonably effective. Assume the tempco of the diode is 2.6mV/°C instead of 2.5mV/°C (an error of 4%). The tempco of the circuit is now:

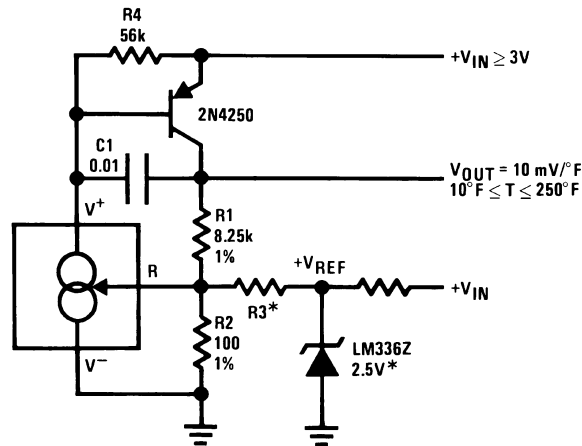
$$\begin{aligned}
 \frac{dI_{SET}}{dT} &= \frac{dI_1}{dT} + \frac{dI_2}{dT} \\
 &= \frac{227 \mu\text{V}/^\circ\text{C}}{133\Omega} + \frac{227 \mu\text{V}/^\circ\text{C} - 2.6 \text{ mV}/^\circ\text{C}}{1330\Omega} \\
 &= -77 \text{ nA}/^\circ\text{C}
 \end{aligned} \tag{11}$$

A 1mA LM134 current source with no temperature compensation would have a set resistor of 68Ω and a resulting tempco of

$$\frac{227 \mu\text{V}/^\circ\text{C}}{68\Omega} = 3.3 \mu\text{A}/^\circ\text{C} \tag{12}$$

So even if the diode's tempco varies as much as ±4% from its estimated value, the circuit still eliminates 98% of the LM134's inherent tempco.

Typical Applications



\*Select  $R_3 = V_{REF}/583\mu A$ .  $V_{REF}$  may be any stable positive voltage  $\geq 2V$   
Trim  $R_3$  to calibrate

Figure 16. Ground Referred Fahrenheit Thermometer

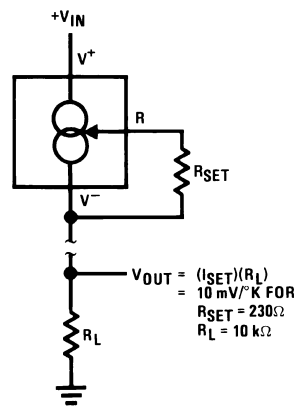
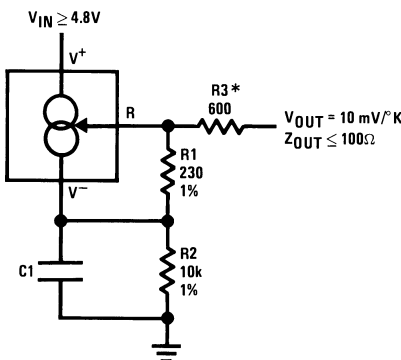


Figure 17. Terminating Remote Sensor for Voltage Output



\*Output impedance of the LM134 at the "R" pin is approximately  $\frac{-R_2}{16}$

where  $R_2$  is the equivalent external resistance connected from the  $V^-$  pin to ground. This negative resistance can be reduced by a factor of 5 or more by inserting an equivalent resistor  $R_3 = (R_2/16)$  in series with the output.

Figure 18. Low Output Impedance Thermometer

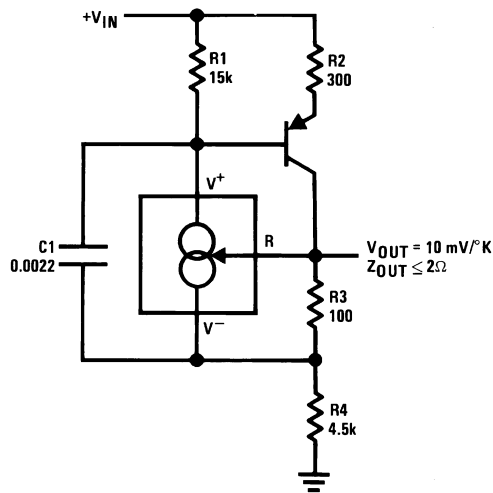
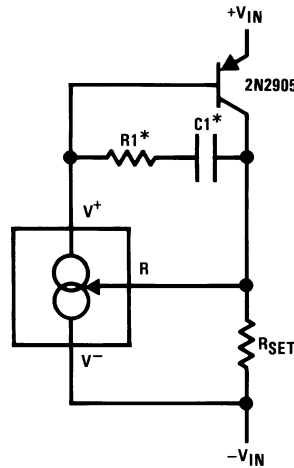


