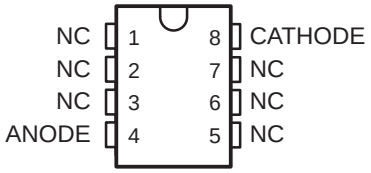
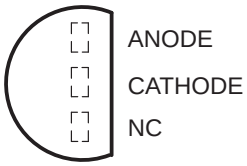
- **Operating Current Range . . . 20 μA to 20 mA**
- **1.5% and 3% Initial Voltage Tolerance**
- **Reference Impedance**
  - **LM385 . . . 1 Ω Max at 25°C**
  - **All Devices . . . 1.5 Ω Max Over Full Temperature Range**
- **Very Low Power Consumption**
- **Applications:**
  - **Portable Meter References**
  - **Portable Test Instruments**
  - **Battery-Operated Systems**
  - **Current-Loop Instrumentation**
  - **Panel Meters**
- **Designed to be Interchangeable With National LM285-2.5 and LM385-2.5**

**D PACKAGE**
**(TOP VIEW)**




**LP PACKAGE**
**(TOP VIEW)**




NC–No internal connection

## description

These micropower two-terminal band-gap voltage references operate over a 20-μA to 20-mA current range and feature exceptionally low dynamic impedance and good temperature stability. On-chip trimming provides tight voltage tolerance. The band-gap reference for these devices has low noise and long-term stability.

The design makes these devices exceptionally tolerant of capacitive loading and thus, easier to use in most reference applications. The wide dynamic operating temperature range accommodates varying current supplies with excellent regulation.

The extremely low power drain of this series makes them useful for micropower circuitry. These voltage references can make portable meters, regulators, or general-purpose analog circuitry with battery life approaching shelf life. The wide operating current range allows them to replace older references with tighter-tolerance parts.

The LM285-2.5 is characterized for operation from –40°C to 85°C. The LM385-2.5 and LM385B-2.5 are characterized for operation from 0°C to 70°C.

**AVAILABLE OPTIONS**

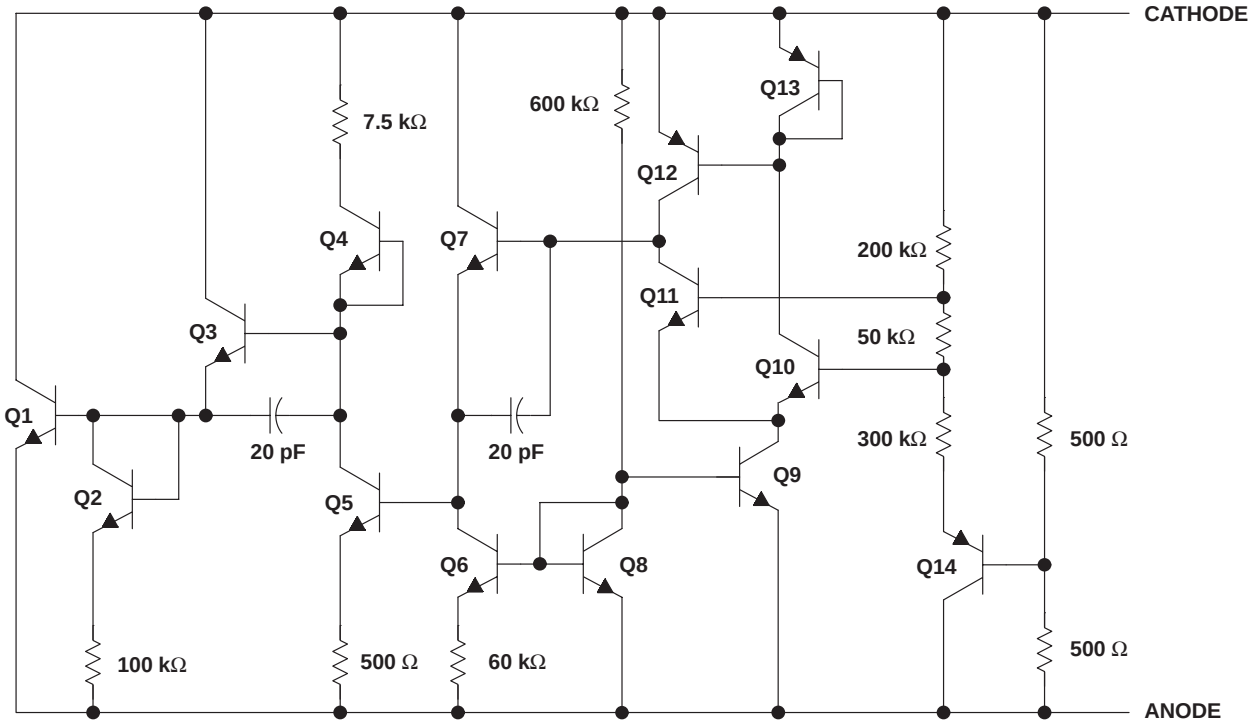
| $T_A$ | $V_Z$ TOLERANCE | PACKAGED DEVICES | | CHIP FORM (Y) |
|---|---|---|---|---|
| | | SMALL OUTLINE (D) | PLASTIC (LP) | |
| 0°C to 70°C | 3% | LM385D-2.5 | LM385LP-2.5 | LM385Y-2.5 |
| | 1.5% | LM385BD-2.5 | LM385BLP-2.5 | |
| –40°C to 85°C | 1.5% | LM285D-2.5 | LM285LP-2.5 | |

