

## PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

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

### FEATURES

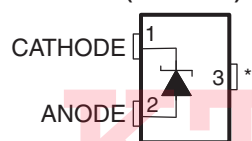
- Qualified for Automotive Applications
- Fixed Output Voltages of 2.048 V, 2.5 V, 4.096 V, 5 V, 8.192 V, and 10 V
- Tight Output Tolerances and Low Temperature Coefficient
  - Max 0.1%, 50 ppm/°C – A Grade
  - Max 0.2%, 50 ppm/°C – B Grade
  - Max 0.5%, 50 ppm/°C – C Grade
- Low Output Noise: 41  $\mu\text{V}_{\text{RMS}}$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

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

### APPLICATIONS

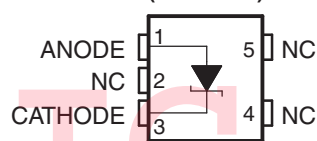
- Data-Acquisition Systems
- Power Supplies and Power-Supply Monitors
- Instrumentation and Test Equipment
- Process Controls
- Precision Audio
- Automotive Electronics
- Energy Management
- Battery-Powered Equipment

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  $\mu\text{A}$  (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<sup>(1)</sup>**

T <sub>A</sub>	DEVICE GRADE	V <sub>KA</sub>	PACKAGE <sup>(2)</sup>		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](http://www.ti.com).

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

**ORDERING INFORMATION <sup>(1)</sup> (continued)**

T <sub>A</sub>	DEVICE GRADE	V <sub>KA</sub>	PACKAGE <sup>(2)</sup>		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 <sup>(1)</sup> (continued)**

T <sub>A</sub>	DEVICE GRADE	V <sub>KA</sub>	PACKAGE <sup>(2)</sup>		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<sup>(1)</sup>**

T <sub>A</sub>	DEVICE GRADE	V <sub>KA</sub>	PACKAGE <sup>(2)</sup>		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](http://www.ti.com).

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

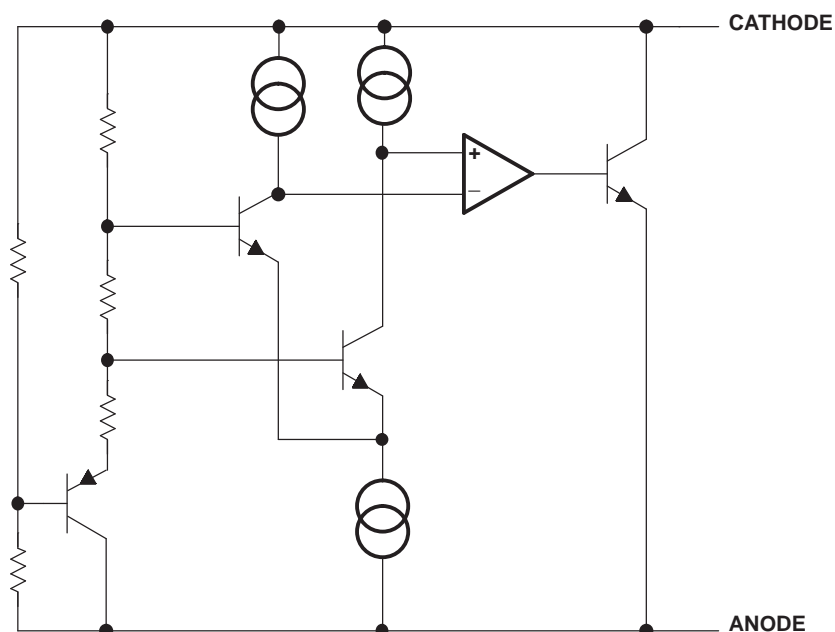
**ORDERING INFORMATION <sup>(1)</sup> (continued)**

T <sub>A</sub>	DEVICE GRADE	V <sub>KA</sub>	PACKAGE <sup>(2)</sup>		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 <sup>(1)</sup> (continued)**

T <sub>A</sub>	DEVICE GRADE	V <sub>KA</sub>	PACKAGE <sup>(2)</sup>		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<sup>(1)</sup>**

over free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
$I_Z$	Continuous cathode current	-10	20	mA
$\theta_{JA}$	Package thermal impedance <sup>(2) (3)</sup>		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  $T_J(max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(max) - T_A)/\theta_{JA}$ . 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	<sup>(1)</sup>	15	mA
$T_A$	Free-air temperature	I temperature	-40	85
		Q temperature	-40	125

- (1) See parametric tables



### TL4050x20I ELECTRICAL CHARACTERISTICS

at industrial temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (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	
$\Delta V_Z$	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		$\mu\text{A}$		
		Full range			65				65				
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	25°C	$\pm 20$			$\pm 20$			$\pm 20$			ppm/°C	
		25°C	$\pm 15$			$\pm 15$			$\pm 15$				
		25°C	$\pm 15$			$\pm 15$			$\pm 15$				
		Full range	$\pm 50$			$\pm 50$			$\pm 50$				
$\frac{\Delta V_Z}{\Delta I_Z}$	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			
			Full range			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			$\Omega$	
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	25°C	34			34			34			$\mu\text{V}_{\text{RMS}}$	
	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	
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		0.7			0.7			0.7			mV	

