

PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

 Check for Samples: [TL4050-Q1](#)

FEATURES

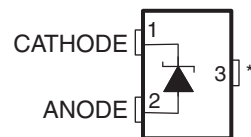
- Qualified for Automotive Applications
- Fixed Output Voltages of 2.048 V, 2.5 V, 4.096 V, 5 V, 8.192 V, and 10 V
- Tight Output Tolerances and Low Temperature Coefficient
 - Max 0.1%, 50 ppm/°C – A Grade
 - Max 0.2%, 50 ppm/°C – B Grade
 - Max 0.5%, 50 ppm/°C – C Grade
- Low Output Noise: 41 μV_{RMS} Typ
- Wide Operating Current Range: 60 μA Typ to 15 mA
- Stable With All Capacitive Loads; No Output Capacitor Required

- Available in Extended Temperature Range: –40°C to 125°C

APPLICATIONS

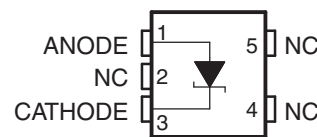
- Data-Acquisition Systems
- Power Supplies and Power-Supply Monitors
- Instrumentation and Test Equipment
- Process Controls
- Precision Audio
- Automotive Electronics
- Energy Management
- Battery-Powered Equipment

DBZ (SOT-23-3) PACKAGE
(TOP VIEW)



*Pin 3 is attached to Substrate and must be connected to ANODE or left open.

DCK (SC-70) PACKAGE
(TOP VIEW)



NC – No internal connection

DESCRIPTION/ORDERING INFORMATION

The TL4050 series of shunt voltage references are versatile easy-to-use references suitable for a wide array of applications. The two-terminal fixed-output device requires no external capacitors for operation and is stable with all capacitive loads. Additionally, the reference offers low dynamic impedance, low noise, and low temperature coefficient to ensure a stable output voltage over a wide range of operating currents and temperatures.

The TL4050 is offered in three initial tolerances, ranging from 0.1% (max) for the A grade to 0.5% (max) for the C grade. Thus, a great deal of flexibility is offered to designers in choosing the best cost-to-performance ratio for their applications. Packaged in the space-saving SOT-23-3 and SC-70 packages and requiring a minimum current of 45 μA (typ), the TL4050 also is ideal for portable applications.

The TL4050xI is characterized for operation over an ambient temperature range of –40°C to 85°C. The TL4050xQ is characterized for operation over an ambient temperature range of –40°C to 125°C.



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.

ORDERING INFORMATION⁽¹⁾

| T _A | DEVICE GRADE | V _{KA} | PACKAGE ⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|--|-----------------|------------------------|--------------|-----------------------|------------------|
| -40°C to 85°C | A grade: 0.1% initial accuracy and 50 ppm/°C temperature coefficient | 2.048 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A20IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A20IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A20IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A20IDCKTQ1 | |
| | | 2.5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A25IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A25IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A25IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A25IDCKTQ1 | |
| | | 4.096 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A41IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A41IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A41IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A41IDCKTQ1 | |
| | | 5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A50IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A50IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A50IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A50IDCKTQ1 | |
| | | 8.192 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A82IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A82IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A82IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A82IDCKTQ1 | |
| | | 10 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A10IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B10IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A10IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B10IDCKTQ1 | |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

ORDERING INFORMATION ⁽¹⁾ (continued)

| T _A | DEVICE GRADE | V _{KA} | PACKAGE ⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|--|-----------------|------------------------|--------------|-----------------------|------------------|
| –40°C to 85°C | B grade: 0.2% initial accuracy and 50 ppm/°C temperature coefficient | 2.048 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B20IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B20IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B20IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B20IDCKTQ1 | |
| | | 2.5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B25IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B25IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B25IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B25IDCKTQ1 | |
| | | 4.096 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B41IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B41IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B41IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B41IDCKTQ1 | |
| | | 5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B50IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B50IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B50IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B50IDCKTQ1 | |
| | | 8.192 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B82IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B82IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B82IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B82IDCKTQ1 | |
| | | 10 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B10IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B10IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B10IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B10IDCKTQ1 | |

ORDERING INFORMATION ⁽¹⁾ (continued)

| T _A | DEVICE GRADE | V _{KA} | PACKAGE ⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|--|-----------------|------------------------|--------------|-----------------------|------------------|
| -40°C to 85°C | C grade: 0.5% initial accuracy and 50 ppm/°C temperature coefficient | 2.048 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C20IDBZRQ1 | TMWU |
| | | | | Reel of 250 | TL4050C20IDBZTQ1 | Product Preview |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C20IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C20IDCKTQ1 | |
| | | 2.5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C25IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C25IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C25IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C25IDCKTQ1 | |
| | | 4.096 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C41IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C41IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C41IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C41IDCKTQ1 | |
| | | 5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C50IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C50IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C50IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C50IDCKTQ1 | |
| | | 8.192 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C82IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C82IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C82IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C82IDCKTQ1 | |
| | | 10 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C10IDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C10IDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C10IDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C10IDCKTQ1 | |

ORDERING INFORMATION⁽¹⁾

| T _A | DEVICE GRADE | V _{KA} | PACKAGE ⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|--|-----------------|------------------------|--------------|-----------------------|------------------|
| -40°C to 125°C | A grade: 0.1% initial accuracy and 50 ppm/°C temperature coefficient | 2.048 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A20QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A20QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A20QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A20QDCKTQ1 | |
| | | 2.5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A25QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A25QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A25QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A25QDCKTQ1 | |
| | | 4.096 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A41QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A41QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A41QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A41QDCKTQ1 | |
| | | 5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A50QDBZRQ1 | TLGU |
| | | | | Reel of 250 | TL4050A50QDBZTQ1 | Product Preview |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A50QDCKRQ1 | 7GU |
| | | | | Reel of 250 | TL4050A50QDCKTQ1 | Product Preview |
| | | 8.192 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A82QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A82QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A82QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A82QDCKTQ1 | |
| | | 10 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050A10QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B10QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050A10QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050A10QDCKTQ1 | |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

