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# LM134-LM234-LM334

## Three terminal adjustable current sources

## Features

- Operates from 1V to 40V
- 0.02%/V current regulation
- Programmable from 1µA to 10mA
- ±3% initial accuracy

## Description

The LM134/LM234/LM334 are 3-terminal adjustable current sources characterized by:

- an operating current range of 10000: 1
- an excellent current regulation
- a wide dynamic voltage range of 1V t 10V

The current is determined by an external resistor without requiring other external components.

Reverse voltages of up to 20V will only draw a current of several microamperes. This enables the circuit to operate as a rectifier and as a source of current in a.c. applications.

For the LM134/LM234/LM334, the voltage on the control pin is 64mV at +25°C and is directly proportional to the absolute temperature (°K). The simplest external resistor connection generates a current with approximately 0.33%/°C temperature dependence. Zero drift can be obtained by adding an additional resistor and a diode to the external circuit.



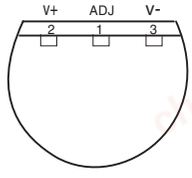
**Z**
**TO-92**
(Plastic package)



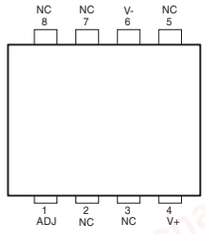
**D**
**SO-8**
(Plastic micropackage)

**Pin connections**

**TO-92**
(Bottom view)




**SO-8**
(Top view)





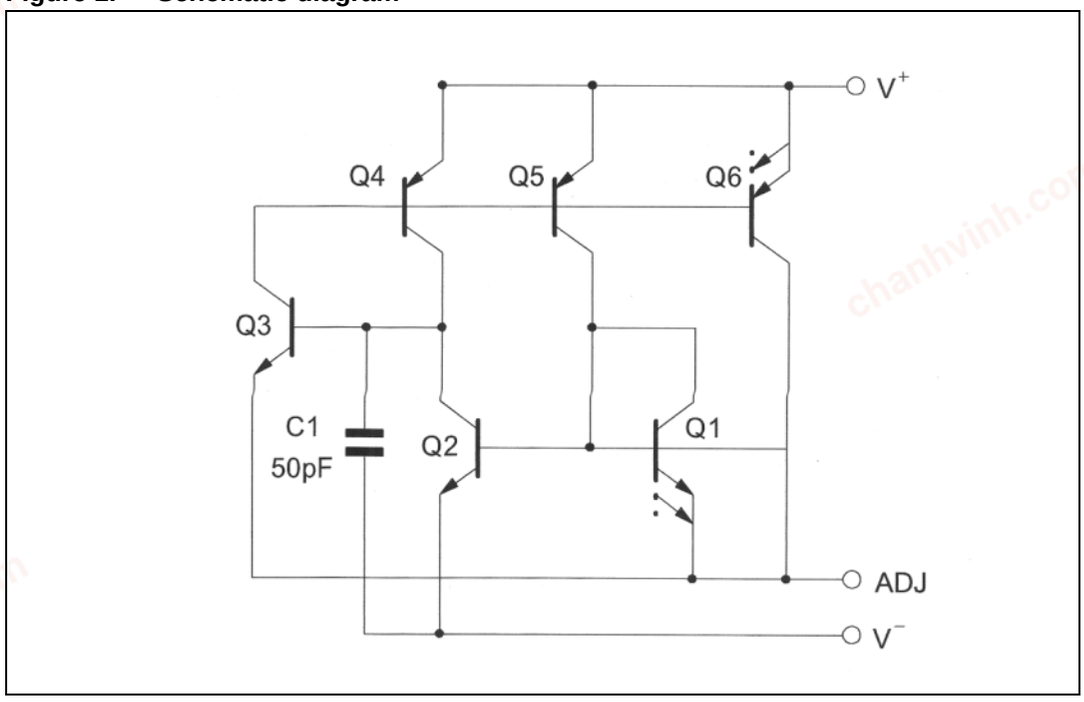

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# 1 Schematic diagram

**Figure 1. Schematic diagram**




# 2 Absolute maximum ratings

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | LM134 | LM234 | LM334 | Unit |
|---|---|---|---|---|---|
| | Voltage V+ to V-<br>Forward<br>Reverse | 40<br>20 | | 30<br>20 | V |
| $V_{ADJ}$- | ADJ pin to V- voltage | 5 | | | V |
| $I_{set}$ | Set current | 10 | | | mA |
| $P_{tot}$ | Power dissipation | 400 | | | mW |
| $T_{stg}$ | Storage temperature range | -65 to +150 | | | °C |
| $T_{oper}$ | Operating free-air temperature range | -55 to +125 | -25 to +100 | 0 to +70 | °C |

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# 3 Electrical characteristics

$T_j$ = +25°C with pulse testing so that junction temperature does not change during testing (unless otherwise specified)