Figure 19. Low Output Impedance Thermometer



\*Select R1 and C1 for optimum stability

Figure 20. Higher Output Current

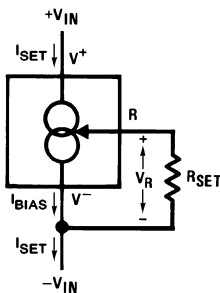


Figure 21. Basic 2-Terminal Current Source

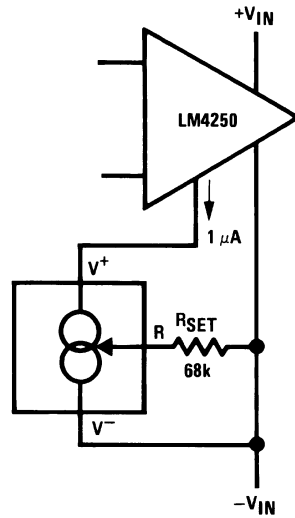


Figure 22. Micropower Bias

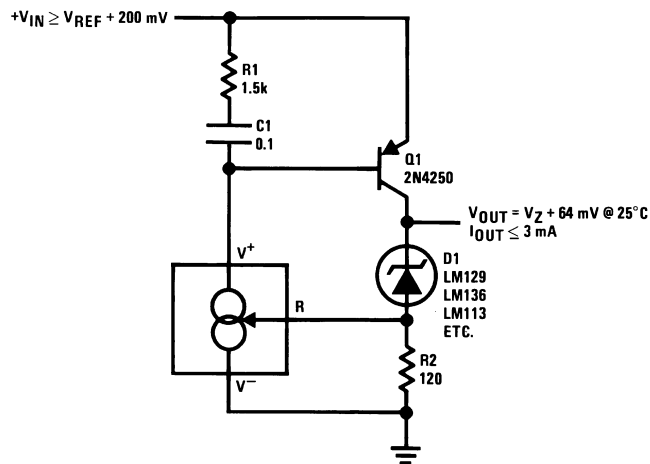


Figure 23. Low Input Voltage Reference Driver

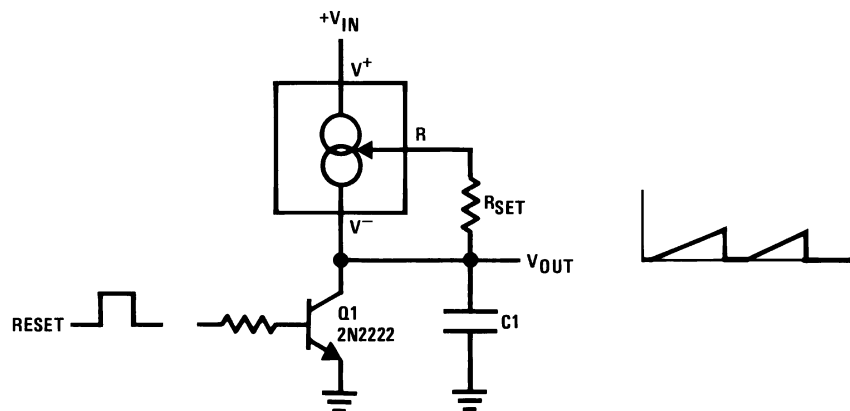
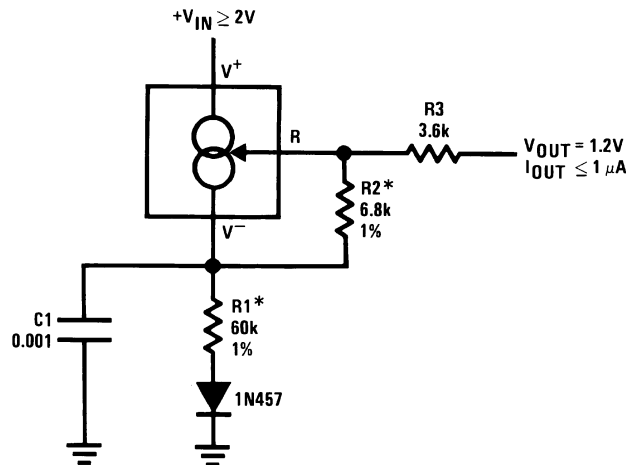
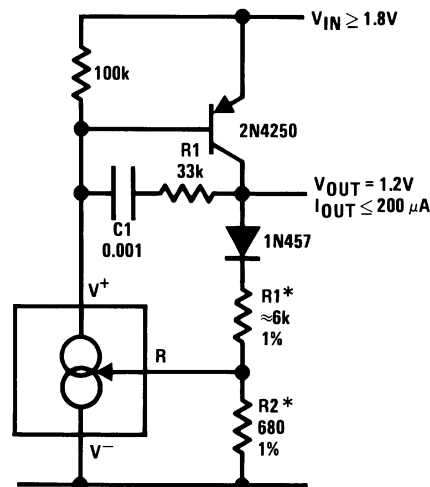


