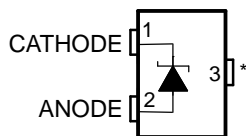


## FEATURES

- 1.225-V Fixed and Adjustable Outputs (1.225 V to 10 V)
- Tight Output Tolerances and Low Temperature Coefficient
  - Max 0.1%, 100 ppm/°C – A Grade
  - Max 0.2%, 100 ppm/°C – B Grade
  - Max 0.5%, 100 ppm/°C – C Grade
  - Max 1.0%, 150 ppm/°C – D Grade
- Low Output Noise . . . 20  $\mu\text{V}_{\text{RMS}}$  (Typ)
- Wide Operating Current Range . . . 45  $\mu\text{A}$  (Typ) to 12 mA
- Stable With All Capacitive Loads; No Output Capacitor Required

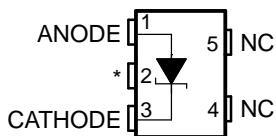
- Available in
  - Industrial Temperature:  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$
  - Extended Temperature:  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$
- Applications
  - Data-Acquisition Systems
  - Power Supplies and Power-Supply Monitors
  - Instrumentation and Test Equipment
  - Process Control
  - Precision Audio
  - Automotive Electronics
  - Energy Management/Metering
  - Battery-Powered Equipment

1.2 V . . . DBZ (SOT-23) PACKAGE  
(TOP VIEW)



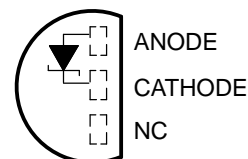
\* Pin 3 must be connected to ANODE or left open.

1.2 V . . . DCK (SC-70) PACKAGE  
(TOP VIEW)



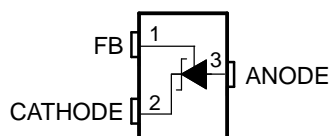
NC – No internal connection  
\* Pin 2 must be connected to ANODE or left open.

1.2 V . . . LP (TO-92/TO-226) PACKAGE  
(TOP VIEW)

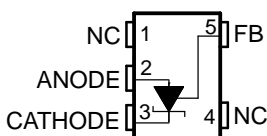


NC – No internal connection

Adjustable . . . DBZ (SOT-23) PACKAGE  
(TOP VIEW)

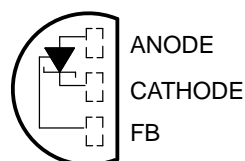


Adjustable . . . DCK (SC-70) PACKAGE  
(TOP VIEW)



NC – No internal connection

Adjustable . . . LP (TO-92/TO-226) PACKAGE  
(TOP VIEW)



## DESCRIPTION/ORDERING INFORMATION

The LM4041 series of shunt voltage references are versatile, easy-to-use references with a vast array of applications. They require no external resistors or capacitors for operation and are stable with all capacitive loads. Additionally, the reference offers low dynamic impedance, low noise, and a low temperature coefficient to ensure a stable output voltage over a wide range of operating currents and temperatures. The LM4041 uses fuse and Zener-zap reverse breakdown voltage trim during wafer sort to offer four output voltage tolerances, ranging from 0.1% (max) for the A grade to 1% (max) for the D grade. Thus, a great deal of flexibility is offered to designers in choosing the best cost-to-performance ratio for their applications. The LM4041 is available in a fixed (1.225 V nominal) or an adjustable version (which requires an external resistor divider to set the output to a value between 1.225 V and 10 V).

Packaged in space-saving SC-70 and SOT-23-3 and requiring a minimum current of 45  $\mu\text{A}$  (typ), the LM4041 also is ideal for portable applications. The TO-92 package also is available for through-hole packaging needs. The LM4041xl is characterized for operation over an ambient temperature range of  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . The LM4041xQ is characterized for operation over an ambient temperature range of  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .



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.