**Table 2. Electrical characteristics**

| Parameter | LM134 - LM234 | | | LM334 | | | Unit |
|---|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| Set current error ($V^+$ = +2.5V) -(1)<br>10µA ≤ $I_{set}$ ≤ 1mA<br>1mA ≤ $I_{set}$ ≤ 5mA<br>2µA ≤ $I_{set}$ ≤ 10µA | | | <br>3<br>5<br>8 | | | <br>6<br>8<br>12 | <br>% |
| Ratio of set current to V. current<br>10µA ≤ $I_{set}$ ≤ 1mA<br>1mA ≤ $I_{set}$ ≤ 5mA<br>2µA ≤ $I_{set}$ ≤ 10µA | <br>14 | <br>18<br>14<br>14 | <br>23 | <br>14 | <br>18<br>14<br>14 | <br>26 | |
| Minimum operating voltage<br>2µA ≤ $I_{set}$ ≤ 100µA<br>100µA ≤ $I_{set}$ ≤ 1mA<br>1mA ≤ $I_{set}$ ≤ 5mA | | <br>0.8<br>0.9<br>1 | | | <br>0.8<br>0.9<br>1 | | <br>V |
| Average change in set current with input voltage<br>2µA ≤ $I_{set}$ ≤ 1mA<br>+1.5V ≤ $V^+$ ≤ +5V<br>+5V ≤ $V^+$ ≤ +40V<br>1mA ≤ $I_{set}$ ≤ 5mA<br>+1.5V ≤ $V^+$ ≤ +5V<br>+5V ≤ $V^+$ ≤ +40V | | <br><br>0.02<br>0.01<br><br>0.03<br>0.02 | <br><br>0.05<br>0.03 | | <br><br>0.02<br>0.01<br><br>0.03<br>0.02 | <br><br>0.1<br>0.05 | <br><br>% / V |
| Temperature dependence of set current - (2)<br>25µA ≤ $I_{set}$ ≤ 1mA | <br>0.96 T | <br>T | <br>1.04 T | <br>0.96 T | <br>T | <br>1.04 T | |
| Effective shunt capacitance | | 15 | | | 15 | | pF |

1. The set current is the current flowing into the V+ pin. It is determined by the following formula:
   $I_{set}$ = 67.7mV/$R_{set}$ ($T_j$ = +25°C)
   The set current error is expressed as a percent deviation from this amount.
2. $I_{set}$ is directly proportional to absolute temperature (°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 To (°K).

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**Figure 2. Output impedance**