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

### TL4050x20Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range  $T_A = -40^\circ\text{C}$  to  $125^\circ\text{C}$  (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	
$\Delta V_Z$	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		$\mu\text{A}$		
		Full range			65				65				
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	25°C	$\pm 20$			$\pm 20$			$\pm 20$			ppm/°C	
		25°C	$\pm 15$			$\pm 15$			$\pm 15$				
		25°C	$\pm 15$			$\pm 15$			$\pm 15$				
		Full range	$\pm 50$			$\pm 50$			$\pm 50$				
$\frac{\Delta V_Z}{\Delta I_Z}$	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			
		25°C	$1 \text{ mA} < I_Z < 15 \text{ mA}$		2.3		6		2.3		6		
			Full range			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			$\Omega$	
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	25°C	34			34			34			$\mu\text{V}_{\text{RMS}}$	
	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	
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^\circ\text{C}$ to $125^\circ\text{C}$		0.7			0.7			0.7			mV	

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

### TL4050x25I ELECTRICAL CHARACTERISTICS

at industrial temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (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 $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	2.5			2.5			2.5			V		
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	-2.5	2.5		-5	5		-13	13		mV		
		Full range	-11	11		-14	14		-21	21				
$I_{Z,\text{min}}$	Minimum cathode current	$25^{\circ}\text{C}$	41		60		41		60		$\mu\text{A}$			
		Full range			65		65		65					
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$			ppm/ $^{\circ}\text{C}$		
		$25^{\circ}\text{C}$	$\pm 15$			$\pm 15$			$\pm 15$					
		$25^{\circ}\text{C}$	$\pm 15$			$\pm 15$			$\pm 15$					
		Full range	$\pm 50$			$\pm 50$			$\pm 50$					
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1 \text{ mA}$	$25^{\circ}\text{C}$	0.3	0.8		0.3	0.8		0.3	0.8		mV	
			Full range	1.2		1.2		1.2						
		$1 \text{ mA} < I_Z < 15 \text{ mA}$	$25^{\circ}\text{C}$	2.3		6		2.3	6		2.3	6		
			Full range	8		8		8		8				
$Z_Z$	Reverse dynamic impedance $I_Z = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.3			0.3			0.3			$\Omega$		
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	$25^{\circ}\text{C}$	41			41			41			$\mu\text{V}_{\text{RMS}}$		
	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		
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		0.7			0.7			0.7			mV		

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

### TL4050x25Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (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	$I_Z = 100\ \mu\text{A}$	$25^{\circ}\text{C}$	2.5			2.5			2.5			V		
$\Delta V_Z$ Reverse breakdown voltage tolerance	$I_Z = 100\ \mu\text{A}$	$25^{\circ}\text{C}$	-2.5	2.5		-5	5		-13	13		mV		
		Full range	-15		15		-18		18		-25		25	
$I_{Z,\text{min}}$ Minimum cathode current		$25^{\circ}\text{C}$	41		60		41		60		41		60	
		Full range			65				65				65	
$\alpha_{VZ}$ Average temperature coefficient of reverse breakdown voltage	$I_Z = 10\ \text{mA}$	$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$			ppm/ $^{\circ}\text{C}$		
	$I_Z = 1\ \text{mA}$	$25^{\circ}\text{C}$	$\pm 15$			$\pm 15$			$\pm 15$					
	$I_Z = 100\ \mu\text{A}$	$25^{\circ}\text{C}$	$\pm 15$			$\pm 15$			$\pm 15$					
		Full range				$\pm 50$			$\pm 50$				$\pm 50$	
$\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1\ \text{mA}$	$25^{\circ}\text{C}$	0.3		0.8		0.3		0.8		0.3		0.8	
		Full range			1.2				1.2				1.2	
	$1\ \text{mA} < I_Z < 15\ \text{mA}$	$25^{\circ}\text{C}$	2.3		6		2.3		6		2.3		6	
		Full range			8				8				8	
$Z_Z$ Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.3			0.3			0.3			$\Omega$		
$e_N$ Wideband noise	$I_Z = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	$25^{\circ}\text{C}$	41			41			41			$\mu\text{V}_{\text{RMS}}$		
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		
$V_{\text{HYST}}$ Thermal hysteresis <sup>(1)</sup>	$\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		0.7			0.7			0.7			mV		