The D package is available taped and reeled. Add the suffix R to the device type (e.g., LM385DR-2-5). Chip forms are tested at 25°C.
For ordering purposes, the decimal point in the part number must be replaced with a hyphen (i.e., show the -2.5 suffix as "-2-5").

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.

## logic symbol


## schematic




NOTE A: All component values shown are nominal.

## absolute maximum ratings over operating free-air temperature range†

Reverse current, $I_R$ . . . . . 30 mA
Forward current, $I_F$ . . . . . 10 mA
Package thermal impedance, $\theta_{JA}$ (see Notes 1 and 2): D package . . . . . 97°C/W
LP package . . . . . 156°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°C
Storage temperature range, $T_{stg}$ . . . . . –65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. Maximum power dissipation is a function of $T_{J(max)}$, $\theta_{JA}$, and $T_A$. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} - T_A)/\theta_{JA}$. Operation at the absolute maximum $T_J$ of 150°C can impact reliability.
2. The package thermal impedance is calculated in accordance with JESD 51, except for through-hole packages which use a trace length of zero.

## recommended operating conditions

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| Reference current, $I_Z$ | | 0.02 | 20 | mA |
| Operating free-air temperature range, $T_A$ | LM285-2.5 | –40 | 85 | °C |
| | LM385-2.5, LM385B-2.5 | 0 | 70 | |

## electrical characteristics at specified free-air temperature

| PARAMETER | | TEST CONDITIONS | $T_A$† | LM285-2.5 | | | LM385-2.5 | | | LM385B-2.5 | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_Z$ | Reference voltage | $I_Z$ = 20 µA to 20 mA | 25°C | 2.462 | 2.5 | 2.538 | 2.425 | 2.5 | 2.575 | 2.462 | 2.5 | 2.538 | V |
| $\alpha_{VZ}$ | Average temperature coefficient of reference voltage‡ | $I_Z$ = 20 µA to 20 mA | 25°C | | ±20 | | | ±20 | | | ±20 | | ppm/°C |
| $\Delta V_Z$ | Change in reference voltage with current | $I_Z$ = 20 µA to 1 mA | 25°C | | | 1 | | | 2 | | | 2 | mV |
| | | | Full range | | | 1.5 | | | 2 | | | 2 | |
| | | $I_Z$ = 1 µA to 20 mA | 25°C | | | 10 | | | 20 | | | 20 | |
| | | | Full range | | | 30 | | | 30 | | | 30 | |
| $\Delta V_Z/\Delta t$ | Long-term change in reference voltage | $I_Z$ = 100 µA | 25°C | | ±20 | | | ±20 | | | ±20 | | ppm/khr |
| $I_{Z(min)}$ | Minimum reference current | | Full range | | 8 | 20 | | 8 | 20 | | 8 | 20 | µA |
| $z_z$ | Reference impedance | $I_Z$ = 100 µA | 25°C | | 0.2 | 0.6 | | 0.4 | 1 | | 0.4 | 1 | Ω |
| | | | Full range | | | 1.5 | | | 1.5 | | | 1.5 | |
| $V_n$ | Broadband noise voltage | $I_Z$ = 100 µA, f = 10 Hz to 10 kHz | 25°C | | 120 | | | 120 | | | 120 | | µV |