Figure 24. Ramp Generator



\*Select ratio of R1 to R2 to obtain zero temperature drift

Figure 25. 1.2V Reference Operates on 10 µA and 2V



\*Select ratio of R1 to R2 for zero temperature drift

Figure 26. 1.2V Regulator with 1.8V Minimum Input

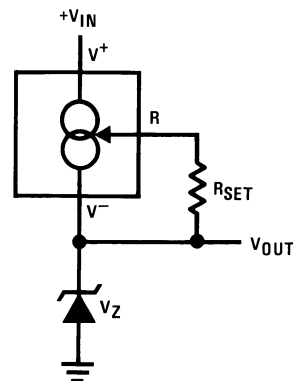
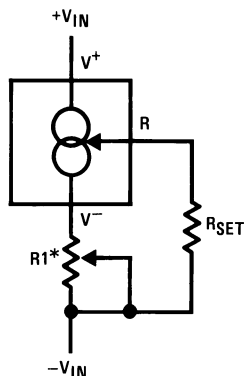
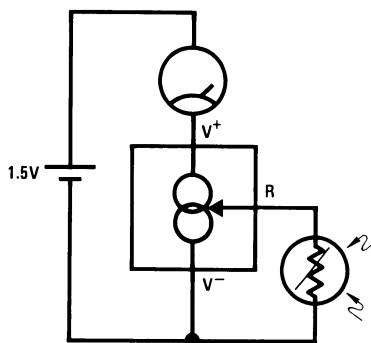


Figure 27. Zener Biasing

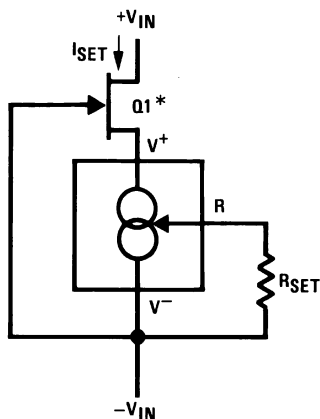


\*For  $\pm 10\%$  adjustment, select  $R_{SET}$  10% high, and make  $R1 \approx 3 R_{SET}$

**Figure 28. Alternate Trimming Technique**



**Figure 29. Buffer for Photoconductive Cell**



\*Select Q1 or Q2 to ensure at least 1V across the LM134.  $V_p (1 - I_{SET}/I_{DSS}) \geq 1.2V$ .

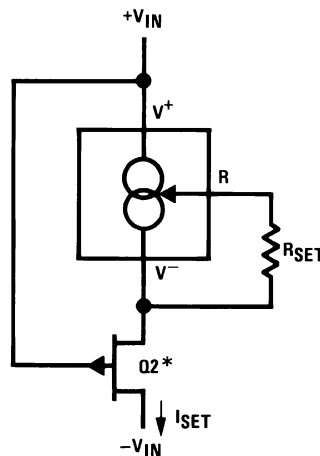
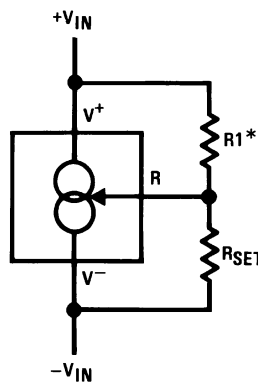
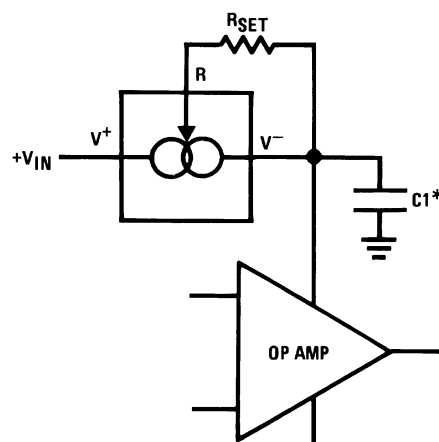