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

### TL4050x41I ELECTRICAL CHARACTERISTICS

at industrial temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (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 $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	4.096			4.096			4.096			V	
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	-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	$25^{\circ}\text{C}$	52		68	52		68	52		68	$\mu\text{A}$	
		Full range			73			73			73		
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	$25^{\circ}\text{C}$	$\pm 30$			$\pm 30$			$\pm 30$			ppm/ $^{\circ}\text{C}$	
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		Full range	$\pm 50$			$\pm 50$			$\pm 50$				
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1 \text{ mA}$	$25^{\circ}\text{C}$	0.2		0.9	0.2		0.9	0.2		0.9	mV
			Full range			1.2			1.2			1.2	
		$1 \text{ mA} < I_Z < 15 \text{ mA}$	$25^{\circ}\text{C}$	2		7	2		7	2		7	
			Full range			10			10			10	
$Z_Z$	Reverse dynamic impedance $I_Z = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.5			0.5			0.5			$\Omega$	
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	$25^{\circ}\text{C}$	93			93			93			$\mu\text{V}_{\text{RMS}}$	
	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	
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		1.148			1.148			1.148			mV	

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

### TL4050x41Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (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 $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	4.096			4.096			4.096			V			
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	-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	$25^{\circ}\text{C}$	52		68		52		68		52		68		
		Full range	78			78			78			78			
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	$25^{\circ}\text{C}$	$\pm 30$			$\pm 30$			$\pm 30$			ppm/ $^{\circ}\text{C}$			
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$						
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$						
		Full range	$\pm 50$			$\pm 50$			$\pm 50$						
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1 \text{ mA}$	$25^{\circ}\text{C}$	0.2		0.9		0.2		0.9		0.2		0.9	
			Full range	1.2			1.2			1.2					
		$1 \text{ mA} < I_Z < 15 \text{ mA}$	$25^{\circ}\text{C}$	2		7		2		7		2		7	
			Full range	10			10			10					
$Z_Z$	Reverse dynamic impedance $I_Z = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.5			0.5			0.5			$\Omega$			
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	$25^{\circ}\text{C}$	93			93			93			$\mu\text{V}_{\text{RMS}}$			
	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			
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		1.148			1.148			1.148			mV			

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

### TL4050x50I ELECTRICAL CHARACTERISTICS

at industrial temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (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 $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	5			5			5			V	
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	-5		5	-10		10	-25		25	mV	
		Full range	-22		22	-27		27	-42		42		
$I_{Z,\text{min}}$	Minimum cathode current	$25^{\circ}\text{C}$	56		74	56		74	56		74	$\mu\text{A}$	
		Full range			80			80			80		
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	$25^{\circ}\text{C}$	$\pm 30$			$\pm 30$			$\pm 30$			ppm/ $^{\circ}\text{C}$	
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		Full range	$\pm 50$			$\pm 50$			$\pm 50$				
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1 \text{ mA}$	$25^{\circ}\text{C}$	0.2		1	0.2		1	0.2		1	mV
			Full range			1.4			1.4			1.4	
		$1 \text{ mA} < I_Z < 15 \text{ mA}$	$25^{\circ}\text{C}$	2		8	2		8	2		8	
			Full range			12			12			12	
$Z_Z$	Reverse dynamic impedance $I_Z = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.5			0.5			0.5			$\Omega$	
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	$25^{\circ}\text{C}$	93			93			93			$\mu\text{V}_{\text{RMS}}$	
	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	
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		1.4			1.4			1.4			mV	

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

### TL4050x50Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (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 $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	5			5			5			V	
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	-5		5	-10		10	-25		25	mV	
		Full range	-30		30	-35		35	-50		50		
$I_{Z,\text{min}}$	Minimum cathode current	$25^{\circ}\text{C}$	56		74	56		74	56		74	$\mu\text{A}$	
		Full range			90			90			90		
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	$25^{\circ}\text{C}$	$\pm 30$			$\pm 30$			$\pm 30$			ppm/ $^{\circ}\text{C}$	
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		Full range	$\pm 50$			$\pm 50$			$\pm 50$				
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1 \text{ mA}$	$25^{\circ}\text{C}$	0.2		1	0.2		1	0.2		1	mV
			Full range			1.4			1.4			1.4	
		$1 \text{ mA} < I_Z < 15 \text{ mA}$	$25^{\circ}\text{C}$	2		8	2		8	2		8	
			Full range			12			12			12	
$Z_Z$	Reverse dynamic impedance $I_Z = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.5			0.5			0.5			$\Omega$	
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	$25^{\circ}\text{C}$	93			93			93			$\mu\text{V}_{\text{RMS}}$	
	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	
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		1.4			1.4			1.4			mV	