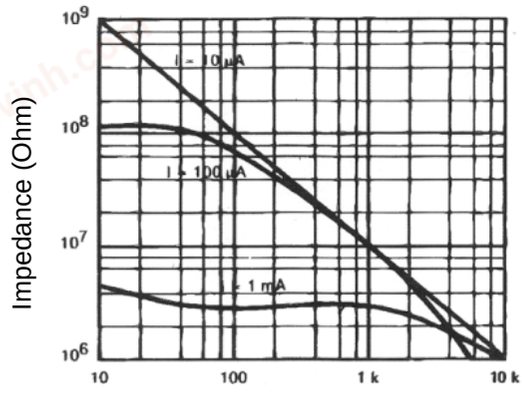



**Figure 3. Maximum slew rate for linear operation**

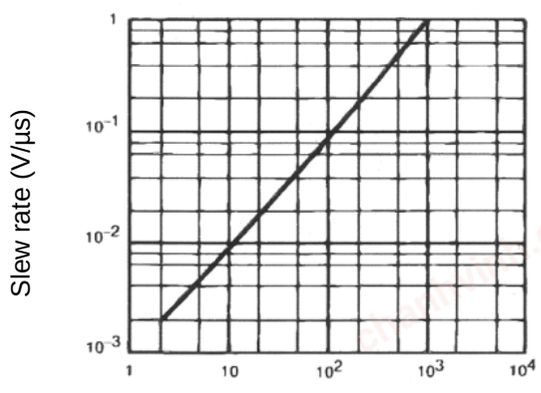



**Figure 4. Startup**

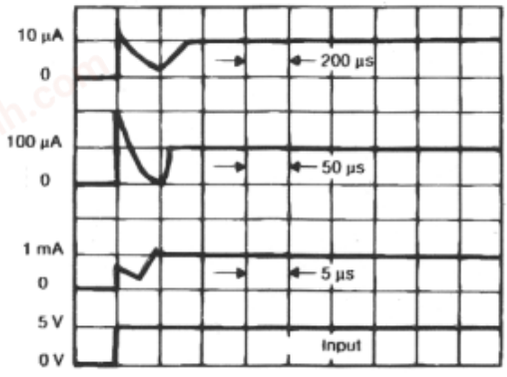



**Figure 5. Transient response**

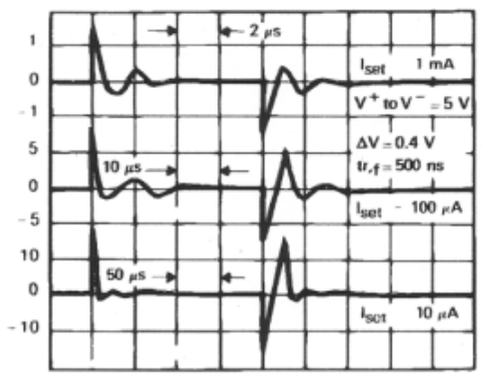



**Figure 6. Voltage across $R_{set}$**

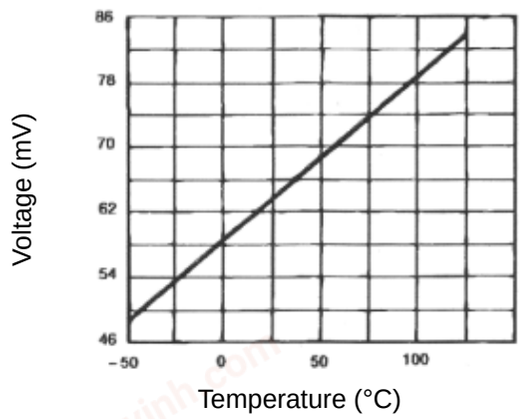
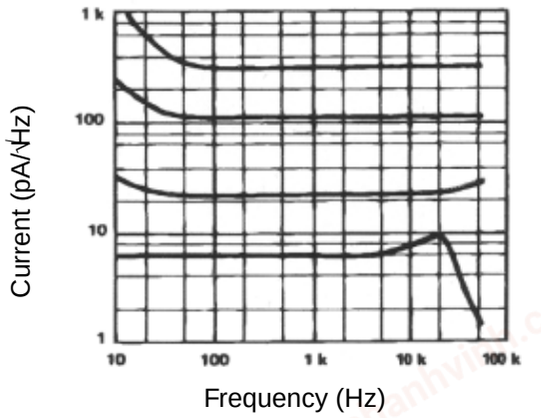



**Figure 7. Current noise**



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**Figure 8. Turn-on voltage**

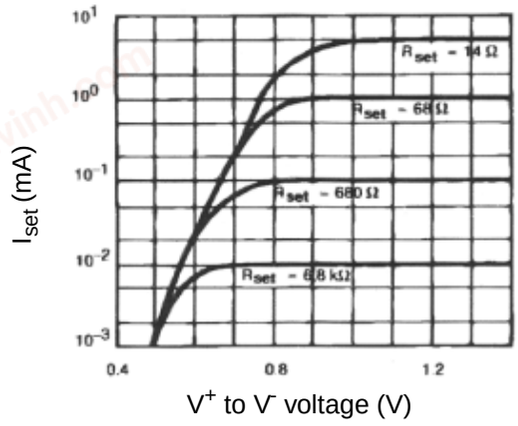
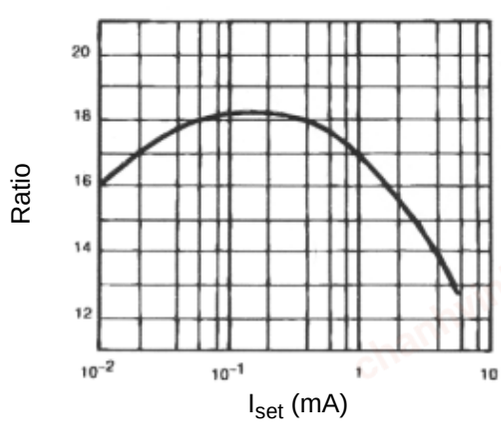



**Figure 9. Ratio of $I_{set}$ to $V^-$ current**



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# 4 Application information

## 4.1 Slew rate

At slew rates above a threshold (see *Figure 4* and *Figure 5*), the LM134, LM234, LM334 can have a non-linear current characteristic. The slew rate at which this takes place is directly proportional to $I_{set}$. At $I_{set}$ = 10µA, dv/dt max. = 0.01V/µs ; at $I_{set}$ = 1mA, dv/dt max. = 1V/µs. Slew rates of more than 1V/µs do not damage the circuit nor do they produce high currents.

## 4.2 Thermal effects

Internal heating can have a significant effect on current regulation for an $I_{set}$ above 100µA. For example, each increase of 1V in the voltage across the LM134 at $I_{set}$ = 1mA will increase the junction temperature by ≈ 0.4°C (in still air). The output current ($I_{set}$) has a temperature coefficient of about 0.33%/°C. Thus the change in current due to the increase in temperature will be (0.4) (0.33) = 0.132%. This is a degradation of 10 : 1 in regulation versus the true electrical effects. Thermal effects should be taken into account when d.c. regulation is critical and $I_{set}$ is higher than 100µA.

## 4.3 Shunt capacitance

In certain applications, the 15pF value for the shunt capacitance should be reduced:

- because of loading problems,
- because of limitation of output impedance of the current source in a.c. applications.

You can easily reduce the capacitance by adding a FET as shown in *Typical applications on page 8*.

The value of this capacitance can be reduced by at least 3pF and regulation can be improved by an order of magnitude without any modifications of the d.c. characteristics (except for the minimum input voltage).

## 4.4 Noise

The current noise produced by LM134, LM234, and LM334 is about 4 times that of a transistor. If the LM134, LM234, LM334 is used as an active load for a transistor amplifier, the noise at the input will increase by about 12dB. In most cases this is acceptable, and a single amplifier can be built with a voltage gain higher than 2000.