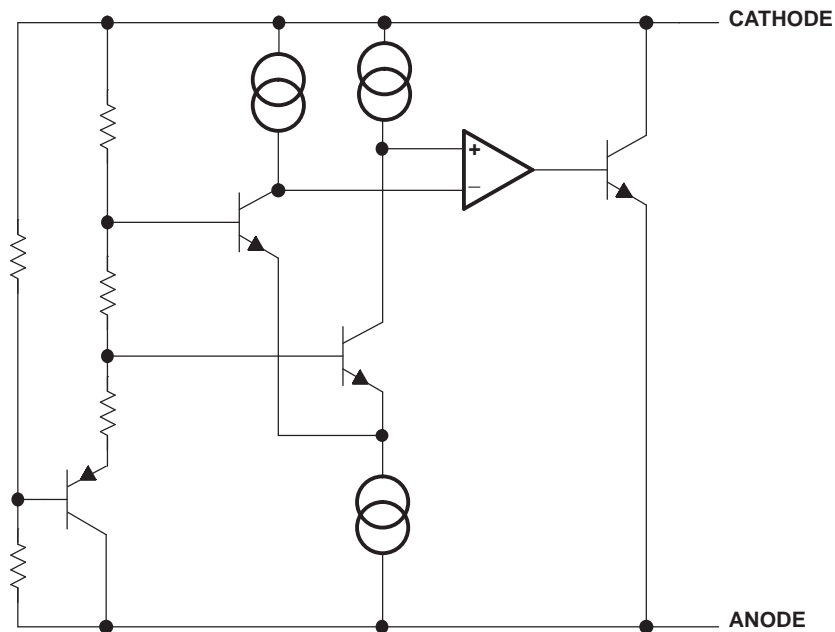
ORDERING INFORMATION ⁽¹⁾ (continued)

| T _A | DEVICE GRADE | V _{KA} | PACKAGE ⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|--|-----------------|------------------------|--------------|-----------------------|------------------|
| -40°C to 125°C | B grade: 0.2% initial accuracy and 50 ppm/°C temperature coefficient | 2.048 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B20QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B20QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B20QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B20QDCKTQ1 | |
| | | 2.5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B25QDBZRQ1 | TLHU |
| | | | | Reel of 250 | TL4050B25QDBZTQ1 | Product Preview |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B25QDCKRQ1 | 7HU |
| | | | | Reel of 250 | TL4050B25QDCKTQ1 | Product Preview |
| | | 4.096 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B41QDBZRQ1 | TMXU |
| | | | | Reel of 250 | TL4050B41QDBZTQ1 | Product Preview |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B41QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B41QDCKTQ1 | |
| | | 5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B50QDBZRQ1 | TLJU |
| | | | | Reel of 250 | TL4050B50QDBZTQ1 | Product Preview |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B50QDCKRQ1 | 7JU |
| | | | | Reel of 250 | TL4050B50QDCKTQ1 | Product Preview |
| | | 8.192 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B82QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B82QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B82QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B82QDCKTQ1 | |
| | | 10 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050B10QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B10QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050B10QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050B10QDCKTQ1 | |

ORDERING INFORMATION ⁽¹⁾ (continued)

| T _A | DEVICE GRADE | V _{KA} | PACKAGE ⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|--|-----------------|------------------------|--------------|-----------------------|------------------|
| –40°C to 125°C | C grade: 0.5% initial accuracy and 50 ppm/°C temperature coefficient | 2.048 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C20QDBZRQ1 | TMYU |
| | | | | Reel of 250 | TL4050C20QDBZTQ1 | Product Preview |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C20QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C20QDCKTQ1 | |
| | | 2.5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C25QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C25QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C25QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C25QDCKTQ1 | |
| | | 4.096 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C41QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C41QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C41QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C41QDCKTQ1 | |
| | | 5 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C50QDBZRQ1 | TKZU |
| | | | | Reel of 250 | TL4050C50QDBZTQ1 | Product Preview |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C50QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C50QDCKTQ1 | |
| | | 8.192 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C82QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C82QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C82QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C82QDCKTQ1 | |
| | | 10 V | SOT-23-3 – DBZ | Reel of 3000 | TL4050C10QDBZRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C10QDBZTQ1 | |
| | | | SC-70 – DCK | Reel of 3000 | TL4050C10QDCKRQ1 | Product Preview |
| | | | | Reel of 250 | TL4050C10QDCKTQ1 | |

FUNCTIONAL BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS⁽¹⁾

over free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|---------------|--|-----|-----|------|
| I_Z | Continuous cathode current | -10 | 20 | mA |
| θ_{JA} | Package thermal impedance ^{(2) (3)} | | 206 | °C/W |
| | | | 252 | |
| T_J | Operating virtual junction temperature | | 150 | °C |
| T_{stg} | Storage temperature range | -65 | 150 | °C |

- (1) 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.
- (2) Maximum power dissipation is a function of $T_J(max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
- (3) The package thermal impedance is calculated in accordance with JESD 51-7.

RECOMMENDED OPERATING CONDITIONS

| | | MIN | MAX | UNIT | |
|-------|----------------------|----------------|-----|------|----|
| I_Z | Cathode current | ⁽¹⁾ | 15 | mA | |
| T_A | Free-air temperature | I temperature | -40 | 85 | °C |
| | | Q temperature | -40 | 125 | |

- (1) See parametric tables

TL4050x20I ELECTRICAL CHARACTERISTICS

 at industrial temperature range, full range $T_A = -40^{\circ}\text{C}$ to 85°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A20I | | | TL4050B20I | | | TL4050C20I | | | UNIT | |
|---------------------------------|--|------------|---|--------|-----|------------|---------|-----|------------|---------|---------------|----------------------------|----|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | |
| V_Z | Reverse breakdown voltage $I_Z = 100\ \mu\text{A}$ | 25°C | 2.048 | | | 2.048 | | | 2.048 | | | V | |
| ΔV_Z | Reverse breakdown voltage tolerance $I_Z = 100\ \mu\text{A}$ | 25°C | -2.048 | 2.048 | | -4.096 | 4.096 | | -10.24 | 10.24 | | mV | |
| | | Full range | -9.0112 | 9.0112 | | -11.4688 | 11.4688 | | -14.7456 | 14.7456 | | | |
| $I_{Z,\text{min}}$ | Minimum cathode current | 25°C | 41 | | 60 | | 41 | | 60 | | μA | | |
| | | Full range | | | 65 | | | | 65 | | | | |
| α_{VZ} | Average temperature coefficient of reverse breakdown voltage $I_Z = 10\ \text{mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | ppm/°C | |
| | | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | | |
| | | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ | Reverse breakdown voltage change with cathode current change | 25°C | $I_{Z,\text{min}} < I_Z < 1\ \text{mA}$ | | 0.3 | | 0.8 | | 0.3 | | 0.8 | | mV |
| | | | Full range | | 1.2 | | 1.2 | | 1.2 | | | | |
| | | 25°C | $1\ \text{mA} < I_Z < 15\ \text{mA}$ | | 2.3 | | 6 | | 2.3 | | 6 | | |
| | | | Full range | | 8 | | 8 | | 8 | | | | |
| Z_Z | Reverse dynamic impedance $I_Z = 1\ \text{mA}$, $f = 120\ \text{Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.3 | | | 0.3 | | | 0.3 | | | Ω | |
| e_N | Wideband noise $I_Z = 100\ \mu\text{A}$, $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$ | 25°C | 34 | | | 34 | | | 34 | | | μV_{RMS} | |
| | Long-term stability of reverse breakdown voltage $t = 1000\ \text{h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100\ \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm | |
| V_{HYST} | Thermal hysteresis ⁽¹⁾ $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 0.7 | | | 0.7 | | | 0.7 | | | mV | |