# LM4041

## PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

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### ORDERING INFORMATION

T <sub>A</sub>	DEVICE GRADE	V <sub>Z</sub>	PACKAGE <sup>(1)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING <sup>(2)</sup>
–40°C to 85°C	A grade: 0.1% initial accuracy and 100 ppm/°C temperature coefficient	1.2 V	SC-70 (DCK)	Reel of 3000	LM4041A12IDCKR	PREVIEW
			SOT-23-3 (DBZ)	Reel of 3000	LM4041A12IDBZR	PREVIEW
				Reel of 250	LM4041A12IDBZT	PREVIEW
			TO-92/TO-226 (LP)	Bulk of 1000	LM4041A12ILP	PREVIEW
				Reel of 2000	LM4041A12ILPR	PREVIEW
	B grade: 0.2% initial accuracy and 100 ppm/°C temperature coefficient	ADJ	SC-70 (DCK)	Reel of 3000	LM4041BIDCKR	PREVIEW
			SOT-23-3 (DBZ)	Reel of 3000	LM4041BIDBZR	PREVIEW
				Reel of 250	LM4041BIDBZT	PREVIEW
			TO-92/TO-226 (LP)	Bulk of 1000	LM4041BILP	PREVIEW
				Reel of 2000	LM4041BILPR	PREVIEW
		1.2 V	SC-70 (DCK)	Reel of 3000	LM4041B12IDCKR	PREVIEW
			SOT-23-3 (DBZ)	Reel of 3000	LM4041B12IDBZR	PREVIEW
				Reel of 250	LM4041B12IDBZT	PREVIEW
			TO-92/TO-226 (LP)	Bulk of 1000	LM4041B12ILP	PREVIEW
				Reel of 2000	LM4041B12ILPR	PREVIEW
	C grade: 0.5% initial accuracy and 100 ppm/°C temperature coefficient	ADJ	SC-70 (DCK)	Reel of 3000	LM4041CIDCKR	MH_
				Reel of 250	LM4041CIDCKT	MH_
			SOT-23-3 (DBZ)	Reel of 3000	LM4041CIDBZR	4MH_
				Reel of 250	LM4041CIDBZT	4MH_
			TO-92/TO-226 (LP)	Bulk of 1000	LM4041CILP	PREVIEW
				Reel of 2000	LM4041CILPR	PREVIEW
		1.2 V	SC-70 (DCK)	Reel of 3000	LM4041C12IDCKR	MM_
			SOT-23-3 (DBZ)	Reel of 3000	LM4041C12IDBZR	4MM_
				Reel of 250	LM4041C12IDBZT	4MM_
			TO-92/TO-226 (LP)	Bulk of 1000	LM4041C12ILP	PREVIEW
				Reel of 2000	LM4041C12ILPR	PREVIEW
	D grade: 1.0% initial accuracy and 150 ppm/°C temperature coefficient	ADJ	SC-70 (DCK)	Reel of 3000	LM4041DIDCKR	MJ_
				Reel of 250	LM4041DIDCKT	MJ_
			SOT-23-3 (DBZ)	Reel of 3000	LM4041DIDBZR	4MJ_
				Reel of 250	LM4041DIDBZT	4MJ_
			TO-92/TO-226 (LP)	Bulk of 1000	LM4041DILP	PREVIEW
				Reel of 2000	LM4041DILPR	PREVIEW
		1.2 V	SC-70 (DCK)	Reel of 3000	LM4041D12IDCKR	MN_
			SOT-23-3 (DBZ)	Reel of 3000	LM4041D12IDBZR	4MN_
				Reel of 250	LM4041D12IDBZT	4MN_
			TO-92/TO-226 (LP)	Bulk of 1000	LM4041D12ILP	PREVIEW
				Reel of 2000	LM4041D12ILPR	PREVIEW

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

(2) DBZ/DCK: The actual top-side marking has one additional character that designates the assembly/test site.

### ORDERING INFORMATION

T <sub>A</sub>	DEVICE GRADE	V <sub>Z</sub>	PACKAGE <sup>(1)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING <sup>(2)</sup>
–40°C to 125°C	C grade: 0.5% initial accuracy and 100 ppm/°C temperature coefficient	ADJ	SOT-23-3 (DBZ)	Reel of 3000	LM4041CQDBZR	4MP_
				Reel of 250	LM4041CQDBZT	
		1.2 V	SOT-23-3 (DBZ)	Reel of 3000	LM4041C12QDBZR	4MS_
				Reel of 250	LM4041C12QDBZT	
	D grade: 1.0% initial accuracy and 150 ppm/°C temperature coefficient	ADJ	SOT-23-3 (DBZ)	Reel of 3000	LM4041DQDBZR	4MR_
				Reel of 250	LM4041DQDBZT	
		1.2 V	SOT-23-3 (DBZ)	Reel of 3000	LM4041D12QDBZR	4MT_
				Reel of 250	LM4041D12QDBZT	

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).