## 4.5 Lead resistance

The sense voltage which determines the current of the LM134, LM234, LM334 is less than 100mV. At this level, the thermocouple effects and the connection resistance should be reduced by locating the current setting resistor close to the device. Do not use sockets for the ICs. A contact resistance of 0.7Ω is sufficient to decrease the output current by 1% at the 1mA level.

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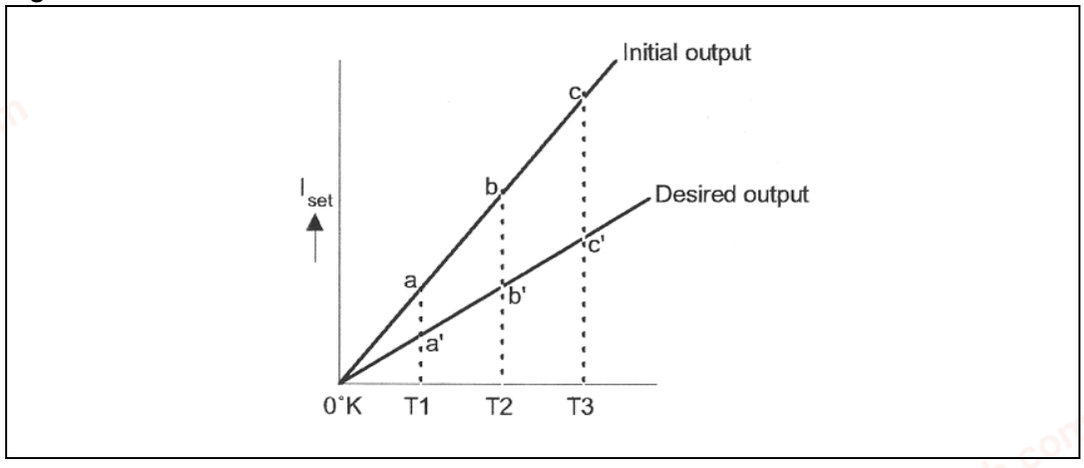
## 4.6 Sensing temperature

The LM134, LM234, LM334 are excellent remote controlled temperature sensors because their operation as current sources preserves their accuracy even in the case of long connecting wires. The output current is directly proportional to the absolute temperature in Kelvin degrees according to the following equation.

$$I_{set} = \frac{(227\mu V/°K)\ (T)}{R_{set}}$$

The calibration of the LM134, LM234, LM334 is simplified by the fact that most of the initial accuracy is due to gain limitation (slope error) and not an offset. Gain adjustment is a one point trim because the output of the device extrapolates to zero at 0°K.

**Figure 10. Device calibration**




This particularity of the LM134, LM234, LM334 is illustrated in the above diagram. Line abc represents the sensor current before adjustment and line a'b'c' represents the desired output. A gain adjustment provided at T2 will move the output from b to b' and will correct the slope at the same time so that the output at T1 and T3 will be correct. This gain adjustment can be carried out by means of $R_{set}$ or the load resistor used in the circuit. After adjustment, the slope error should be less than 1%. A low temperature coefficient for $R_{set}$ is necessary to keep this accuracy. A 33ppm/°C temperature drift of $R_{set}$ will give an error of 1% on the slope because the resistance follows the same temperature variations as the LM134, LM234, LM334.

Three wires are required to isolate $R_{set}$ from the LM134, LM234, LM334. Since this solution is not recommended, metal-film resistors with a drift of less than 20ppm/°C are now available. Wirewound resistors can be used when very high stability is required.