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



## TL4050x82I ELECTRICAL CHARACTERISTICS

at industrial temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (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 $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	8.192			8.192			8.192			V	
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	-8.2		8.2	-16		16	-41		41	mV	
		Full range	-35		35	-43		43	-68		68		
$I_{Z,\text{min}}$	Minimum cathode current	$25^{\circ}\text{C}$	74		91	74		91	74		91	$\mu\text{A}$	
		Full range			95			95			95		
$\alpha_{V_Z}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	$25^{\circ}\text{C}$	$\pm 40$			$\pm 40$			$\pm 40$			ppm/ $^{\circ}\text{C}$	
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		Full range	$\pm 50$			$\pm 50$			$\pm 50$				
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1 \text{ mA}$	$25^{\circ}\text{C}$	0.6		1.3	0.6		1.3	0.6		1.3	mV
			Full range			2.5			2.5			2.5	
		$1 \text{ mA} < I_Z < 15 \text{ mA}$	$25^{\circ}\text{C}$	7		10	7		10	7		10	
			Full range			18			18			18	
$Z_Z$	Reverse dynamic impedance $I_Z = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.6			0.6			0.6			$\Omega$	
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	$25^{\circ}\text{C}$	150			150			150			$\mu\text{V}_{\text{RMS}}$	
	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	
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		2.3			2.3			2.3			mV	

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

### TL4050x82Q ELECTRICAL CHARACTERISTICS

at extended temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (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	$I_Z = 100\ \mu\text{A}$	$25^{\circ}\text{C}$	8.192			8.192			8.192			V
$\Delta V_Z$ Reverse breakdown voltage tolerance	$I_Z = 100\ \mu\text{A}$	$25^{\circ}\text{C}$	-8.2	8.2		-16	16		-41	41		mV
		Full range	-49	49		-57	57		-82	82		
$I_{Z,\text{min}}$ Minimum cathode current		$25^{\circ}\text{C}$	74		91		74		91		$\mu\text{A}$	
		Full range			100				100			
$\alpha_{VZ}$ Average temperature coefficient of reverse breakdown voltage	$I_Z = 10\ \text{mA}$	$25^{\circ}\text{C}$	$\pm 40$			$\pm 40$			$\pm 40$			ppm/ $^{\circ}\text{C}$
	$I_Z = 1\ \text{mA}$	$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$			
	$I_Z = 100\ \mu\text{A}$	$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$			
		Full range	$\pm 50$			$\pm 50$			$\pm 50$			
$\frac{\Delta V_Z}{\Delta I_Z}$ Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1\ \text{mA}$	$25^{\circ}\text{C}$	0.6	1.3		0.6	1.3		0.6	1.3		mV
		Full range			2.5				2.5			
	$1\ \text{mA} < I_Z < 15\ \text{mA}$	$25^{\circ}\text{C}$	7		10		7		10			
		Full range			18				18			
$Z_Z$ Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.6			0.6			0.6			$\Omega$
$e_N$ Wideband noise	$I_Z = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	$25^{\circ}\text{C}$	150			150			150			$\mu\text{V}_{\text{RMS}}$
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
$V_{\text{HYST}}$ Thermal hysteresis <sup>(1)</sup>	$\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		2.3			2.3			2.3			mV

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

### TL4050x10I ELECTRICAL CHARACTERISTICS

at industrial temperature range, full range  $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  (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 $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	10			10			10			V	
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$	-10		10	-20		20	-50		50	mV	
		Full range	-43		43	-53		53	-83		83		
$I_{Z,\text{min}}$	Minimum cathode current	$25^{\circ}\text{C}$	80		100	80		100	80		100	$\mu\text{A}$	
		Full range			103			103			103		
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage $I_Z = 10 \text{ mA}$	$25^{\circ}\text{C}$	$\pm 40$			$\pm 40$			$\pm 40$			ppm/ $^{\circ}\text{C}$	
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		$25^{\circ}\text{C}$	$\pm 20$			$\pm 20$			$\pm 20$				
		Full range	$\pm 50$			$\pm 50$			$\pm 50$				
$\frac{\Delta V_Z}{\Delta I_Z}$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1 \text{ mA}$	$25^{\circ}\text{C}$	0.8	1.5	0.8	1.5	0.8	1.5	0.8	1.5	mV	
			Full range	3.5		3.5		3.5					
		$1 \text{ mA} < I_Z < 15 \text{ mA}$	$25^{\circ}\text{C}$	8		12	8		12	8			12
			Full range			23			23				23
$Z_Z$	Reverse dynamic impedance $I_Z = 1 \text{ mA}$ , $f = 120 \text{ Hz}$ , $I_{AC} = 0.1 I_Z$	$25^{\circ}\text{C}$	0.7			0.7			0.7			$\Omega$	
$e_N$	Wideband noise $I_Z = 100 \mu\text{A}$ , $10 \text{ Hz} \leq f \leq 10 \text{ kHz}$	$25^{\circ}\text{C}$	150			150			150			$\mu\text{V}_{\text{RMS}}$	
	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	
$V_{\text{HYST}}$	Thermal hysteresis <sup>(1)</sup> $\Delta T_A = -40^{\circ}\text{C}$ to $125^{\circ}\text{C}$		2.8			2.8			2.8			mV	