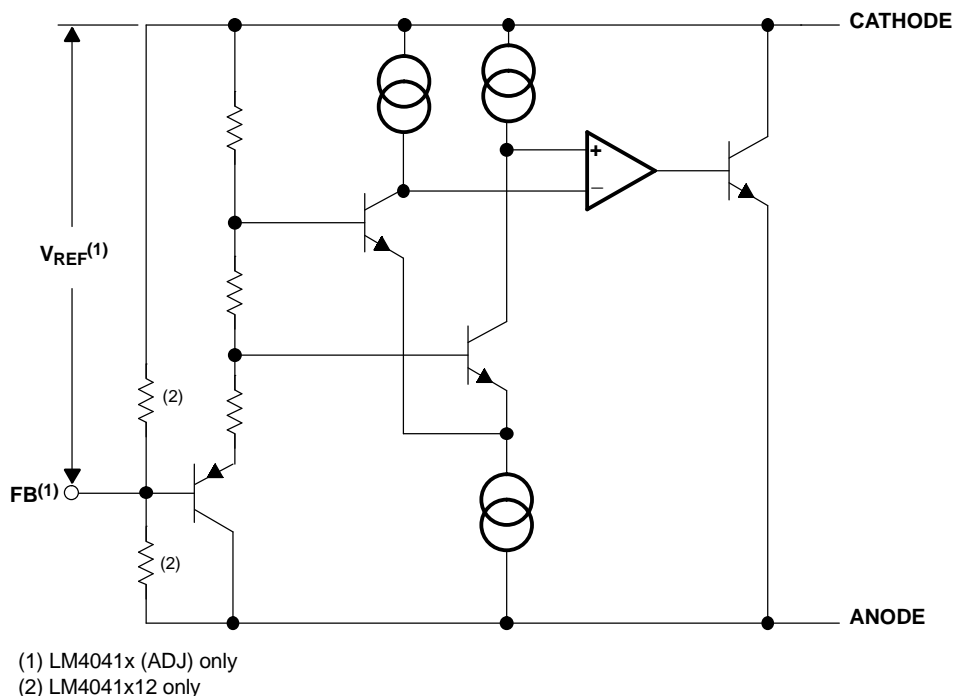
(2) DBZ/DCK: The actual top-side marking has one additional character that designates the assembly/test site.

# LM4041

## PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

SLCS146C—FEBRUARY 2005—REVISED MAY 2005

### FUNCTIONAL BLOCK DIAGRAM



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

over free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
$V_Z$	Continuous cathode voltage		15	V
$I_Z$	Continuous cathode current	-10	25	mA
$\theta_{JA}$	Package thermal impedance <sup>(2)(3)</sup>	DBZ package	206	°C/W
		DCK package	252	
		LP package	156	
$T_J$	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  $T_J(\text{max})$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$ . 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)	12	mA
$V_Z$	Reverse breakdown voltage (adjustable version)		10	V
$T_A$	Free-air temperature	LM4041 (I temperature)	-40	°C
		LM4041 (Q temperature)	-40	