† Full range is 0°C to 70°C for the LM385-2.5 and LM385B-2.5, and –40°C to 85°C for the LM285-2.5.
‡ The average temperature coefficient of reference voltage is defined as the total change in reference voltage divided by the specified temperature range.

## electrical characteristics at $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | LM385Y-2.5 | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | |
| $V_Z$ | Reference voltage | $I_Z$ = 20 µA to 20 mA | 2.462 | 2.5 | 2.575 | V |
| $\alpha_{VZ}$ | Average temperature coefficient of reference voltage‡ | $I_Z$ = 20 µA to 20 mA | | ±20 | | ppm/°C |
| $\Delta V_Z/\Delta t$ | Long-term change in reference voltage | $I_Z$ = 100 µA | | ±20 | | ppm/khr |
| $z_z$ | Reference impedance | $I_Z$ = 100 µA | | 0.4 | 1 | Ω |
| $V_n$ | Broadband noise voltage | $I_Z$ = 100 µA, f = 10 Hz to 10 kHz | | 120 | | µV |

‡ The average temperature coefficient of reference voltage is defined as the total change in reference voltage divided by the specified temperature range.

## TYPICAL CHARACTERISTICS†

**REVERSE CURRENT vs REVERSE VOLTAGE**

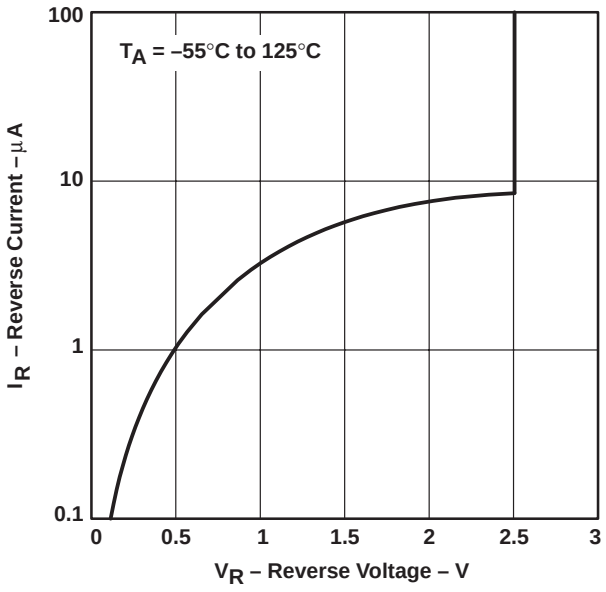



Figure 1

**REFERENCE VOLTAGE CHANGE vs REVERSE CURRENT**

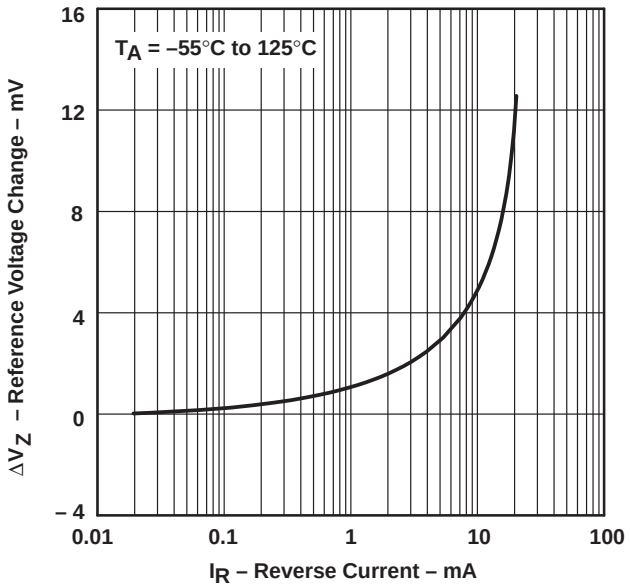