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## Typical applications

**Figure 11. Basic 2-terminal current source**

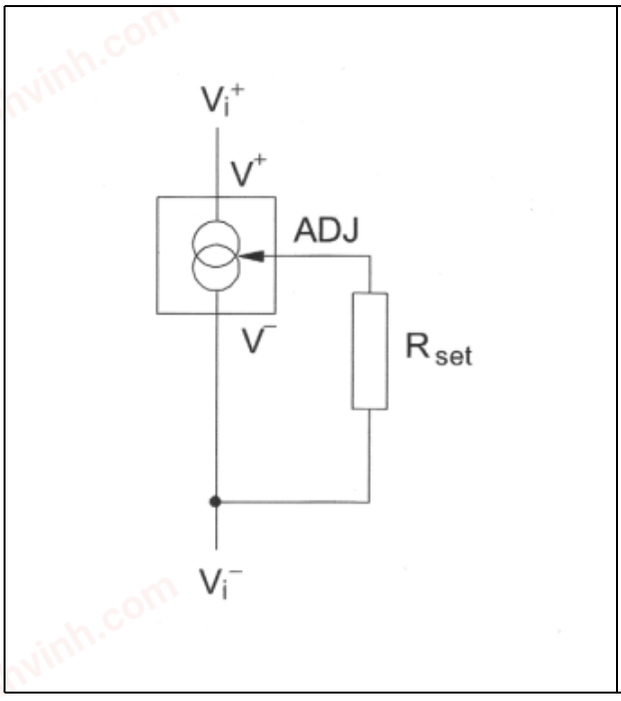



**Figure 12. Alternate trimming technique**

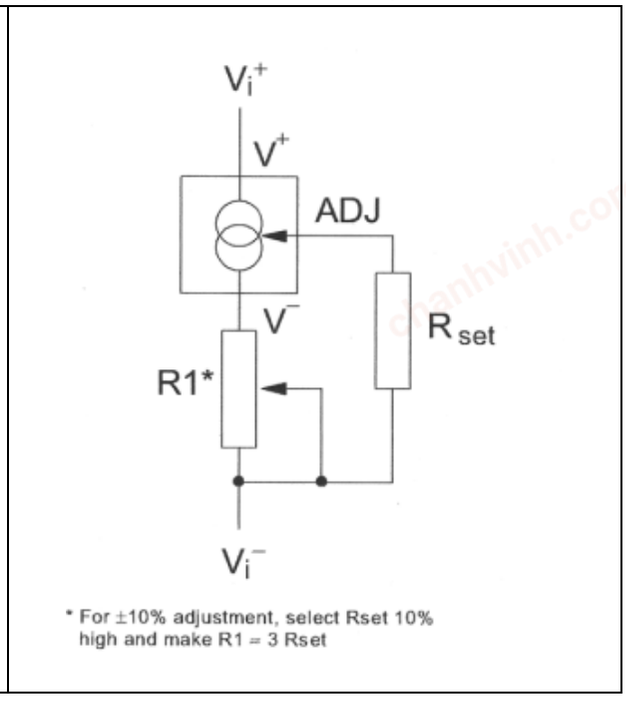



**Figure 13. Terminating remote sensor for voltage output**

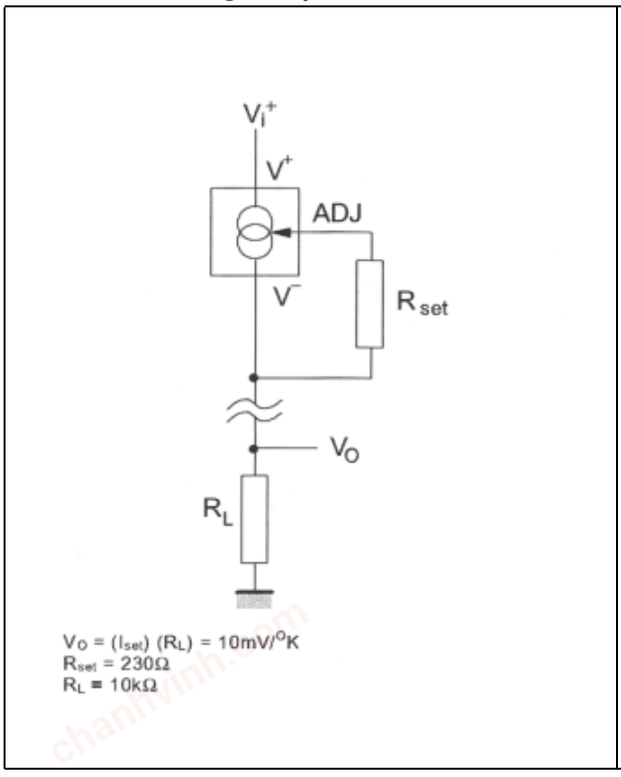
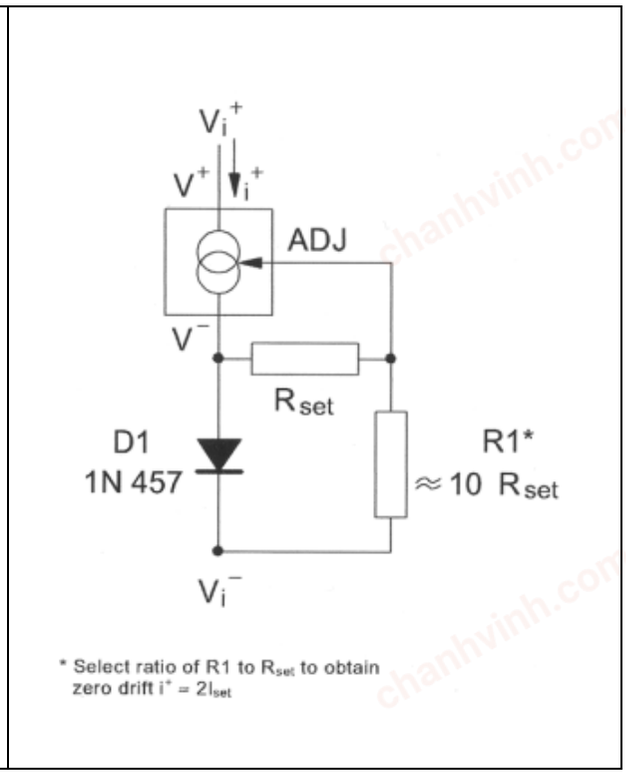