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

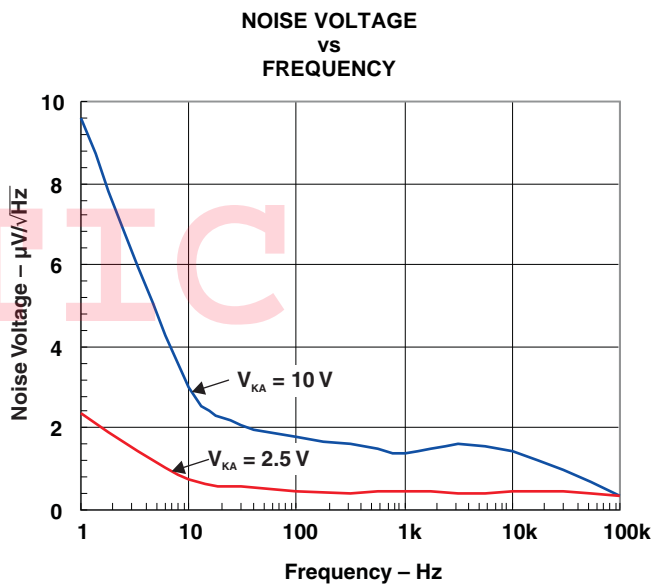
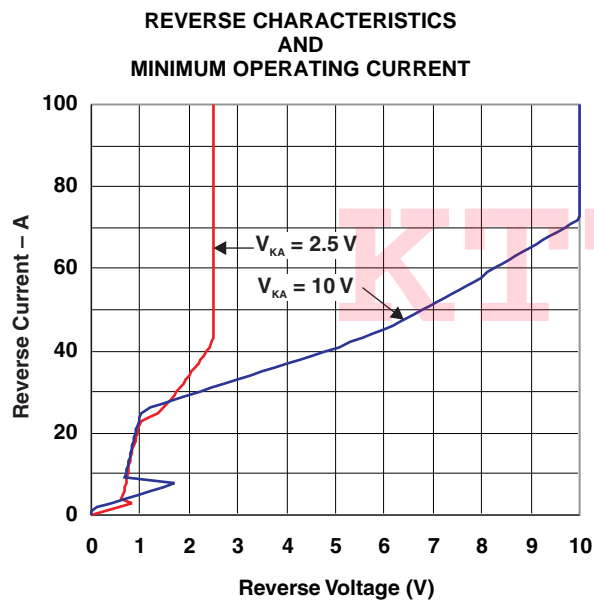
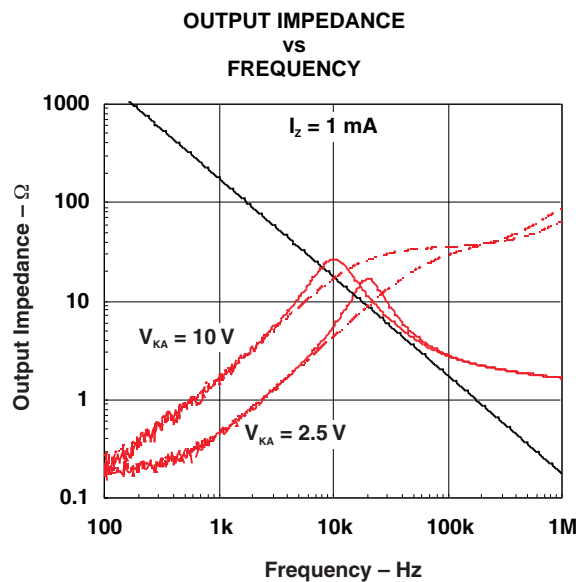
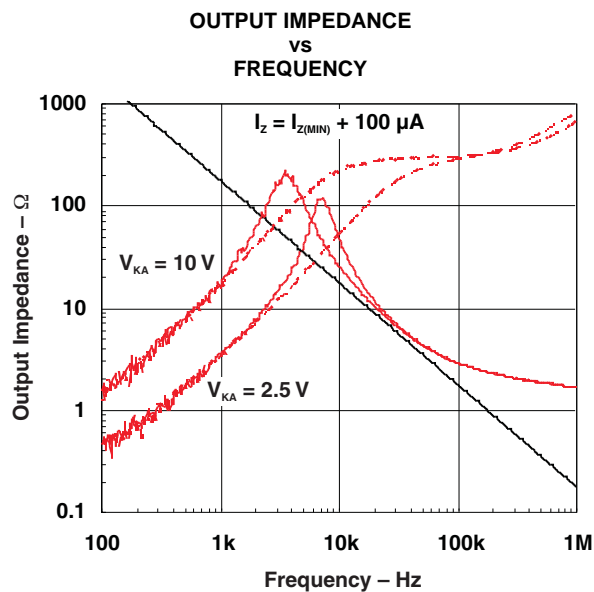
### TL4050x10Q ELECTRICAL CHARACTERISTICS