- (1) See parametric tables

## LM4041x12I Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	$T_A$	LM4041A12I			LM4041B12I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_Z$	Reverse breakdown voltage	$I_Z = 100\ \mu\text{A}$		1.225			1.225		V
	Reverse breakdown voltage tolerance	$I_Z = 100\ \mu\text{A}$		25°C	–1.2	1.2	–2.4	2.4	mV
				Full range	–9.2	9.2	–10.4	10.4	
$I_{Z,\text{min}}$	Minimum cathode current			25°C	45	75	45	75	$\mu\text{A}$
				Full range		80		80	
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage	$I_Z = 10\ \text{mA}$		25°C	$\pm 20$		$\pm 20$		ppm/°C
		$I_Z = 1\ \text{mA}$		25°C	$\pm 15$		$\pm 15$		
				Full range		$\pm 100$		$\pm 100$	
		$I_Z = 100\ \mu\text{A}$		25°C	$\pm 15$		$\pm 15$		
$\Delta V_Z / \Delta I_Z$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1\ \text{mA}$		25°C	0.7	1.5	0.7	1.5	mV
				Full range		2		2	
		$1\ \text{mA} < I_Z < 12\ \text{mA}$		25°C	4	6	4	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	0.5	1.5	0.5	1.5	$\Omega$
$e_N$	Wideband noise	$I_Z = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$		25°C	20		20		$\mu\text{V}_{\text{RMS}}$
	Long-term stability of reverse breakdown voltage	$t = 1000\ \text{h}$ , $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ , $I_Z = 100\ \mu\text{A}$		25°C	120		120		ppm

# LM4041

## PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

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### LM4041x12I Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	$T_A$	LM4041C12I			LM4041D12I			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_Z$	Reverse breakdown voltage	$I_Z = 100\ \mu\text{A}$		1.225			1.225		V
	Reverse breakdown voltage tolerance	$I_Z = 100\ \mu\text{A}$		25°C					mV
				Full range					
$I_{Z,\text{min}}$	Minimum cathode current			25°C					$\mu\text{A}$
				Full range					
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage	$I_Z = 10\ \text{mA}$		25°C					ppm/°C
		$I_Z = 1\ \text{mA}$		25°C					
				Full range					
		$I_Z = 100\ \mu\text{A}$		25°C					
$\Delta V_Z / \Delta I_Z$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1\ \text{mA}$		25°C					mV
				Full range					
		$1\ \text{mA} < I_Z < 12\ \text{mA}$		25°C					
				Full range					
$Z_Z$	Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$		25°C					$\Omega$
$e_N$	Wideband noise	$I_Z = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$		25°C					$\mu\text{V}_{\text{RMS}}$
	Long-term stability of reverse breakdown voltage	$t = 1000\ \text{h}$ , $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ , $I_Z = 100\ \mu\text{A}$		25°C					ppm

## LM4041x12Q Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	$T_A$	LM4041C12Q			LM4041D12Q			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_Z$	Reverse breakdown voltage	$I_Z = 100\ \mu\text{A}$		1.225			1.225		V
	Reverse breakdown voltage tolerance	$I_Z = 100\ \mu\text{A}$		25°C			25°C		mV
				Full range			Full range		
$I_{Z,\text{min}}$	Minimum cathode current			25°C			25°C		$\mu\text{A}$
				Full range			Full range		
$\alpha_{VZ}$	Average temperature coefficient of reverse breakdown voltage	$I_Z = 10\ \text{mA}$		25°C			25°C		ppm/°C
		$I_Z = 1\ \text{mA}$		25°C			25°C		
				Full range			Full range		
		$I_Z = 100\ \mu\text{A}$		25°C			25°C		
$\Delta V_Z / \Delta I_Z$	Reverse breakdown voltage change with cathode current change	$I_{Z,\text{min}} < I_Z < 1\ \text{mA}$		25°C			25°C		mV
				Full range			Full range		
		$1\ \text{mA} < I_Z < 12\ \text{mA}$		25°C			25°C		
				Full range			Full range		
$Z_Z$	Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$		25°C			25°C		$\Omega$
				Full range			Full range		
$e_N$	Wideband noise	$I_Z = 100\ \mu\text{A}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$		25°C			25°C		$\mu\text{V}_{\text{RMS}}$
	Long-term stability of reverse breakdown voltage	$t = 1000\ \text{h}$ , $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ , $I_Z = 100\ \mu\text{A}$		25°C			25°C		ppm