 (1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x20Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range $T_A = -40^{\circ}\text{C}$ to 125°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A20Q | | | TL4050B20Q | | | TL4050C20Q | | | UNIT |
|---------------------------------|---|------------|------------|--------|-----|------------|---------|-----|------------|---------|---------------|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z | Reverse breakdown voltage $I_Z = 100 \mu\text{A}$ | 25°C | 2.048 | | | 2.048 | | | 2.048 | | | V |
| ΔV_Z | Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$ | 25°C | -2.048 | 2.048 | | -4.096 | 4.096 | | -10.24 | 10.24 | | mV |
| | | Full range | -12.288 | 12.288 | | -14.7456 | 14.7456 | | -17.2032 | 17.2032 | | |
| $I_{Z,\text{min}}$ | Minimum cathode current | 25°C | 41 | | 60 | | 41 | | 60 | | μA | |
| | | Full range | | | 65 | | | | 65 | | | |
| α_{VZ} | Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | ppm/°C |
| | | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | |
| | | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ | Reverse breakdown voltage change with cathode current change $I_{Z,\text{min}} < I_Z < 1 \text{ mA}$ | 25°C | 0.3 | 0.8 | | 0.3 | 0.8 | | 0.3 | 0.8 | | mV |
| | | Full range | | | 1.2 | | | | 1.2 | | | |
| | 25°C | 2.3 | | 6 | | 2.3 | | 6 | | 2.3 | | |
| | | Full range | | | 8 | | | | 8 | | 8 | |
| Z_Z | Reverse dynamic impedance $I_Z = 1 \text{ mA}$, $f = 120 \text{ Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.3 | | | 0.3 | | | 0.3 | | | Ω |
| e_N | Wideband noise $I_Z = 100 \mu\text{A}$, $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ | 25°C | 34 | | | 34 | | | 34 | | | μV_{RMS} |
| | Long-term stability of reverse breakdown voltage $t = 1000 \text{ h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100 \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} | Thermal hysteresis ⁽¹⁾ $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 0.7 | | | 0.7 | | | 0.7 | | | mV |

(1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x25I ELECTRICAL CHARACTERISTICS

 at industrial temperature range, full range $T_A = -40^{\circ}\text{C}$ to 85°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A25I | | | TL4050B25I | | | TL4050C25I | | | UNIT |
|--|--|----------------------|------------|-----|-----|------------|-----|-----|------------|----------|-----|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100\ \mu\text{A}$ | 25°C | 2.5 | | | 2.5 | | | 2.5 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100\ \mu\text{A}$ | 25°C | -2.5 | | 2.5 | -5 | | 5 | -13 | | 13 | mV |
| | | Full range | -11 | | 11 | -14 | | 14 | -21 | | 21 | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 41 | | 60 | 41 | | 60 | 41 | | 60 | μA |
| | | Full range | | | 65 | | | 65 | | | 65 | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10\ \text{mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1\ \text{mA}$ | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | |
| | $I_Z = 100\ \mu\text{A}$ | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | |
| | | Full range | | | | ± 50 | | | | ± 50 | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1\ \text{mA}$ | 25°C | 0.3 | | 0.8 | 0.3 | | 0.8 | 0.3 | | 0.8 | mV |
| | | Full range | | | 1.2 | | | 1.2 | | | 1.2 | |
| | $1\ \text{mA} < I_Z < 15\ \text{mA}$ | 25°C | 2.3 | | 6 | 2.3 | | 6 | 2.3 | | 6 | |
| | | Full range | | | 8 | | | 8 | | | 8 | |
| Z_Z Reverse dynamic impedance | $I_Z = 1\ \text{mA}$, $f = 120\ \text{Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.3 | | | 0.3 | | | 0.3 | | | Ω |
| e_N Wideband noise | $I_Z = 100\ \mu\text{A}$, $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$ | 25°C | 41 | | | 41 | | | 41 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000\ \text{h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100\ \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 0.7 | | | 0.7 | | | 0.7 | | | mV |

 (1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x25Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range $T_A = -40^{\circ}\text{C}$ to 125°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A25Q | | | TL4050B25Q | | | TL4050C25Q | | | UNIT | |
|--|---|----------------------|------------|-----|-----|------------|-----|-----|------------|-----|---------------|----------------------------|--|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | | |
| V_Z Reverse breakdown voltage | $I_Z = 100 \mu\text{A}$ | 25°C | 2.5 | | | 2.5 | | | 2.5 | | | V | |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100 \mu\text{A}$ | 25°C | -2.5 | 2.5 | | -5 | 5 | | -13 | 13 | | mV | |
| | | Full range | -15 | 15 | | -18 | 18 | | -25 | 25 | | | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 41 | | 60 | | 41 | | 60 | | μA | | |
| | | Full range | | | 65 | | 65 | | 65 | | | | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10 \text{ mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | ppm/ $^{\circ}\text{C}$ | |
| | $I_Z = 1 \text{ mA}$ | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | | |
| | $I_Z = 100 \mu\text{A}$ | 25°C | ± 15 | | | ± 15 | | | ± 15 | | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1 \text{ mA}$ | 25°C | 0.3 | 0.8 | | 0.3 | 0.8 | | 0.3 | 0.8 | | mV | |
| | | Full range | | | 1.2 | | 1.2 | | 1.2 | | | | |
| | $1 \text{ mA} < I_Z < 15 \text{ mA}$ | 25°C | 2.3 | | 6 | | 2.3 | 6 | | 2.3 | 6 | | |
| | | Full range | | | 8 | | 8 | | 8 | | 8 | | |
| Z_Z Reverse dynamic impedance | $I_Z = 1 \text{ mA}$, $f = 120 \text{ Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.3 | | | 0.3 | | | 0.3 | | | Ω | |
| e_N Wideband noise | $I_Z = 100 \mu\text{A}$, $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ | 25°C | 41 | | | 41 | | | 41 | | | μV_{RMS} | |
| Long-term stability of reverse breakdown voltage | $t = 1000 \text{ h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100 \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm | |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 0.7 | | | 0.7 | | | 0.7 | | | mV | |

(1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x41I ELECTRICAL CHARACTERISTICS

 at industrial temperature range, full range $T_A = -40^{\circ}\text{C}$ to 85°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A41I | | | TL4050B41I | | | TL4050C41I | | | UNIT |
|--|--|----------------------|------------|-----|------|------------|-----|-----|------------|-----|-----|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100\ \mu\text{A}$ | 25°C | 4.096 | | | 4.096 | | | 4.096 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100\ \mu\text{A}$ | 25°C | -4.1 | 4.1 | -8.2 | 8.2 | -21 | 21 | | | | mV |
| | | Full range | -18 | 18 | -22 | 22 | -34 | 34 | | | | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 52 | 68 | 52 | 68 | 52 | 68 | | | | μA |
| | | Full range | 73 | | 73 | | | | | | | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10\ \text{mA}$ | 25°C | ± 30 | | | ± 30 | | | ± 30 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1\ \text{mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100\ \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1\ \text{mA}$ | 25°C | 0.2 | 0.9 | 0.2 | 0.9 | 0.2 | 0.9 | | | | mV |
| | | Full range | 1.2 | | 1.2 | | | | | | | |
| | $1\ \text{mA} < I_Z < 15\ \text{mA}$ | 25°C | 2 | 7 | 2 | 7 | 2 | 7 | | | | |
| | | Full range | 10 | | 10 | | | | | | | |
| Z_Z Reverse dynamic impedance | $I_Z = 1\ \text{mA}$, $f = 120\ \text{Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.5 | | | 0.5 | | | 0.5 | | | Ω |
| e_N Wideband noise | $I_Z = 100\ \mu\text{A}$, $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$ | 25°C | 93 | | | 93 | | | 93 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000\ \text{h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100\ \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 1.148 | | | 1.148 | | | 1.148 | | | mV |