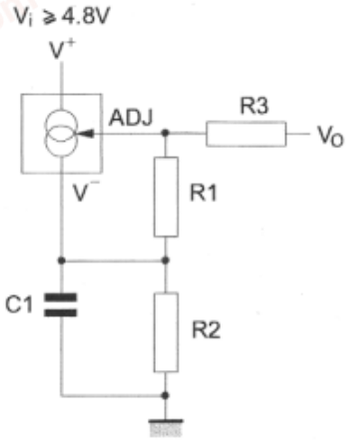

**Figure 14. Zero temperature coefficient current source**



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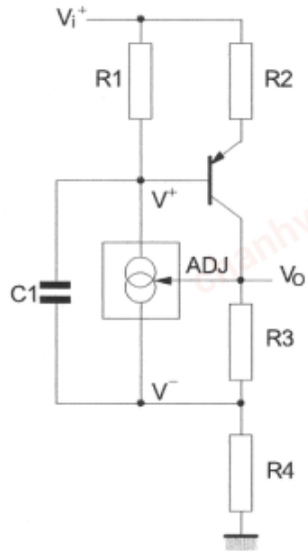
**Figure 15. Low output impedance thermometer**




R1 = 230Ω, 1% $V_O$ = 10mV/°K
R2 = 10kΩ, 1% $Z_O$ ≤ 100Ω
R3 = 600Ω

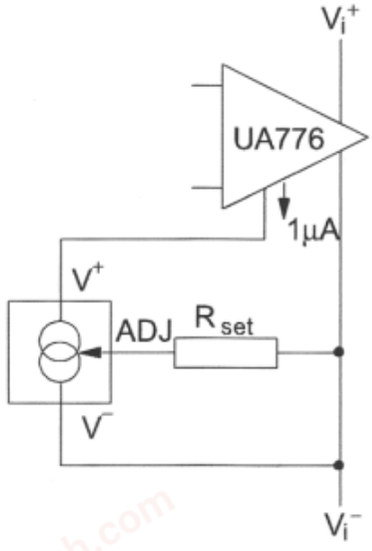
Output impedance of the LM134, LM234, LM334 at the "ADJ" pin is approximately $\frac{-R_o\Omega}{16}$ where $R_o$ is the equivalent external resistance connected to the V⁻ pin. This negative resistance can be reduced by a factor of 5 or more by inserting an equivalent resistor in series with the output

**Figure 16. Low output impedance thermometer**



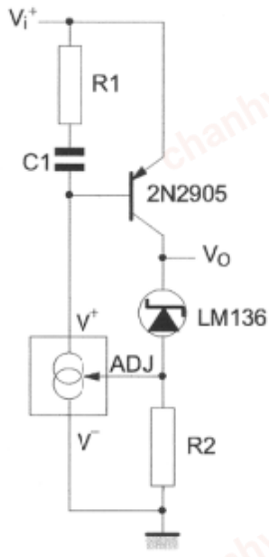

R1 = 15kΩ
R2 = 300Ω
R3 = 100Ω
R4 = 4.5kΩ
C1 = 2.2nF
$V_O$ = 10mV/°K
$Z_O$ ≤ 2Ω

**Figure 17. Micropower bias**




$R_{set}$ = 68kΩ

**Figure 18. Low input voltage reference driver**

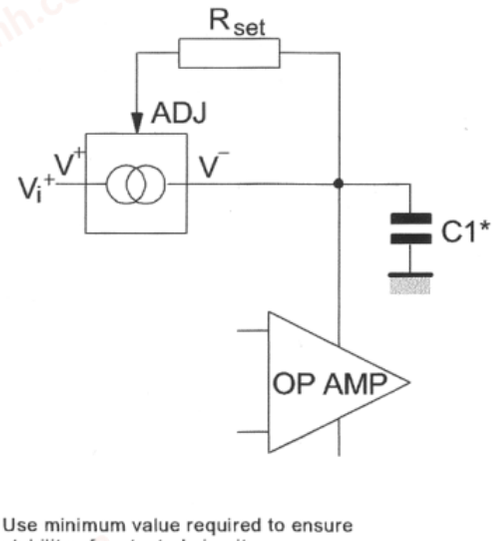



R1 = 1.5kΩ
R2 = 120Ω
C1 = 0.1µF
$I_O$ ≤ 3mA
$V_I$ ≥ Vref +200mV
$V_O$ = $V_Z$ +64mV (+25°C)

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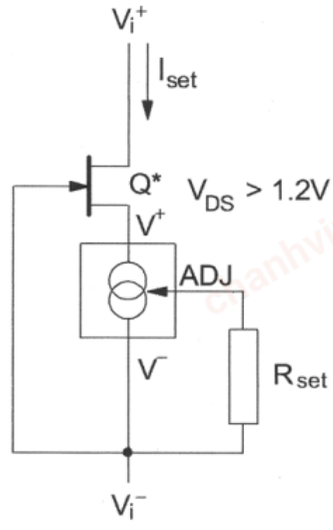


**Figure 19. In-line current limiter**




* Use minimum value required to ensure stability of protected circuit

**Figure 20. Fet cascading for low capacitance**




* Select Q to ensure at least 1V across the LM134, LM234, LM334. $V_P\ (1 - I_{set}/I_{DSS}) \geq 1.2V$