# LM4041

## PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

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### LM4041xl (Adjustable Version) Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	$T_A$	LM4041BI			LM4041CI			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{REF}$	Reference voltage	$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$		1.233			1.233		V
	Reference voltage tolerance <sup>(1)</sup>	$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$		25°C	–2.5	2.5	–6.2	6.2	mV
				Full range	–10.5	10.5	–14	14	
$I_{Z,min}$	Minimum cathode current			25°C	45	75	45	75	$\mu\text{A}$
				Full range		80		80	
$\Delta V_{REF}/\Delta I_Z$	Reference voltage change with cathode current change	$I_{Z,min} < I_Z < 1\ \text{mA}$		25°C	0.7	1.5	0.7	1.5	mV
				Full range		2		2	
		$1\ \text{mA} < I_Z < 12\ \text{mA}$		25°C	2	4	2	4	
				Full range		6		6	
$\Delta V_{REF}/\Delta V_{KA}$	Reference voltage change with output voltage change	$I_Z = 1\ \text{mA}$		25°C	–1.55	–2	–1.55	–2	mV/V
				Full range		–2.5		–2.5	
$I_{FB}$	Feedback current			25°C	60	100	60	100	nA
				Full range		120		120	
$\alpha V_{REF}$	Average temperature coefficient of reference voltage <sup>(1)</sup>	$I_Z = 10\ \text{mA}$ , $V_Z = 5\ \text{V}$		25°C	±20		±20		ppm/°C
		$I_Z = 1\ \text{mA}$ , $V_Z = 5\ \text{V}$		25°C	±15		±15		
				Full range		±100		±100	
		$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$		25°C	±15		±15		
$Z_Z$	Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$ , $V_Z = V_{REF}$		25°C	0.3		0.3		$\Omega$
		$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$ , $V_Z = 10\ \text{V}$		25°C	2		2		
$e_N$	Wideband noise	$I_Z = 100\ \mu\text{A}$ , $V_Z = V_{REF}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$		25°C	20		20		$\mu\text{V}_{RMS}$
	Long-term stability of reverse breakdown voltage	$t = 1000\ \text{h}$ , $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ , $I_Z = 100\ \mu\text{A}$		25°C	120		120		ppm

(1) Reference voltage tolerance and average temperature coefficient change with output voltage ( $V_Z$ ). See *Typical Characteristics*.



## LM4041xl (Adjustable Version) Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	$T_A$	LM4041DI			UNIT
				MIN	TYP	MAX	
$V_{REF}$	Reference voltage	$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$	$25^{\circ}\text{C}$		1.233		V
	Reference voltage tolerance <sup>(1)</sup>	$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$	$25^{\circ}\text{C}$	–12		12	mV
			Full range	–24		24	
$I_{Z,min}$	Minimum cathode current		$25^{\circ}\text{C}$		45	75	$\mu\text{A}$
			Full range			80	
$\Delta V_{REF}/\Delta I_Z$	Reference voltage change with cathode current change	$I_{Z,min} < I_Z < 1\ \text{mA}$	$25^{\circ}\text{C}$		0.7	2	mV
			Full range			2.5	
		$1\ \text{mA} < I_Z < 12\ \text{mA}$	$25^{\circ}\text{C}$		2	6	
			Full range			8	
$\Delta V_{REF}/\Delta V_{KA}$	Reference voltage change with output voltage change	$I_Z = 1\ \text{mA}$	$25^{\circ}\text{C}$		–1.55	–2	mV/V
			Full range			–3	
$I_{FB}$	Feedback current		$25^{\circ}\text{C}$		60	150	nA
			Full range			200	
$\alpha V_{REF}$	Average temperature coefficient of reference voltage <sup>(1)</sup>	$I_Z = 10\ \text{mA}$ , $V_Z = 5\ \text{V}$	$25^{\circ}\text{C}$		$\pm 20$		ppm/ $^{\circ}\text{C}$
		$I_Z = 1\ \text{mA}$ , $V_Z = 5\ \text{V}$	$25^{\circ}\text{C}$		$\pm 15$		
			Full range			$\pm 150$	
		$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$	$25^{\circ}\text{C}$		$\pm 15$		
$Z_Z$	Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$ , $V_Z = V_{REF}$	$25^{\circ}\text{C}$		0.3		$\Omega$
		$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$ , $V_Z = 10\ \text{V}$	$25^{\circ}\text{C}$		2		
$e_N$	Wideband noise	$I_Z = 100\ \mu\text{A}$ , $V_Z = V_{REF}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$	$25^{\circ}\text{C}$		20		$\mu\text{V}_{RMS}$
	Long-term stability of reverse breakdown voltage	$t = 1000\ \text{h}$ , $T_A = 25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ , $I_Z = 100\ \mu\text{A}$	$25^{\circ}\text{C}$		120		ppm

(1) Reference voltage tolerance and average temperature coefficient change with output voltage ( $V_Z$ ). See *Typical Characteristics*.