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

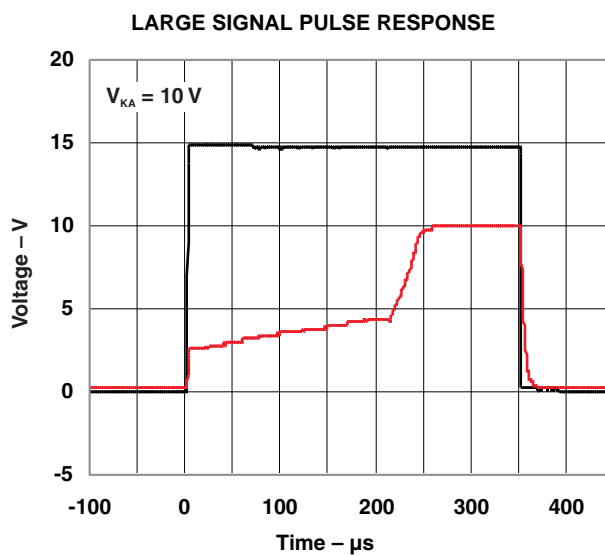
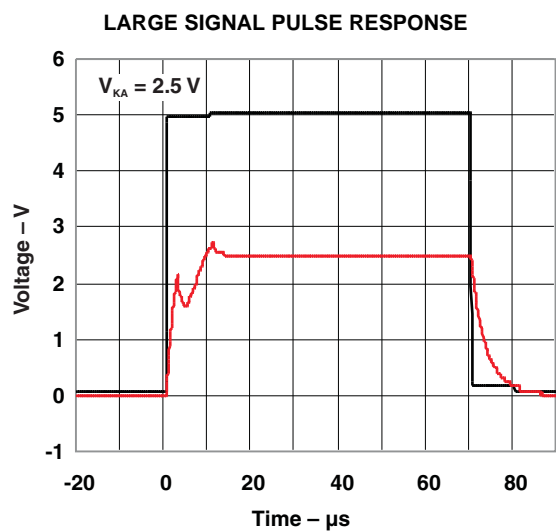
PARAMETER	TEST CONDITIONS	$T_A$	TL4050A10Q			TL4050B10Q			TL4050C10Q			UNIT	
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
$V_Z$	Reverse breakdown voltage $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$		10			10			10	V		
$\Delta V_Z$	Reverse breakdown voltage tolerance $I_Z = 100 \mu\text{A}$	$25^{\circ}\text{C}$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