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# 5 Package information

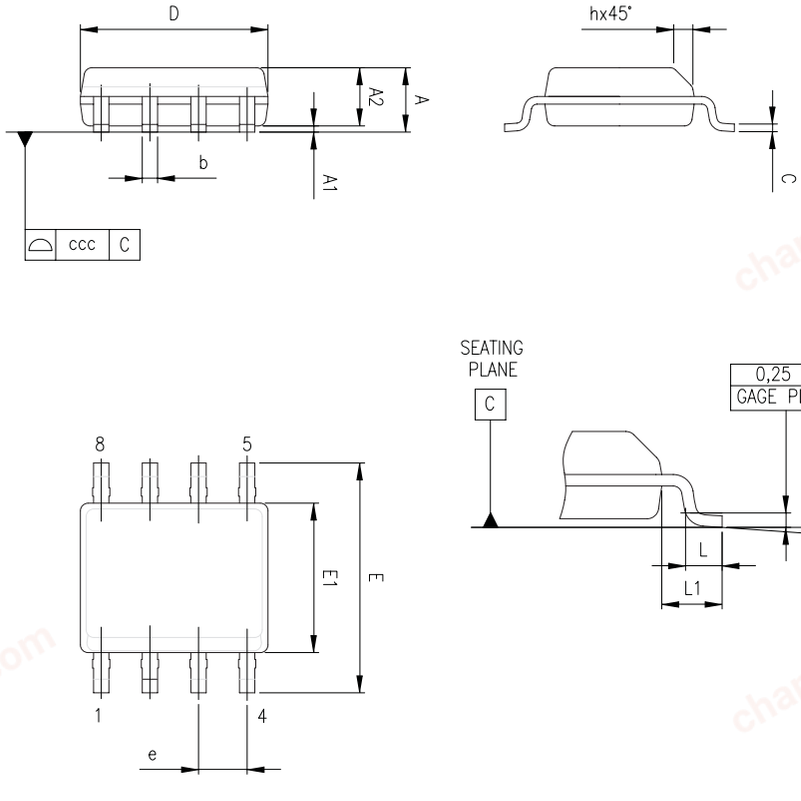
In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: www.st.com.

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## 5.1 SO-8 package mechanical data

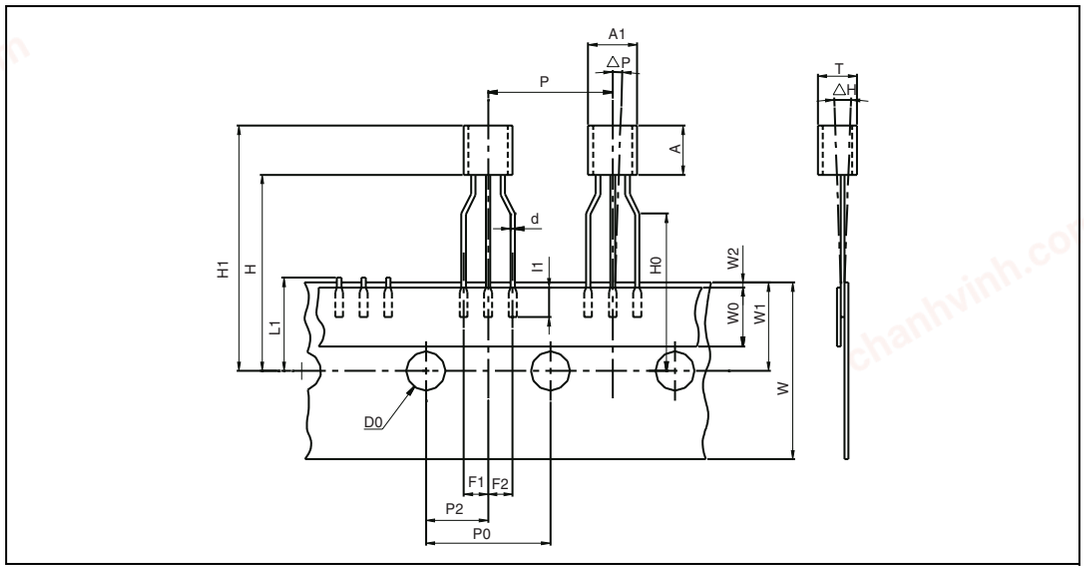
| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.25 | | | 0.049 | | |
| b | 0.28 | | 0.48 | 0.011 | | 0.019 |
| c | 0.17 | | 0.23 | 0.007 | | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| H | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | | 1.27 | | | 0.050 | |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| k | 1° | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |



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## 5.2 TO-92 ammopack and tape & reel package mechanical data