 (1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x41Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range $T_A = -40^{\circ}\text{C}$ to 125°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A41Q | | | TL4050B41Q | | | TL4050C41Q | | | UNIT |
|--|--|----------------------|------------|-----|------|------------|-----|-----|------------|-----|-----|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100\ \mu\text{A}$ | 25°C | 4.096 | | | 4.096 | | | 4.096 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100\ \mu\text{A}$ | 25°C | -4.1 | 4.1 | -8.2 | 8.2 | -21 | 21 | | | | mV |
| | | Full range | -25 | 25 | -29 | 29 | -41 | 41 | | | | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 52 | 68 | 52 | 68 | 52 | 68 | | | | μA |
| | | Full range | 78 | | 78 | | 78 | | | | | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10\ \text{mA}$ | 25°C | ± 30 | | | ± 30 | | | ± 30 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1\ \text{mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100\ \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1\ \text{mA}$ | 25°C | 0.2 | 0.9 | 0.2 | 0.9 | 0.2 | 0.9 | | | | mV |
| | | Full range | 1.2 | | 1.2 | | 1.2 | | | | | |
| | $1\ \text{mA} < I_Z < 15\ \text{mA}$ | 25°C | 2 | 7 | 2 | 7 | 2 | 7 | | | | |
| | | Full range | 10 | | 10 | | 10 | | | | | |
| Z_Z Reverse dynamic impedance | $I_Z = 1\ \text{mA}$, $f = 120\ \text{Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.5 | | | 0.5 | | | 0.5 | | | Ω |
| e_N Wideband noise | $I_Z = 100\ \mu\text{A}$, $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$ | 25°C | 93 | | | 93 | | | 93 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000\ \text{h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100\ \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 1.148 | | | 1.148 | | | 1.148 | | | mV |

(1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x50I ELECTRICAL CHARACTERISTICS

 at industrial temperature range, full range $T_A = -40^{\circ}\text{C}$ to 85°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A50I | | | TL4050B50I | | | TL4050C50I | | | UNIT |
|--|--|----------------------|------------|-----|----------|------------|-----|----------|------------|-----|----------|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100\ \mu\text{A}$ | 25°C | 5 | | | 5 | | | 5 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100\ \mu\text{A}$ | 25°C | -5 | | 5 | -10 | | 10 | -25 | | 25 | mV |
| | | Full range | -22 | | 22 | -27 | | 27 | -42 | | 42 | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 56 | | 74 | 56 | | 74 | 56 | | 74 | μA |
| | | Full range | | | 80 | | | 80 | | | 80 | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10\ \text{mA}$ | 25°C | ± 30 | | | ± 30 | | | ± 30 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1\ \text{mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100\ \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | | | ± 50 | | | ± 50 | | | ± 50 | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1\ \text{mA}$ | 25°C | 0.2 | | 1 | 0.2 | | 1 | 0.2 | | 1 | mV |
| | | Full range | | | 1.4 | | | 1.4 | | | 1.4 | |
| | $1\ \text{mA} < I_Z < 15\ \text{mA}$ | 25°C | | 2 | | 8 | | 2 | | 8 | | |
| | | Full range | | | 12 | | | 12 | | | 12 | |
| Z_Z Reverse dynamic impedance | $I_Z = 1\ \text{mA}$, $f = 120\ \text{Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.5 | | | 0.5 | | | 0.5 | | | Ω |
| e_N Wideband noise | $I_Z = 100\ \mu\text{A}$, $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$ | 25°C | 93 | | | 93 | | | 93 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000\ \text{h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100\ \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 1.4 | | | 1.4 | | | 1.4 | | | mV |

 (1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x50Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range $T_A = -40^{\circ}\text{C}$ to 125°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A50Q | | | TL4050B50Q | | | TL4050C50Q | | | UNIT |
|--|---|----------------------|------------|-----|-----|------------|-----|-----|------------|-----|-----|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100 \mu\text{A}$ | 25°C | 5 | | | 5 | | | 5 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100 \mu\text{A}$ | 25°C | -5 | | 5 | -10 | | 10 | -25 | | 25 | mV |
| | | Full range | -30 | | 30 | -35 | | 35 | -50 | | 50 | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 56 | | 74 | 56 | | 74 | 56 | | 74 | μA |
| | | Full range | | | 90 | | | 90 | | | 90 | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10 \text{ mA}$ | 25°C | ± 30 | | | ± 30 | | | ± 30 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1 \text{ mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100 \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1 \text{ mA}$ | 25°C | 0.2 | | 1 | 0.2 | | 1 | 0.2 | | 1 | mV |
| | | Full range | | | 1.4 | | | 1.4 | | | 1.4 | |
| | $1 \text{ mA} < I_Z < 15 \text{ mA}$ | 25°C | 2 | | 8 | 2 | | 8 | 2 | | 8 | |
| | | Full range | | | 12 | | | 12 | | | 12 | |
| Z_Z Reverse dynamic impedance | $I_Z = 1 \text{ mA}$, $f = 120 \text{ Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.5 | | | 0.5 | | | 0.5 | | | Ω |
| e_N Wideband noise | $I_Z = 100 \mu\text{A}$, $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ | 25°C | 93 | | | 93 | | | 93 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000 \text{ h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100 \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 1.4 | | | 1.4 | | | 1.4 | | | mV |

(1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x82I ELECTRICAL CHARACTERISTICS

 at industrial temperature range, full range $T_A = -40^{\circ}\text{C}$ to 85°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A82I | | | TL4050B82I | | | TL4050C82I | | | UNIT |
|--|--|----------------------|------------|-----|-----|------------|-----|-----|------------|-----|-----|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100\ \mu\text{A}$ | 25°C | 8.192 | | | 8.192 | | | 8.192 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100\ \mu\text{A}$ | 25°C | -8.2 | 8.2 | -16 | 16 | -41 | 41 | | | | mV |
| | | Full range | -35 | 35 | -43 | 43 | -68 | 68 | | | | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 74 | 91 | 74 | 91 | 74 | 91 | | | | μA |
| | | Full range | 95 | | 95 | | 95 | | | | | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10\ \text{mA}$ | 25°C | ± 40 | | | ± 40 | | | ± 40 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1\ \text{mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100\ \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1\ \text{mA}$ | 25°C | 0.6 | 1.3 | 0.6 | 1.3 | 0.6 | 1.3 | | | | mV |
| | | Full range | 2.5 | | 2.5 | | 2.5 | | | | | |
| | $1\ \text{mA} < I_Z < 15\ \text{mA}$ | 25°C | 7 | 10 | 7 | 10 | 7 | 10 | | | | |
| | | Full range | 18 | | 18 | | 18 | | | | | |
| Z_Z Reverse dynamic impedance | $I_Z = 1\ \text{mA}$, $f = 120\ \text{Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.6 | | | 0.6 | | | 0.6 | | | Ω |
| e_N Wideband noise | $I_Z = 100\ \mu\text{A}$, $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$ | 25°C | 150 | | | 150 | | | 150 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000\ \text{h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100\ \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 2.3 | | | 2.3 | | | 2.3 | | | mV |