Figure 30. FET Cascoding for Low Capacitance and/or Ultra High Output Impedance



\* $Z_{OUT} \approx -16 \cdot R1$  ( $R1/V_{IN}$  must not exceed  $I_{SET}$ )

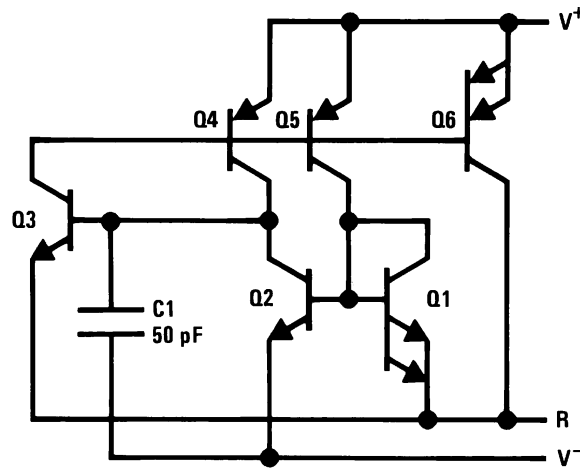
Figure 31. Generating Negative Output Impedance



\*Use minimum value required to ensure stability of protected device. This minimizes inrush current to a direct short.

Figure 32. In-Line Current Limiter

### Schematic Diagram





## REVISION HISTORY

Changes from Revision C (April 2013) to Revision D	Page
<ul style="list-style-type: none"><li>• Changed layout of National Data Sheet to TI format .....</li></ul>	<a href="#">16</a>

**PACKAGING INFORMATION**

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM134 MDC	Active	Production	DIESALE (Y)   0	400   NOT REQUIRED	Yes	Call TI	Level-1-NA-UNLIM	-40 to 85	
<a href="#">LM134H</a>	Active	Production	TO (NDV)   3	1000   BULK	No	Call TI	Level-1-NA-UNLIM	-55 to 125	( LM134H, LM134H)
<a href="#">LM134H/NOPB</a>	Active	Production	TO (NDV)   3	1000   BULK	Yes	Call TI	Level-1-NA-UNLIM	-55 to 125	( LM134H, LM134H)
<a href="#">LM234Z-3/NOPB</a>	Active	Production	TO-92 (LP)   3	1800   BULK	Yes	Call TI	N/A for Pkg Type	-25 to 100	LM234 Z-3
LM234Z-3/NOPB.B	Active	Production	TO-92 (LP)   3	1800   BULK	Yes	Call TI	N/A for Pkg Type	-25 to 100	LM234 Z-3
<a href="#">LM234Z-6/NOPB</a>	Active	Production	TO-92 (LP)   3	1800   BULK	Yes	Call TI	N/A for Pkg Type	-25 to 100	LM234 Z-6
LM234Z-6/NOPB.B	Active	Production	TO-92 (LP)   3	1800   BULK	Yes	Call TI	N/A for Pkg Type	-25 to 100	LM234 Z-6
LM334 MWC	Active	Production	WAFERSALE (YS)   0	1   NOT REQUIRED	-	Call TI	Level-1-NA-UNLIM	-40 to 85	
<a href="#">LM334M/NOPB</a>	Active	Production	SOIC (D)   8	95   TUBE	Yes	SN	Level-1-260C-UNLIM	0 to 70	LM334 M
LM334M/NOPB.B	Active	Production	SOIC (D)   8	95   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LM334 M
<a href="#">LM334MX/NOPB</a>	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	LM334 M
LM334MX/NOPB.B	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LM334 M
<a href="#">LM334SM/NOPB</a>	Active	Production	SOIC (D)   8	95   TUBE	Yes	SN	Level-1-260C-UNLIM	0 to 70	LM334 SM
LM334SM/NOPB.B	Active	Production	SOIC (D)   8	95   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LM334 SM
<a href="#">LM334SMX/NOPB</a>	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	0 to 70	LM334 SM
LM334SMX/NOPB.B	Active	Production	SOIC (D)   8	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LM334 SM
<a href="#">LM334Z/LFT1</a>	Active	Production	TO-92 (LP)   3	2000   LARGE T&R	Yes	SN	N/A for Pkg Type	-40 to 85	LM334 Z
LM334Z/LFT1.B	Active	Production	TO-92 (LP)   3	2000   LARGE T&R	Yes	SN	N/A for Pkg Type	-40 to 85	LM334 Z