# LM4041

## PRECISION MICROPOWER SHUNT VOLTAGE REFERENCE

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### LM4041xQ (Adjustable Version) Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	$T_A$	LM4041CQ			LM4041DQ			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$V_{REF}$	Reference voltage	$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$		1.233			1.233		V
	Reference voltage tolerance <sup>(1)</sup>	$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$		25°C	–6.2	6.2	–12	12	mV
				Full range	–18	18	–30	30	
$I_{Z,min}$	Minimum cathode current			25°C	45	75	45	75	$\mu\text{A}$
				Full range		80		80	
$\Delta V_{REF}/\Delta I_Z$	Reference voltage change with cathode current change	$I_{Z,min} < I_Z < 1\ \text{mA}$		25°C	0.7	1.5	0.7	2	mV
				Full range		2		2.5	
		$1\ \text{mA} < I_Z < 12\ \text{mA}$		25°C	2	4	2	6	
				Full range		8		10	
$\Delta V_{REF}/\Delta V_{KA}$	Reference voltage change with output voltage change	$I_Z = 1\ \text{mA}$		25°C	–1.55	–2	–1.55	–2.5	mV/V
				Full range		–3		–4	
$I_{FB}$	Feedback current			25°C	60	100	60	150	nA
				Full range		120		200	
$\alpha V_{REF}$	Average temperature coefficient of reference voltage <sup>(1)</sup>	$I_Z = 10\ \text{mA}$ , $V_Z = 5\ \text{V}$		25°C	$\pm 20$		$\pm 20$		ppm/°C
		$I_Z = 1\ \text{mA}$ , $V_Z = 5\ \text{V}$		25°C	$\pm 15$		$\pm 15$		
				Full range		$\pm 100$		$\pm 150$	
		$I_Z = 100\ \mu\text{A}$ , $V_Z = 5\ \text{V}$		25°C	$\pm 15$		$\pm 15$		
$Z_Z$	Reverse dynamic impedance	$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$ , $V_Z = V_{REF}$		25°C	0.3		0.3		$\Omega$
		$I_Z = 1\ \text{mA}$ , $f = 120\ \text{Hz}$ , $I_{AC} = 0.1\ I_Z$ , $V_Z = 10\ \text{V}$		25°C	2		2		
$e_N$	Wideband noise	$I_Z = 100\ \mu\text{A}$ , $V_Z = V_{REF}$ , $10\ \text{Hz} \leq f \leq 10\ \text{kHz}$		25°C	20		20		$\mu\text{V}_{RMS}$
	Long-term stability of reverse breakdown voltage	$t = 1000\ \text{h}$ , $T_A = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ , $I_Z = 100\ \mu\text{A}$		25°C	120		120		ppm

(1) Reference voltage tolerance and average temperature coefficient change with output voltage ( $V_Z$ ). See *Typical Characteristics*.