 (1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x82Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range $T_A = -40^{\circ}\text{C}$ to 125°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A82Q | | | TL4050B82Q | | | TL4050C82Q | | | UNIT |
|--|---|----------------------|------------|-----|-----|------------|-----|-----|------------|-----|-----|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100 \mu\text{A}$ | 25°C | 8.192 | | | 8.192 | | | 8.192 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100 \mu\text{A}$ | 25°C | -8.2 | 8.2 | -16 | 16 | -41 | 41 | | | | mV |
| | | Full range | -49 | 49 | -57 | 57 | -82 | 82 | | | | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 74 | 91 | 74 | 91 | 74 | 91 | | | | μA |
| | | Full range | 100 | | 100 | | 100 | | | | | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10 \text{ mA}$ | 25°C | ± 40 | | | ± 40 | | | ± 40 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1 \text{ mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100 \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1 \text{ mA}$ | 25°C | 0.6 | 1.3 | 0.6 | 1.3 | 0.6 | 1.3 | | | | mV |
| | | Full range | 2.5 | | 2.5 | | 2.5 | | | | | |
| | $1 \text{ mA} < I_Z < 15 \text{ mA}$ | 25°C | 7 | 10 | 7 | 10 | 7 | 10 | | | | |
| | | Full range | 18 | | 18 | | 18 | | | | | |
| Z_Z Reverse dynamic impedance | $I_Z = 1 \text{ mA}$, $f = 120 \text{ Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.6 | | | 0.6 | | | 0.6 | | | Ω |
| e_N Wideband noise | $I_Z = 100 \mu\text{A}$, $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ | 25°C | 150 | | | 150 | | | 150 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000 \text{ h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100 \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 2.3 | | | 2.3 | | | 2.3 | | | mV |

(1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TL4050x10I ELECTRICAL CHARACTERISTICS

 at industrial temperature range, full range $T_A = -40^{\circ}\text{C}$ to 85°C (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | T_A | TL4050A10I | | | TL4050B10I | | | TL4050C10I | | | UNIT |
|--|--|----------------------|------------|-----|-----|------------|-----|-----|------------|-----|---------------|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100\ \mu\text{A}$ | 25°C | 10 | | | 10 | | | 10 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100\ \mu\text{A}$ | 25°C | -10 | 10 | | -20 | 20 | | -50 | 50 | | mV |
| | | Full range | -43 | 43 | | -53 | 53 | | -83 | 83 | | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 80 | | 100 | | 80 | | 100 | | μA | |
| | | Full range | | | 103 | | | | 103 | | | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10\ \text{mA}$ | 25°C | ± 40 | | | ± 40 | | | ± 40 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1\ \text{mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100\ \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1\ \text{mA}$ | 25°C | 0.8 | 1.5 | | 0.8 | 1.5 | | 0.8 | 1.5 | | mV |
| | | Full range | | | 3.5 | | | | 3.5 | | | |
| | $1\ \text{mA} < I_Z < 15\ \text{mA}$ | 25°C | 8 | | 12 | | 8 | | 12 | | | |
| | | Full range | | | 23 | | | | 23 | | | |
| Z_Z Reverse dynamic impedance | $I_Z = 1\ \text{mA}$, $f = 120\ \text{Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.7 | | | 0.7 | | | 0.7 | | | Ω |
| e_N Wideband noise | $I_Z = 100\ \mu\text{A}$, $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$ | 25°C | 150 | | | 150 | | | 150 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000\ \text{h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100\ \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 2.8 | | | 2.8 | | | 2.8 | | | mV |

 (1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

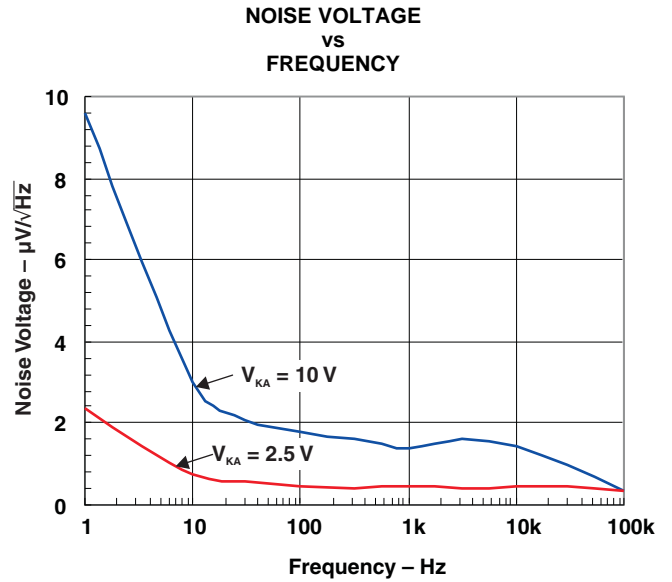
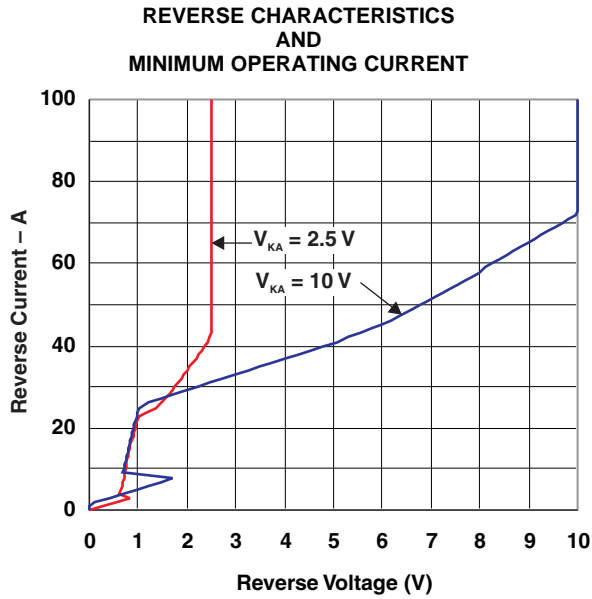
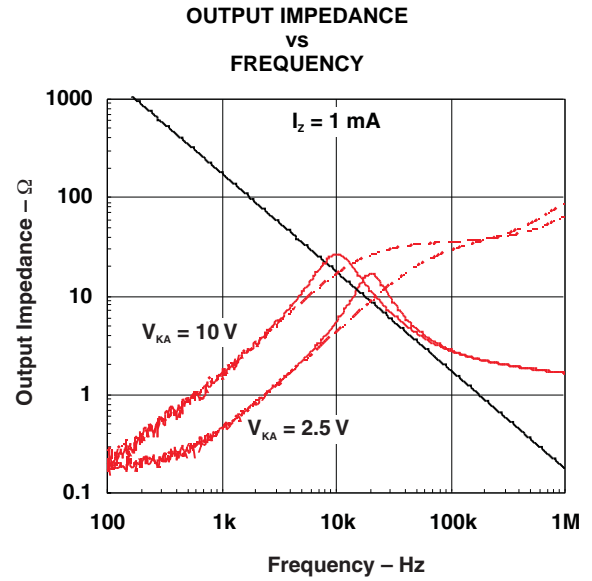
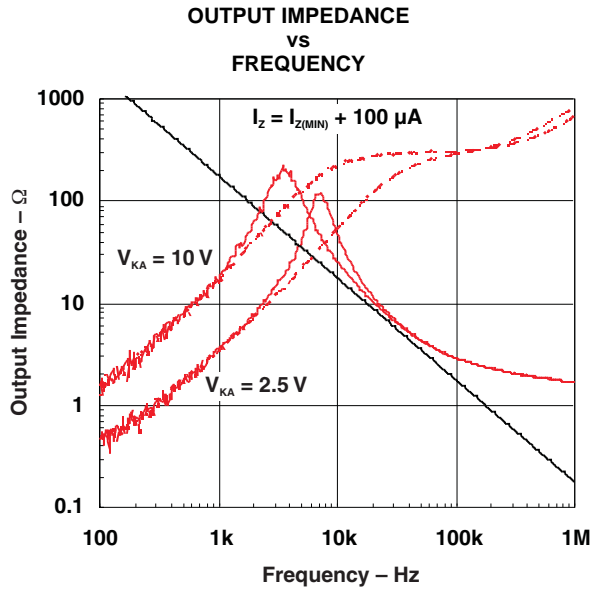
TL4050x10Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range $T_A = -40^{\circ}\text{C}$ to 125°C (unless otherwise noted)