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">LM334Z/NOPB</a>	Active	Production	TO-92 (LP)   3	1800   BULK	Yes	Call TI	N/A for Pkg Type	0 to 70	LM334 Z
LM334Z/NOPB.B	Active	Production	TO-92 (LP)   3	1800   BULK	Yes	Call TI	N/A for Pkg Type	-40 to 85	LM334 Z

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM334MX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM334SMX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM334MX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM334SMX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
LM334M/NOPB	D	SOIC	8	95	495	8	4064	3.05
LM334M/NOPB.B	D	SOIC	8	95	495	8	4064	3.05
LM334SM/NOPB	D	SOIC	8	95	495	8	4064	3.05
LM334SM/NOPB.B	D	SOIC	8	95	495	8	4064	3.05

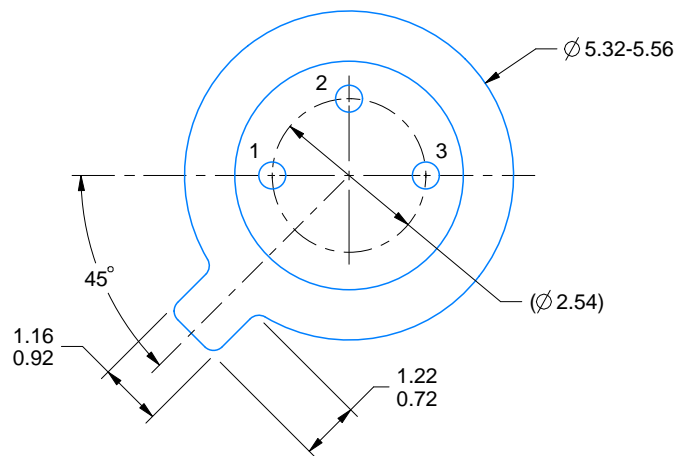
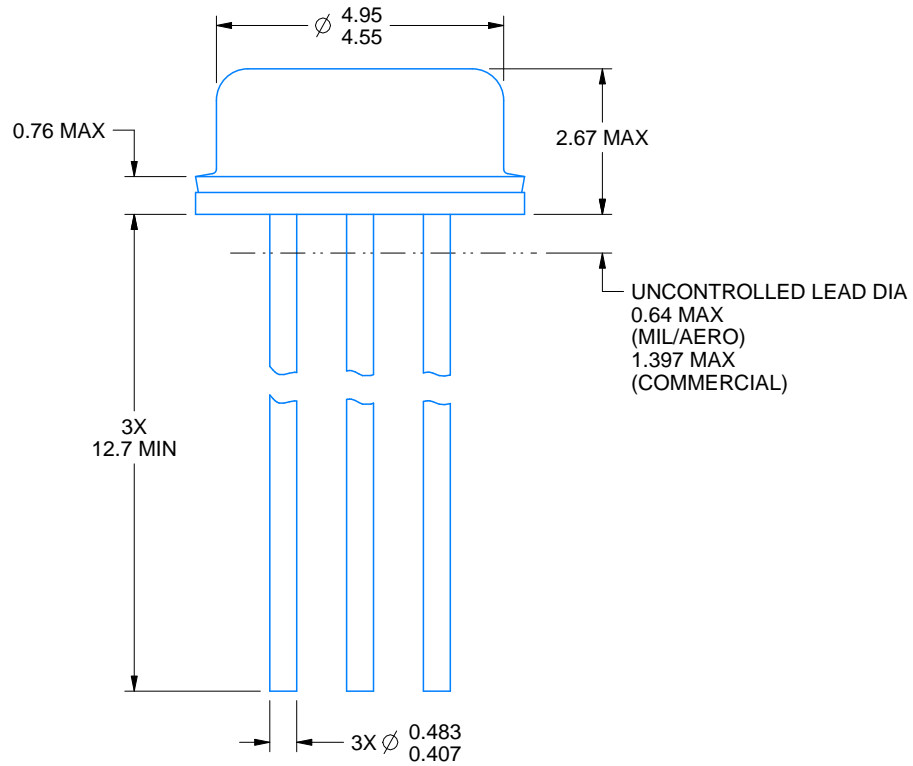
NDV0003H