## TYPICAL CHARACTERISTICS

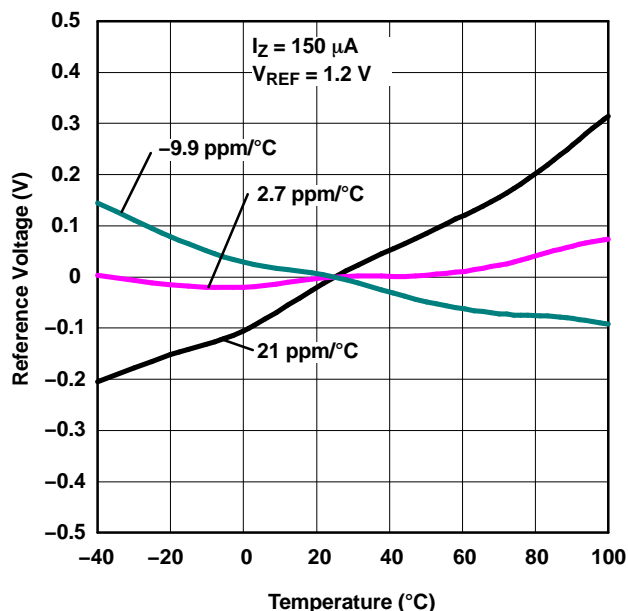


Figure 1. Temperature Drift for Different Average Temperature Coefficients

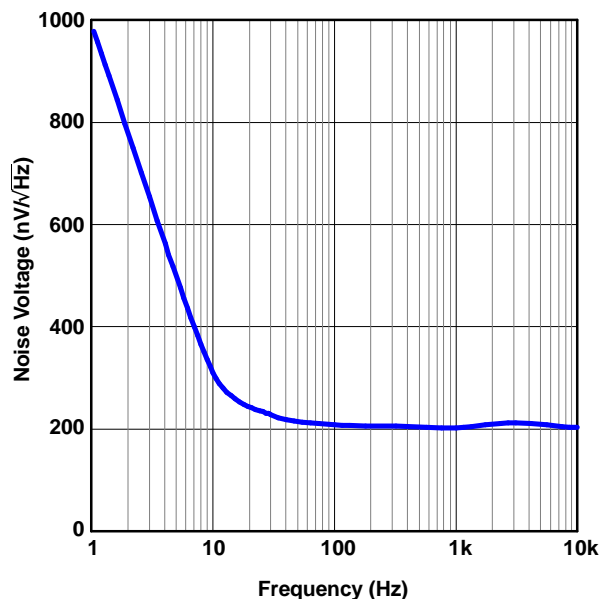


Figure 2. Noise Voltage vs Frequency

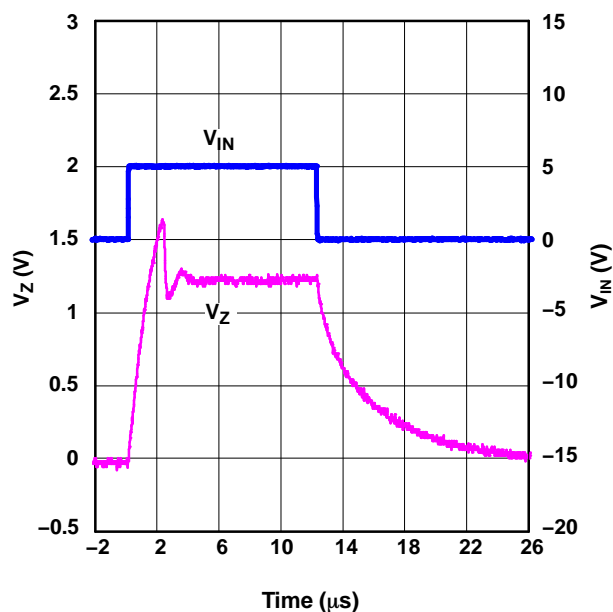


Figure 3. Start-Up Characteristics

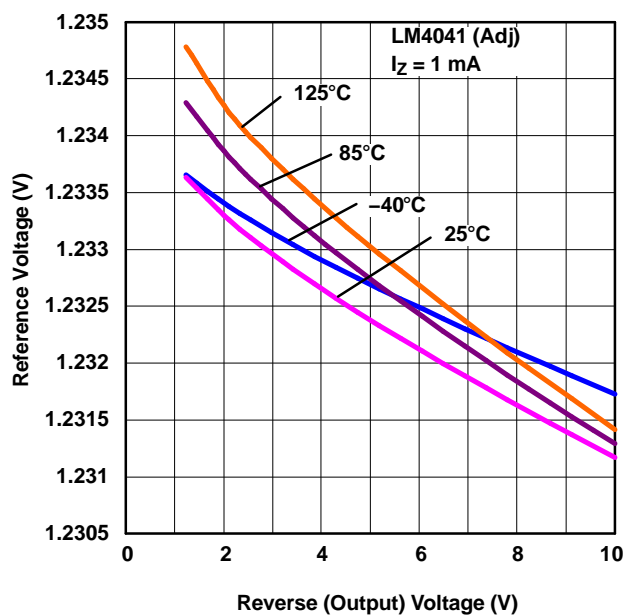


Figure 4. Reference Voltage vs Reverse (Output) Voltage (for Different Temperatures)