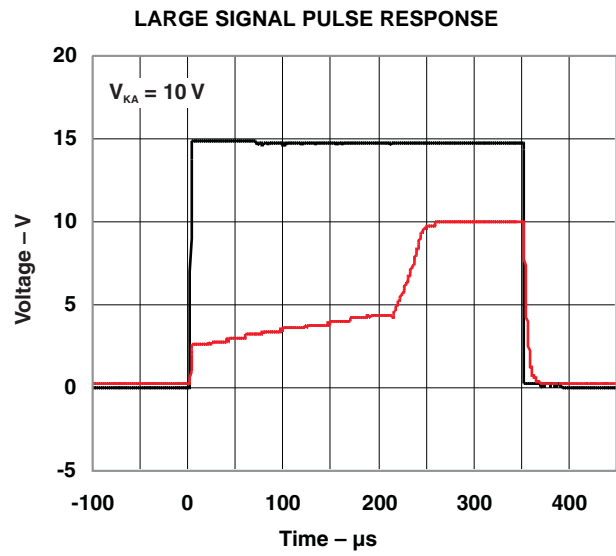
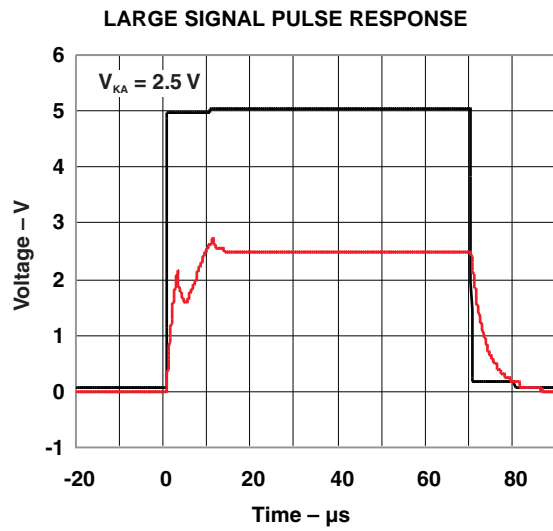
| PARAMETER | TEST CONDITIONS | T_A | TL4050A10Q | | | TL4050B10Q | | | TL4050C10Q | | | UNIT |
|--|---|----------------------|------------|-----|-----|------------|-----|-----|------------|-----|---------------|----------------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_Z Reverse breakdown voltage | $I_Z = 100 \mu\text{A}$ | 25°C | 10 | | | 10 | | | 10 | | | V |
| ΔV_Z Reverse breakdown voltage tolerance | $I_Z = 100 \mu\text{A}$ | 25°C | -10 | 10 | | -20 | 20 | | -50 | 50 | | mV |
| | | Full range | -60 | 60 | | -70 | 70 | | -100 | 100 | | |
| $I_{Z,\text{min}}$ Minimum cathode current | | 25°C | 80 | | 100 | | 80 | | 100 | | μA | |
| | | Full range | | | 110 | | 110 | | 110 | | | |
| α_{VZ} Average temperature coefficient of reverse breakdown voltage | $I_Z = 10 \text{ mA}$ | 25°C | ± 40 | | | ± 40 | | | ± 40 | | | ppm/ $^{\circ}\text{C}$ |
| | $I_Z = 1 \text{ mA}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | $I_Z = 100 \mu\text{A}$ | 25°C | ± 20 | | | ± 20 | | | ± 20 | | | |
| | | Full range | ± 50 | | | ± 50 | | | ± 50 | | | |
| $\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change | $I_{Z,\text{min}} < I_Z < 1 \text{ mA}$ | 25°C | 0.8 | 1.5 | | 0.8 | 1.5 | | 0.8 | 1.5 | | mV |
| | | Full range | | | 3.5 | | 3.5 | | 3.5 | | | |
| | $1 \text{ mA} < I_Z < 15 \text{ mA}$ | 25°C | 8 | | 12 | | 8 | | 12 | | | |
| | | Full range | | | 23 | | 23 | | 23 | | | |
| Z_Z Reverse dynamic impedance | $I_Z = 1 \text{ mA}$, $f = 120 \text{ Hz}$, $I_{AC} = 0.1 I_Z$ | 25°C | 0.7 | | | 0.7 | | | 0.7 | | | Ω |
| e_N Wideband noise | $I_Z = 100 \mu\text{A}$, $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$ | 25°C | 150 | | | 150 | | | 150 | | | μV_{RMS} |
| Long-term stability of reverse breakdown voltage | $t = 1000 \text{ h}$, $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$, $I_Z = 100 \mu\text{A}$ | | 120 | | | 120 | | | 120 | | | ppm |
| V_{HYST} Thermal hysteresis ⁽¹⁾ | $\Delta T_A = -40^{\circ}\text{C}$ to 125°C | | 2.8 | | | 2.8 | | | 2.8 | | | mV |

(1) Thermal hysteresis is defined as $V_{Z,25^{\circ}\text{C}}$ (after cycling to -40°C) – $V_{Z,25^{\circ}\text{C}}$ (after cycling to 125°C).

TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS (continued)



APPLICATION INFORMATION

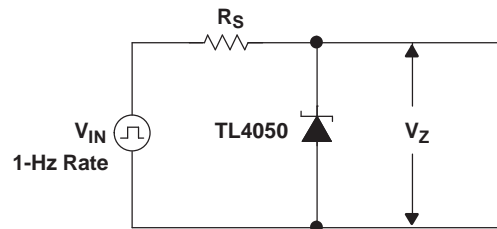


Figure 1. Start-Up Test Circuit

Output Capacitor

The TL4050 does not require an output capacitor across cathode and anode for stability. However, if an output bypass capacitor is desired, the TL4050 is designed to be stable with all capacitive loads.

SOT-23 Pin Connections

There is a parasitic Schottky diode connected between pins 2 and 3 of the SOT-23 packaged device. Thus, pin 3 of the SOT-23 package must be left floating or connected to pin 2.

Use With ADCs or DACs

The TL4050x-41 is designed to be a cost-effective voltage reference as required in 12-bit data-acquisition systems. For 12-bit systems operating from 5-V supplies, such as the ADS7842 (see Figure 2), the TL4050x-41 (4.096 V) permits operation with an LSB of 1 mV.

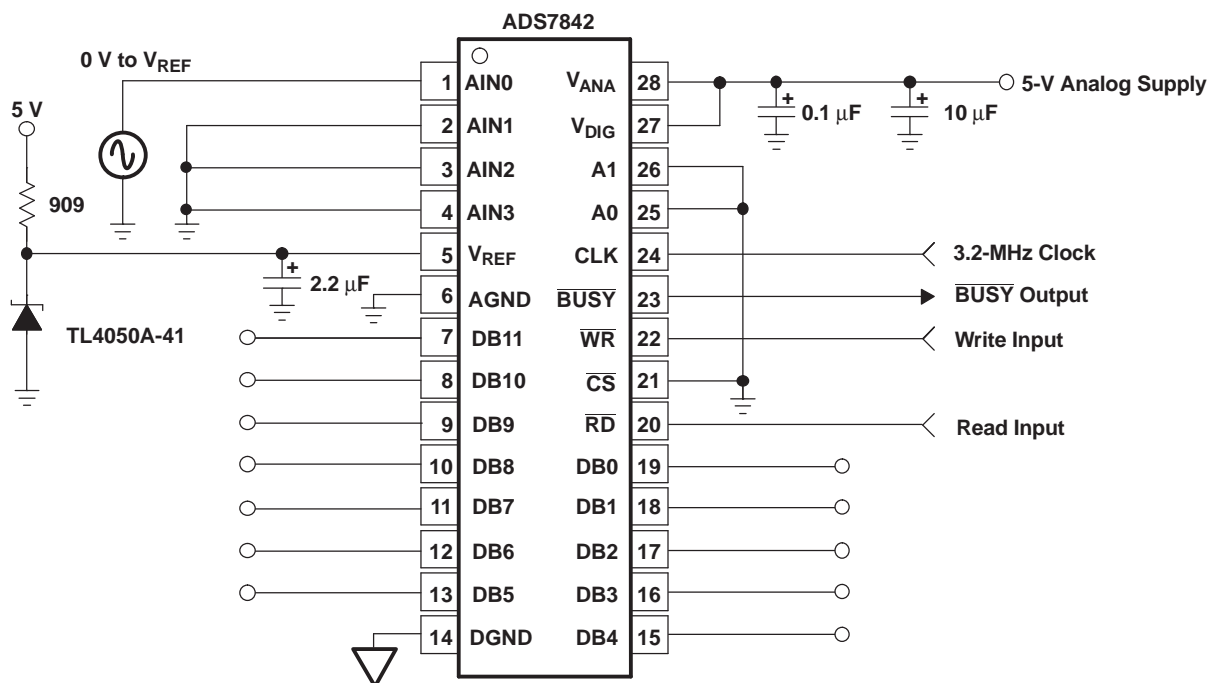


Figure 2. Data-Acquisition Circuit With TL4050x-41

Cathode and Load Currents

In a typical shunt-regulator configuration (see [Figure 3](#)), an external resistor, R_S , is connected between the supply and the cathode of the TL4050. R_S must be set properly, as it sets the total current available to supply the load (I_L) and bias the TL4050 (I_Z). In all cases, I_Z must stay within a specified range for proper operation of the reference. Taking into consideration one extreme in the variation of the load and supply voltage (maximum I_L and minimum V_S), R_S must be small enough to supply the minimum I_Z required for operation of the regulator, as given by data-sheet parameters. At the other extreme, maximum V_S and minimum I_L , R_S must be large enough to limit I_Z to less than its maximum-rated value of 15 mA.

R_S is calculated according to [Equation 1](#):

$$R_S = \frac{(V_S - V_Z)}{(I_L + I_Z)} \quad (1)$$

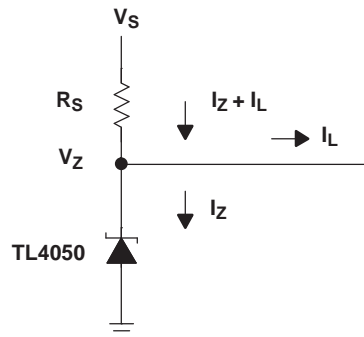


Figure 3. Shunt Regulator

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| TL4050B25QDBZRQ1 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TL4050B25QDCKRQ1 | ACTIVE | SC70 | DCK | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TL4050B41QDBZRQ1 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TL4050B50QDCKRQ1 | ACTIVE | SC70 | DCK | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TL4050C20QDBZRQ1 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TL4050C50QDBZRQ1 | ACTIVE | SOT-23 | DBZ | 3 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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OTHER QUALIFIED VERSIONS OF TL4050B25-Q1, TL4050B41-Q1, TL4050B50-Q1, TL4050C50-Q1 :