Figure 2

**FORWARD VOLTAGE vs FORWARD CURRENT**

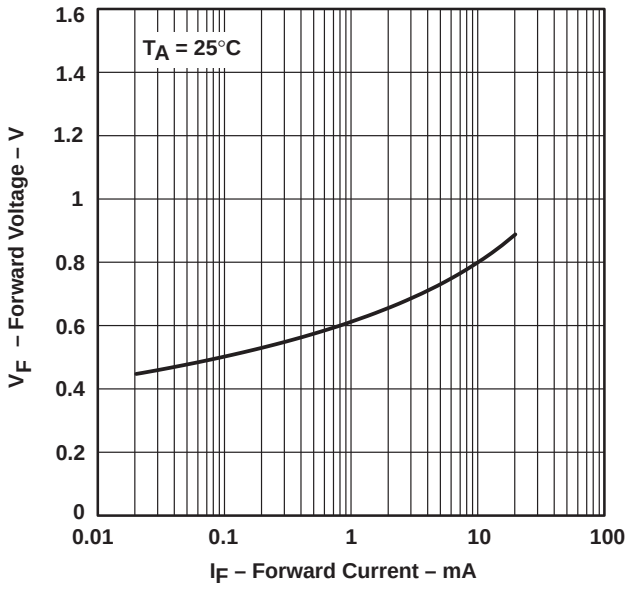



Figure 3

**REFERENCE VOLTAGE vs FREE-AIR TEMPERATURE**

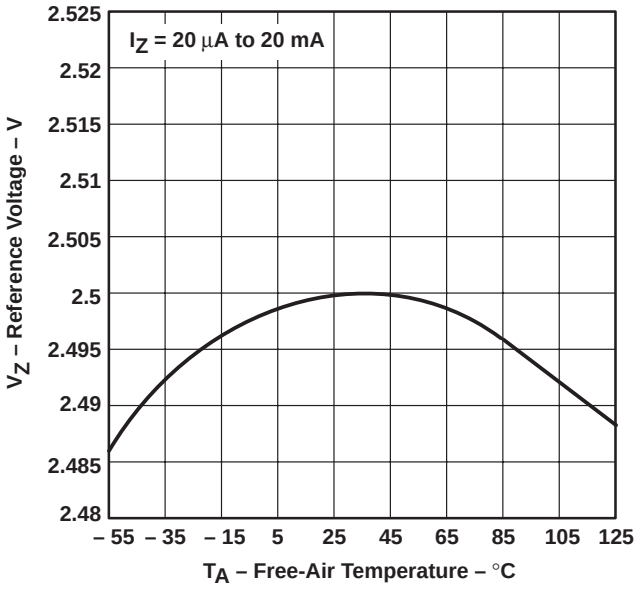



Figure 4

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS†

**REFERENCE IMPEDANCE vs REFERENCE CURRENT**

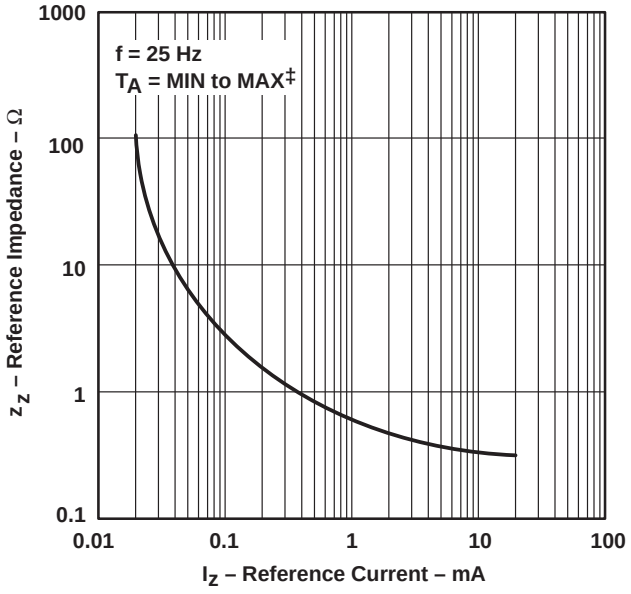



Figure 5

**REFERENCE IMPEDANCE vs FREQUENCY**

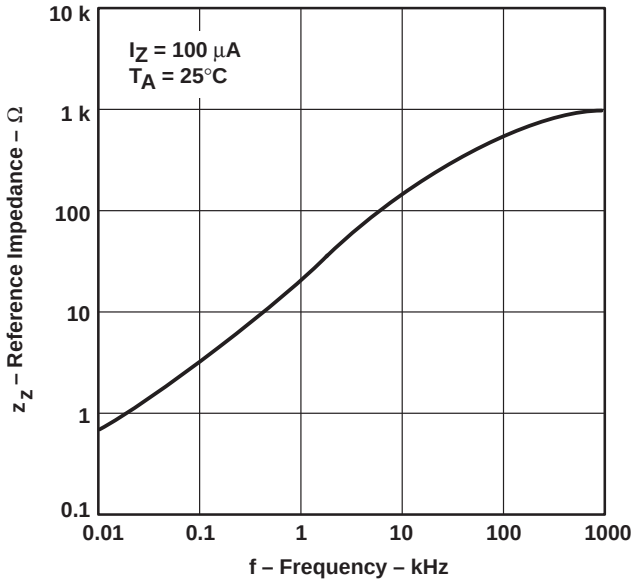



Figure 6

**NOISE VOLTAGE vs FREQUENCY**

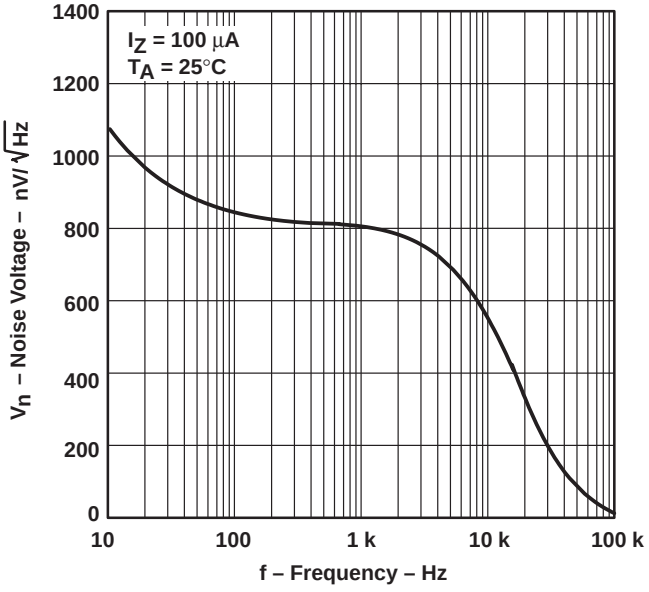



Figure 7

**FILTERED RMS OUTPUT NOISE VOLTAGE vs FREQUENCY**

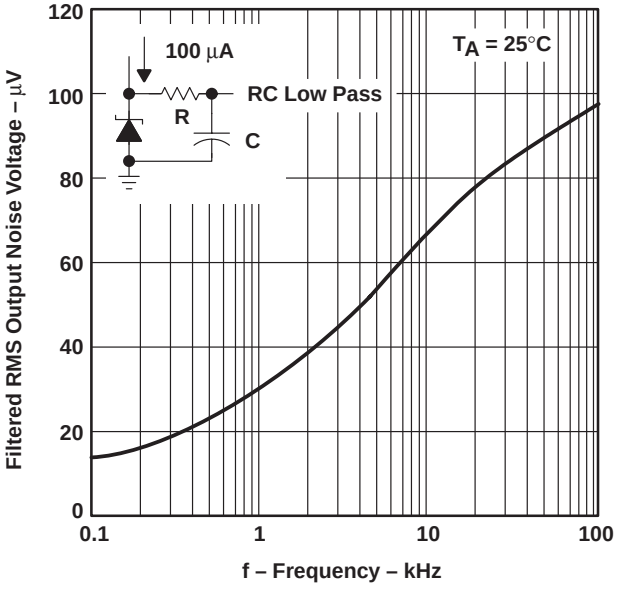