# PACKAGE OUTLINE

## TO-CAN - 2.67 mm max height

TRANSISTOR OUTLINE



4219876/B 09/2024

NOTES:

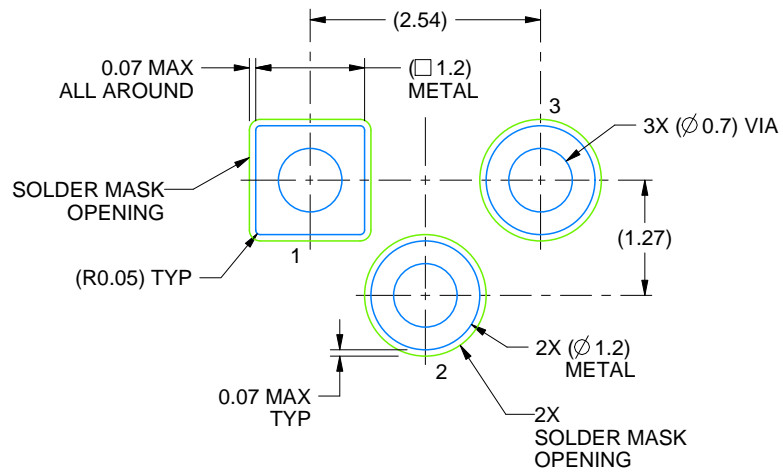
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-46.

# EXAMPLE BOARD LAYOUT

NDV0003H

TO-CAN - 2.67 mm max height

TRANSISTOR OUTLINE



LAND PATTERN EXAMPLE  
NON-SOLDER MASK DEFINED  
SCALE:12X

4219876/B 09/2024





D0008A

# PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

### NOTES:

- Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed  $.006$  [0.15] per side.
- This dimension does not include interlead flash.
- Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
 EXPOSED METAL SHOWN  
 SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