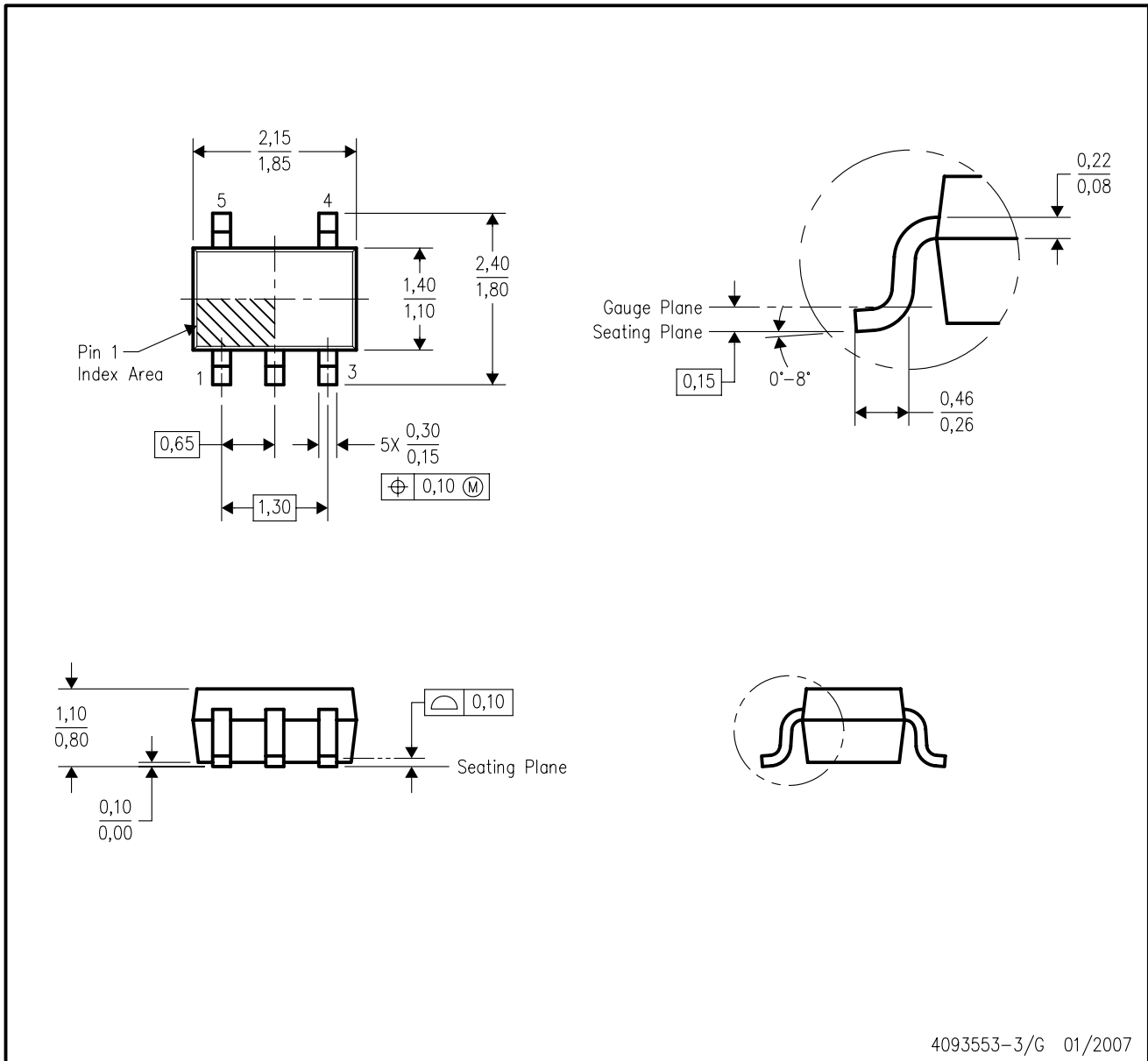
● Catalog: [TL4050B25](#), [TL4050B41](#), [TL4050B50](#), [TL4050C50](#)

NOTE: Qualified Version Definitions:

● Catalog - TI's standard catalog product

DCK (R-PDSO-G5)

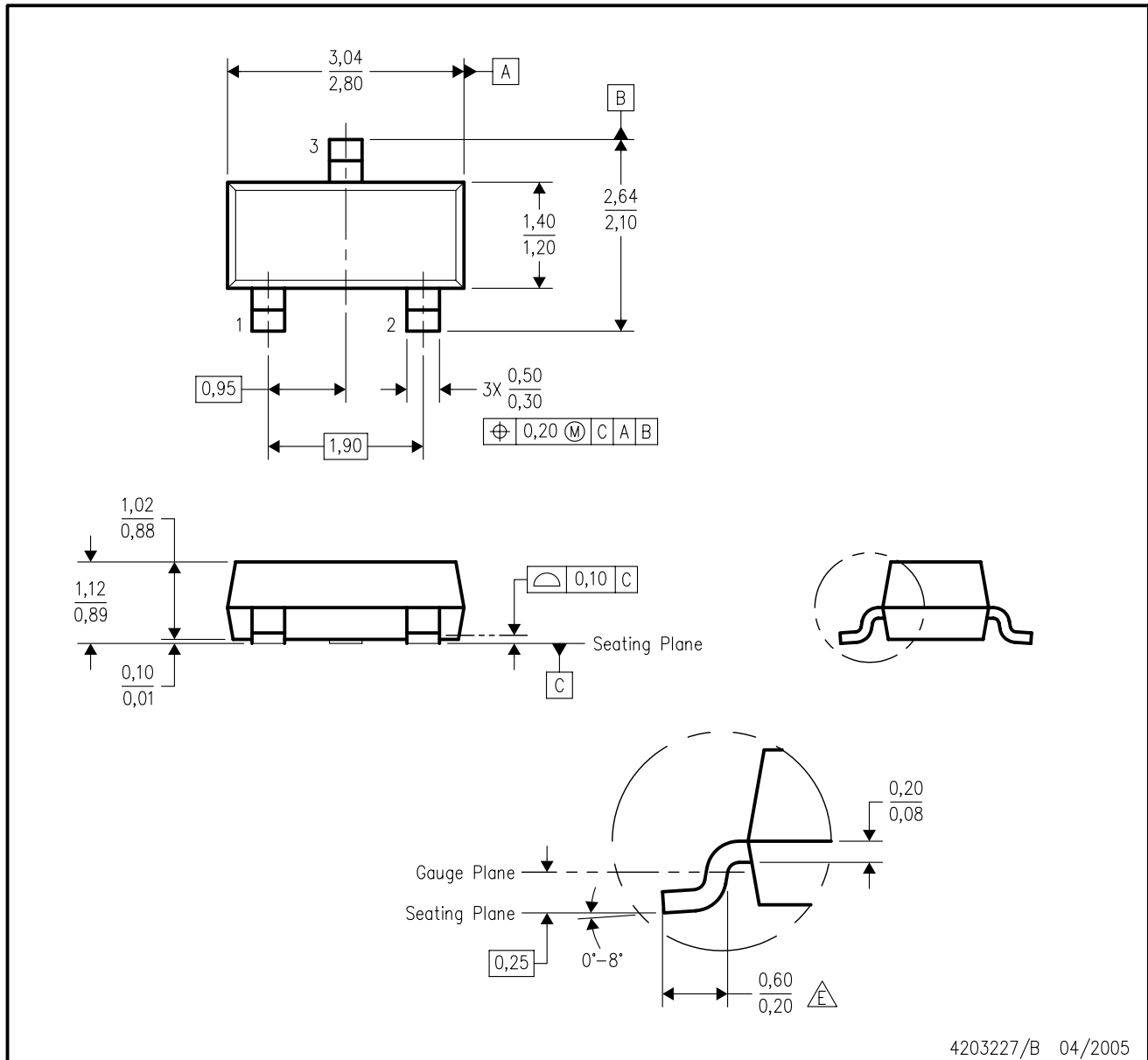
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - Falls within JEDEC MO-203 variation AA.

DBZ (R-PDSO-G3)

PLASTIC SMALL-OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Lead dimensions are inclusive of plating.
 - D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.
- △ Falls within JEDEC TO-236 variation AB, except minimum foot length.

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