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

TYPICAL CHARACTERISTICS



### TYPICAL CHARACTERISTICS (continued)



KTTIC

### APPLICATION INFORMATION

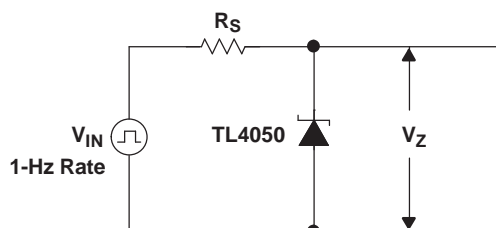


Figure 1. Start-Up Test Circuit

### 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.

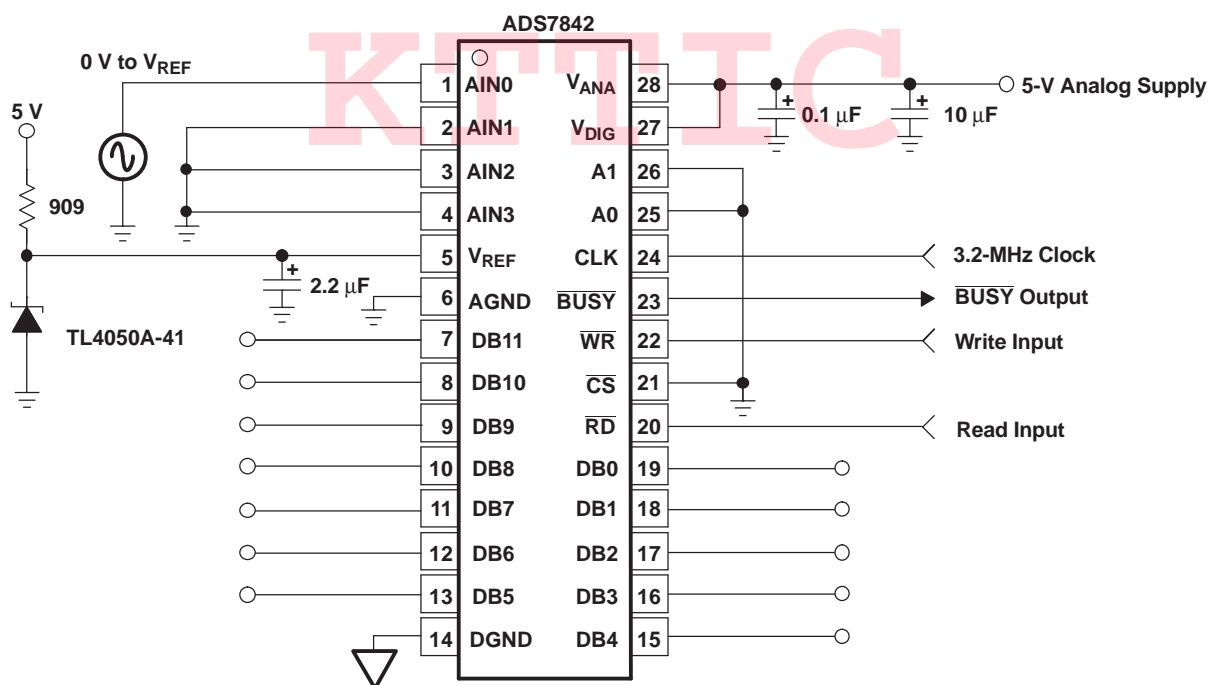


Figure 2. Data-Acquisition Circuit With TL4050x-41

### 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](#):

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

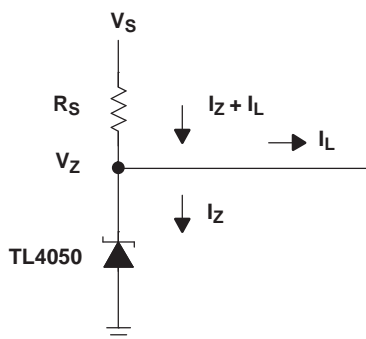


Figure 3. Shunt Regulator

KTTIC



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
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

<sup>(1)</sup> 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.

<sup>(2)</sup> 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)

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

**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.

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

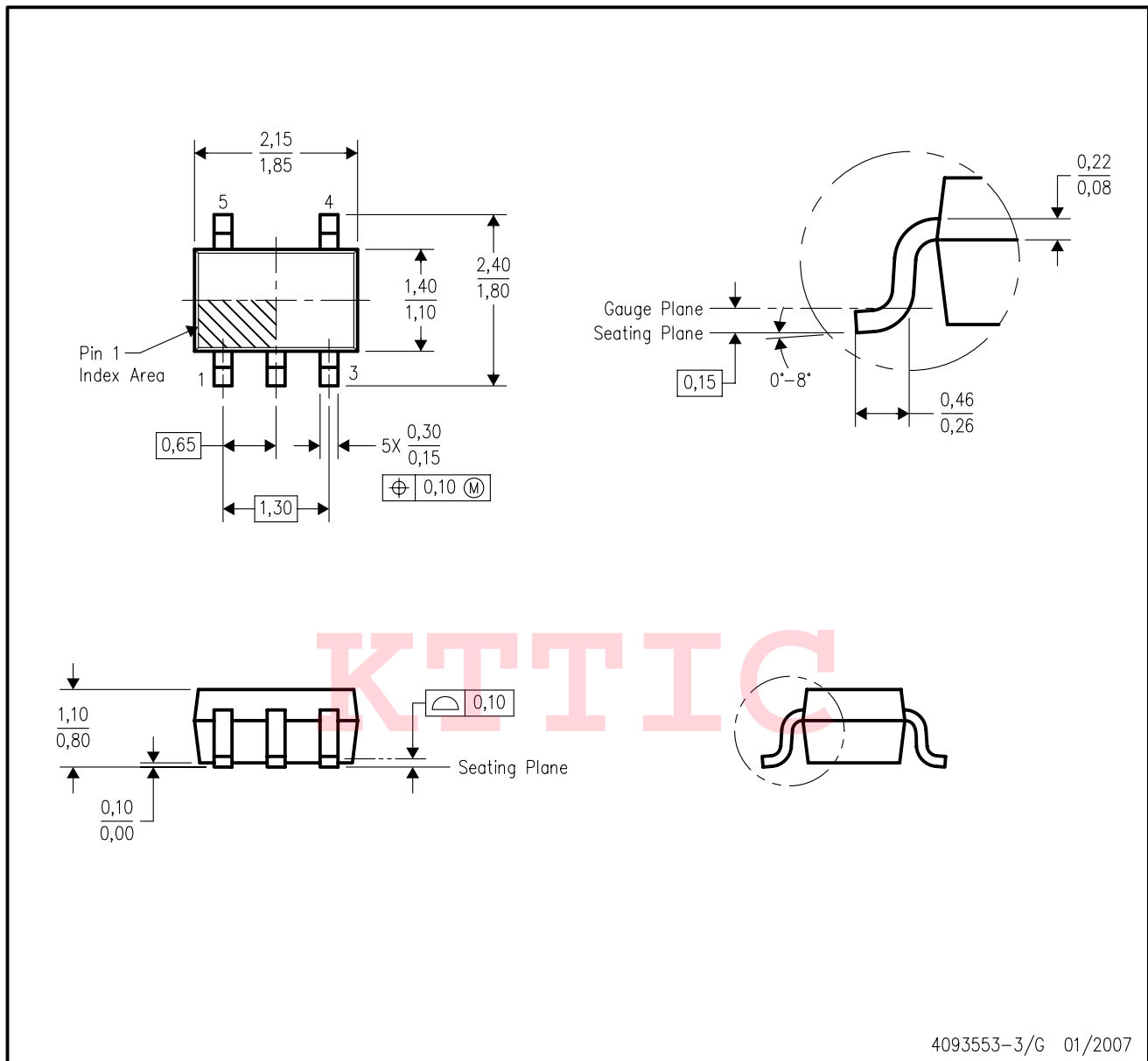
- Catalog: [TL4050B25](#), [TL4050B41](#), [TL4050B50](#), [TL4050C50](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