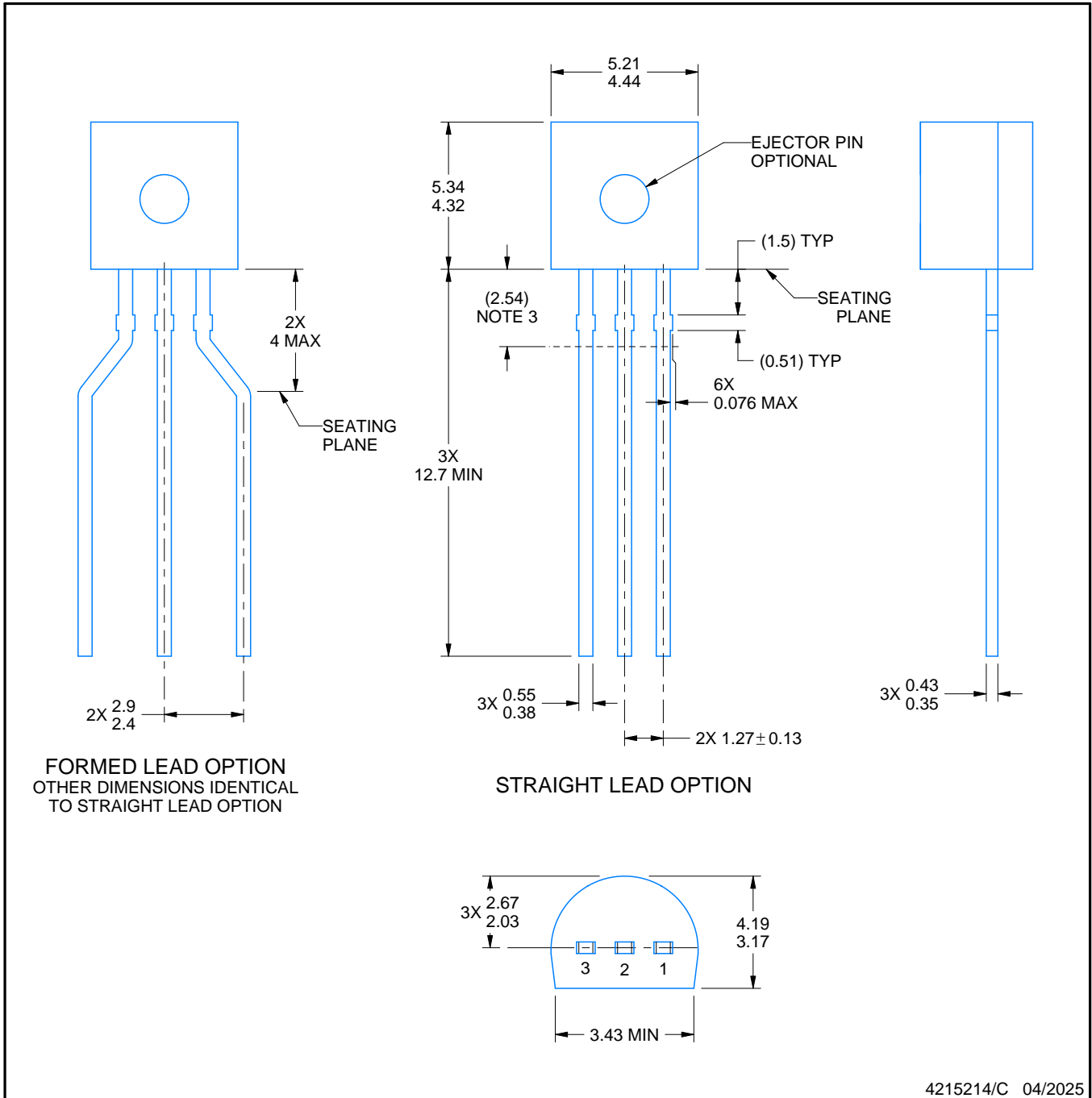
LP0003A



PACKAGE OUTLINE

TO-92 - 5.34 mm max height

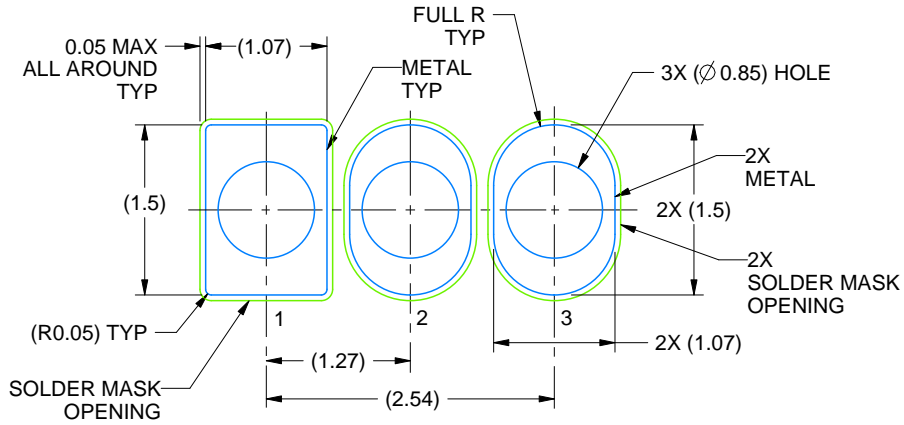
TO-92



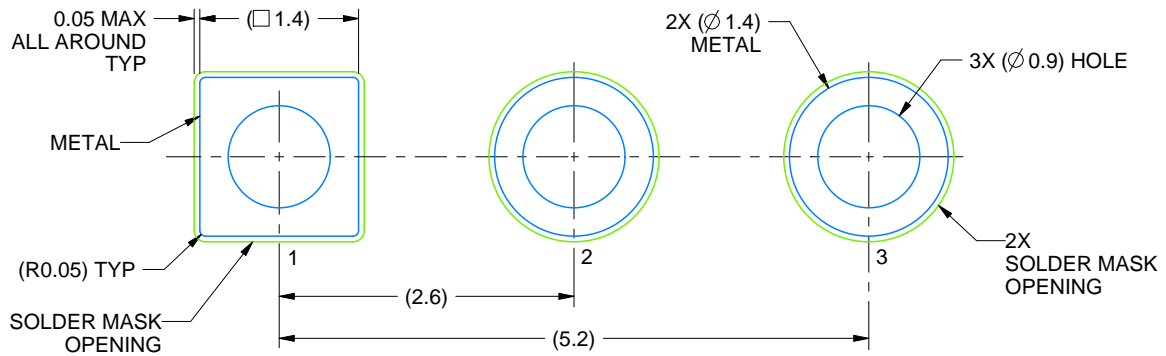
4215214/C 04/2025

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
  - a. Straight lead option available in bulk pack only.
  - b. Formed lead option available in tape and reel or ammo pack.
  - c. Specific products can be offered in limited combinations of shipping medium and lead options.
  - d. Consult product folder for more information on available options.