Figure 8

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

## TYPICAL CHARACTERISTICS†

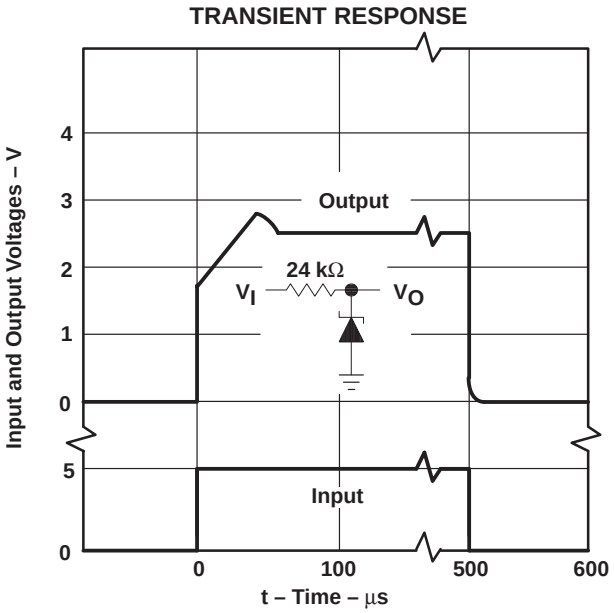
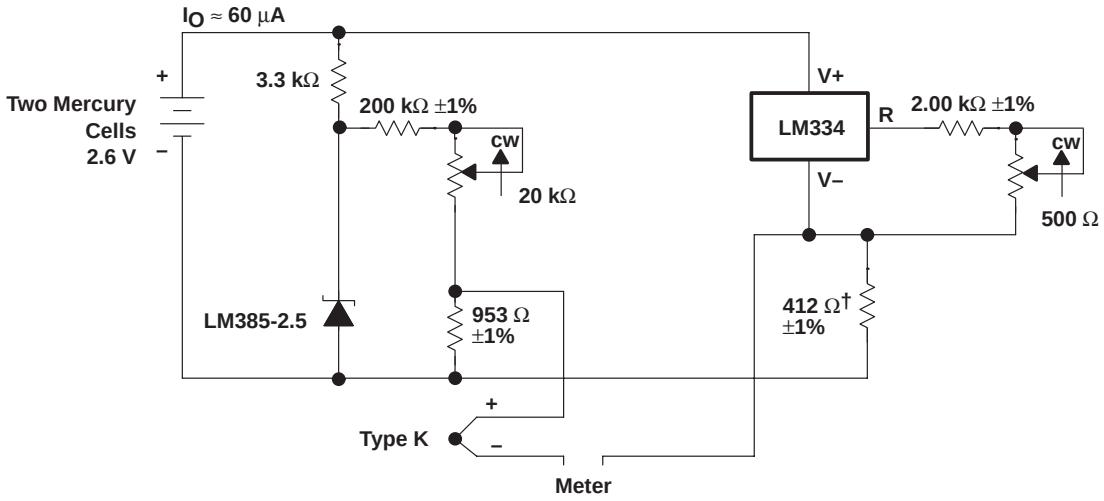



**Figure 9**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## APPLICATION INFORMATION




†Adjust for 12.17 mV at 25°C across 412 Ω

**Figure 10. Thermocouple Cold-Junction Compensator**

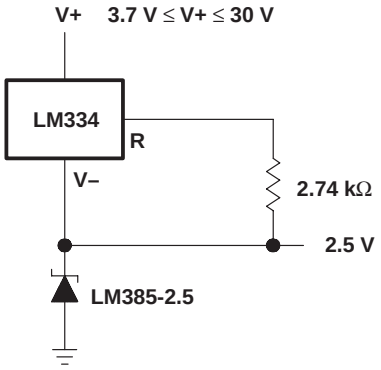



**Figure 11. Operation Over a Wide Supply Range**

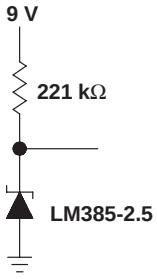



**Figure 12. Reference From a 9-V Battery**

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