DCK (R-PDSO-G5)

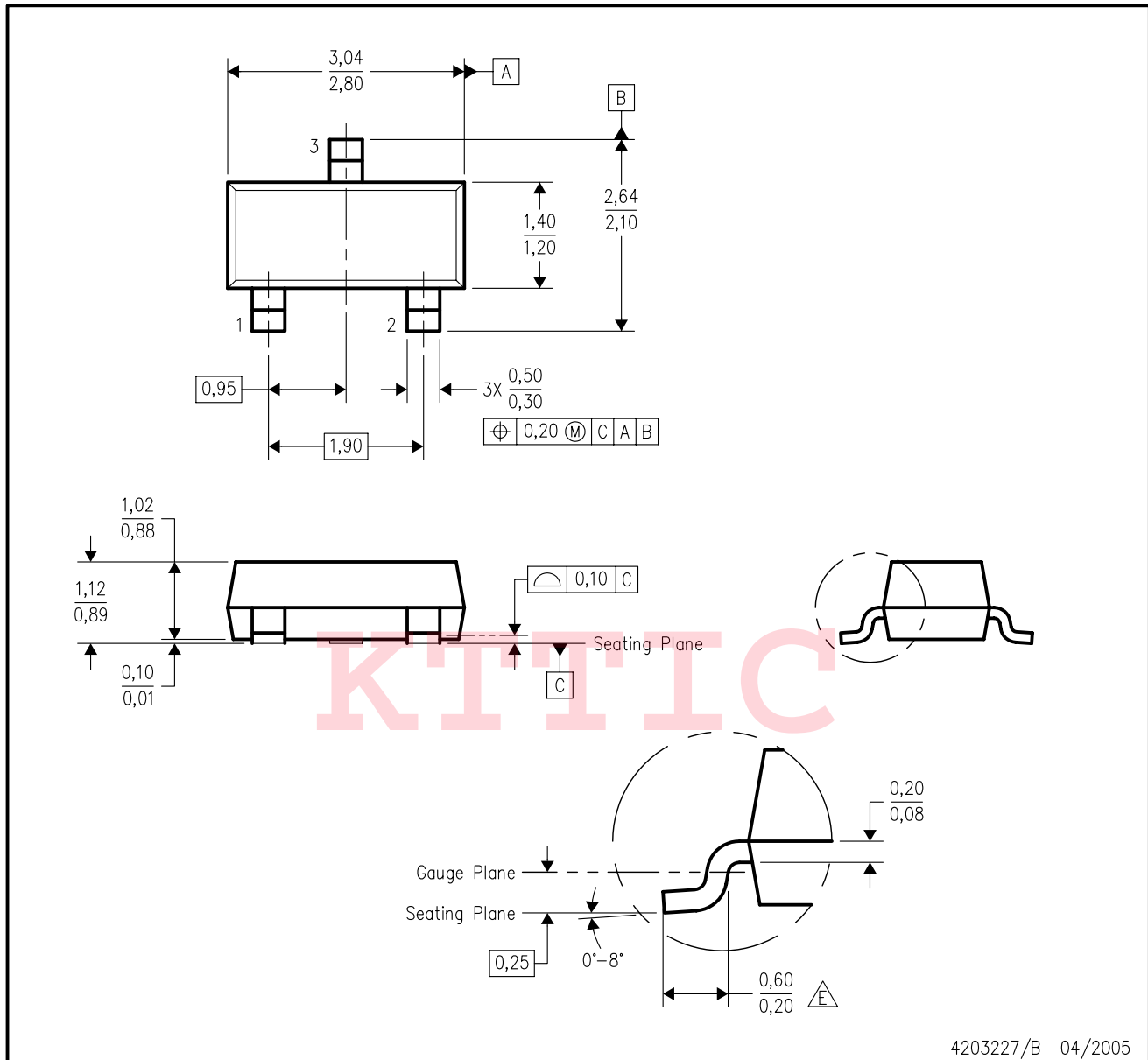
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. 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.
- $\triangle E$  Falls within JEDEC TO-236 variation AB, except minimum foot length.

**IMPORTANT NOTICE**

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

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

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

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

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

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

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

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

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

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

<b>Products</b>		<b>Applications</b>	
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>	Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>	Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Energy	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>	Space, Avionics & Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>	Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
		Wireless	<a href="http://www.ti.com/wireless-apps">www.ti.com/wireless-apps</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2010, Texas Instruments Incorporated