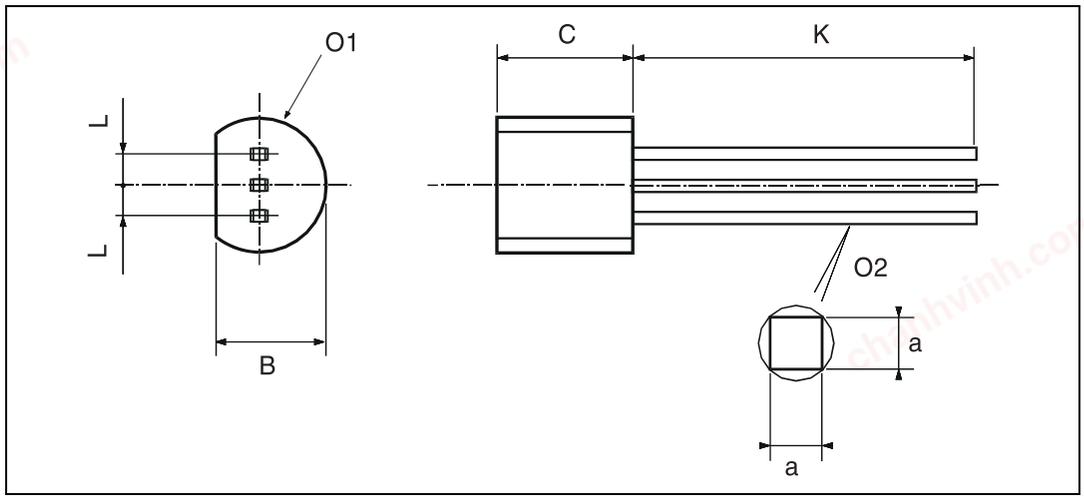



| Dim. | Millimeters | | | Inches | | |
|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| AL | | | 5.0 | | | 0.197 |
| A | | | 5.0 | | | 0.197 |
| T | | | 4.0 | | | 0.157 |
| d | | 0.45 | | | 0.018 | |
| I1 | 2.5 | | | 0.098 | | |
| P | 11.7 | 12.7 | 13.7 | 0.461 | 0.500 | 0.539 |
| PO | 12.4 | 12.7 | 13 | 0.488 | 0.500 | 0.512 |
| P2 | 5.95 | 6.35 | 6.75 | 0.234 | 0.250 | 0.266 |
| F1/F2 | 2.4 | 2.5 | 2.8 | 0.094 | 0.098 | 0.110 |
| Δh | -1 | 0 | 1 | -0.039 | 0 | 0.039 |
| ΔP | -1 | 0 | 1 | -0.039 | 0 | 0.039 |
| W | 17.5 | 18.0 | 19.0 | 0.689 | 0.709 | 0.748 |
| W0 | 5.7 | 6 | 6.3 | 0.224 | 0.236 | 0.248 |
| W1 | 8.5 | 9 | 9.75 | 0.335 | 0.354 | 0.384 |
| W2 | | | 0.5 | | | 0.020 |
| H | | | 20 | | | 0.787 |
| H0 | 15.5 | 16 | 16.5 | 0.610 | 0.630 | 0.650 |
| H1 | | | 25 | | | 0.984 |
| DO | 3.8 | 4.0 | 4.2 | 0.150 | 0.157 | 0.165 |
| L1 | | | 11 | | | 0.433 |

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## 5.3 TO-92 bulk package mechanical data




| Dim. | Millimeters | | | Inches | | |
|---|---|---|---|---|---|---|
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| L | | 1.27 | | | 0.05 | |
| B | 3.2 | 3.7 | 4.2 | 0.126 | 0.1457 | 0.1654 |
| O1 | 4.45 | 5.00 | 5.2 | 0.1752 | 0.1969 | 0.2047 |
| C | 4.58 | 5.03 | 5.33 | 0.1803 | 0.198 | 0.2098 |
| K | 12.7 | | | 0.5 | | |
| O2 | 0.407 | 0.5 | 0.508 | 0.016 | 0.0197 | 0.02 |
| a | 0.35 | | | 0.0138 | | |

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# 6 Ordering information

**Table 3. Order codes**

| Part number | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| LM134D/DT | -55°C to +125°C | SO-8 | Tube or Tape & reel | LM134 |
| LM134Z/ZT/AP | -55°C to +125°C | TO-92 | Bulk or Tape & reel or Ammopack | LM134 |
| LM234D/DT | -25°C to +100°C | SO-8 | Tube or Tape & reel | LM234 |
| LM234Z/ZT/AP | -24°C to +100°C | TO-92 | Bulk or Tape & reel or Ammopack | LM234 |
| LM334D/DT | -0°C to +70°C | SO-8 | Tube or Tape & reel | LM334 |
| LM334Z/ZT/AP | -0°C to +70°C | TO-92 | Bulk or Tape & reel or Ammopack | LM334 |
| LM334AD/ADT | -0°C to +70°C | SO-8 | Tube or Tape & reel | LM334A |
| LM334AZ/AZT/AAP | -0°C to +70°C | TO-92 | Bulk or Tape & reel or Ammopack | LM334A |

# 7 Revision history

| Date | Revision | Changes |
|---|---|---|
| 2-May-2003 | 1 | Initial release. |
| 28-Oct-2005 | 2 | Internal revision. |
| 29-May-2007 | 3 | Corrected error in pinout diagram for TO-92 package on cover page (it is a bottom view, not a top view).<br>Updated *Section 5: Package information* and expanded *Table 3: Order codes*. |

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