LAND PATTERN EXAMPLE  
STRAIGHT LEAD OPTION  
NON-SOLDER MASK DEFINED  
SCALE:15X



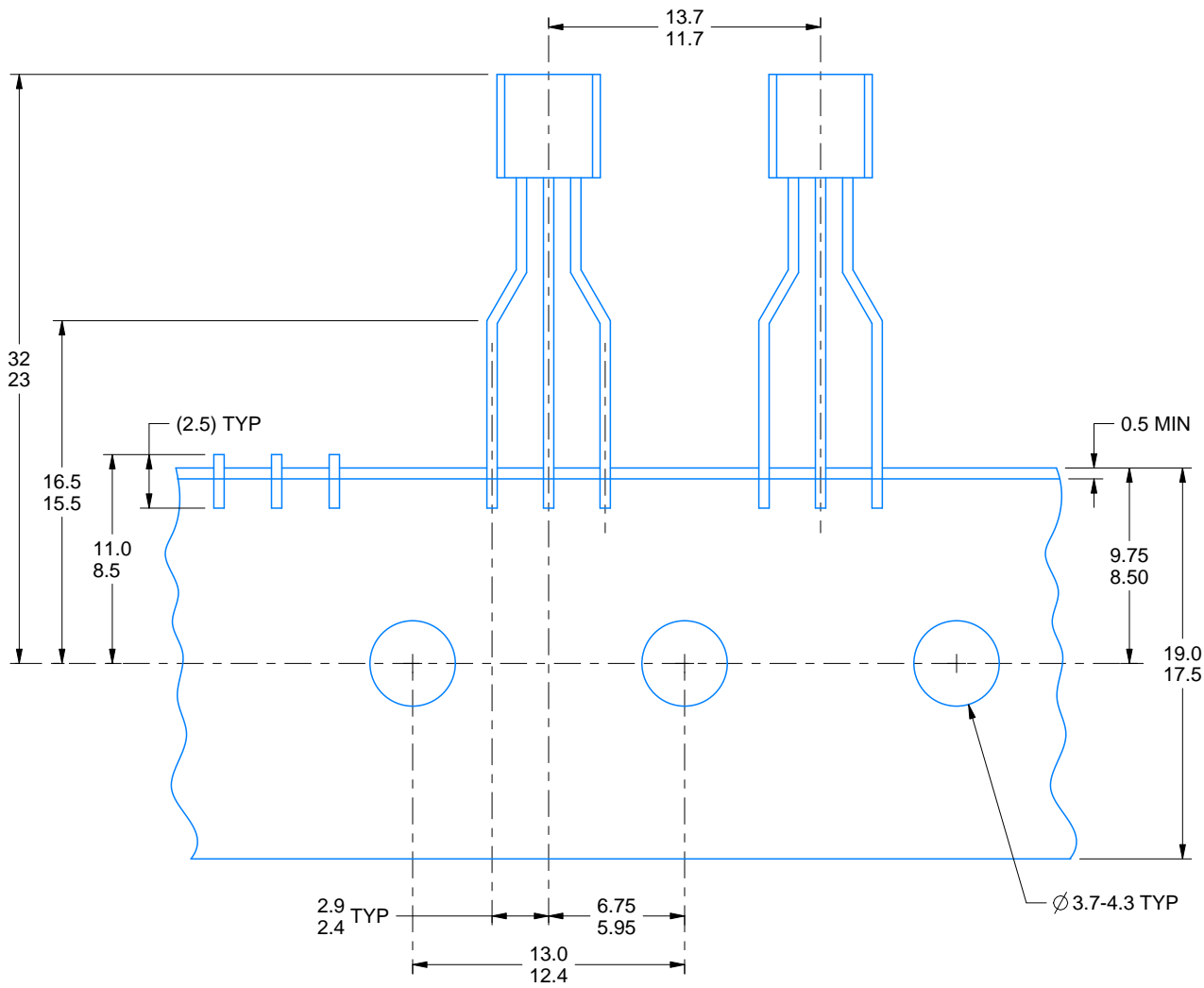
LAND PATTERN EXAMPLE  
FORMED LEAD OPTION  
NON-SOLDER MASK DEFINED  
SCALE:15X

**TAPE SPECIFICATIONS**

**LP0003A**

**TO-92 - 5.34 mm max height**

TO-92



FOR FORMED LEAD OPTION PACKAGE

4215214/C 04/2025

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2025, Texas Instruments Incorporated

Last updated 10/2025