## TYPICAL CHARACTERISTICS

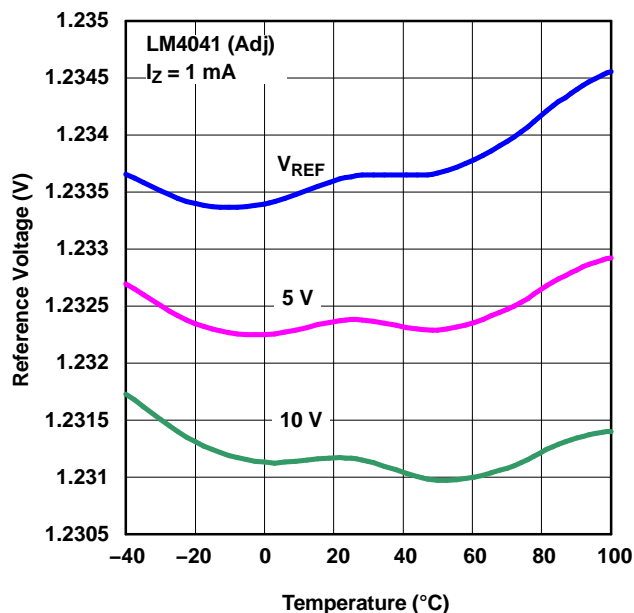


Figure 5. Reference Voltage vs Temperature (for Different Reverse Voltages)

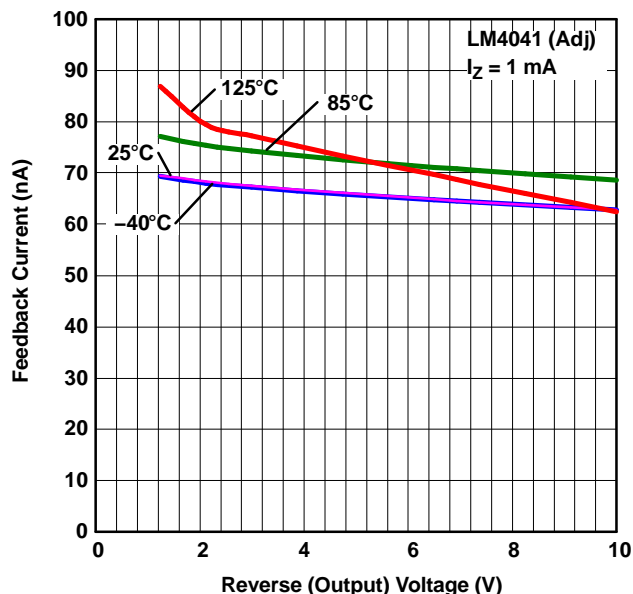


Figure 6. Feedback Current vs Reverse (Output) Voltage (for Different Temperatures)

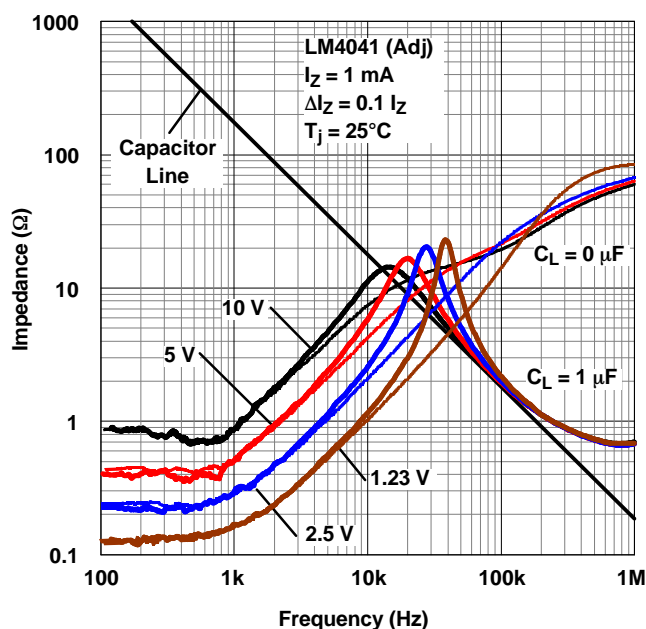


Figure 7. Output Impedance vs Frequency

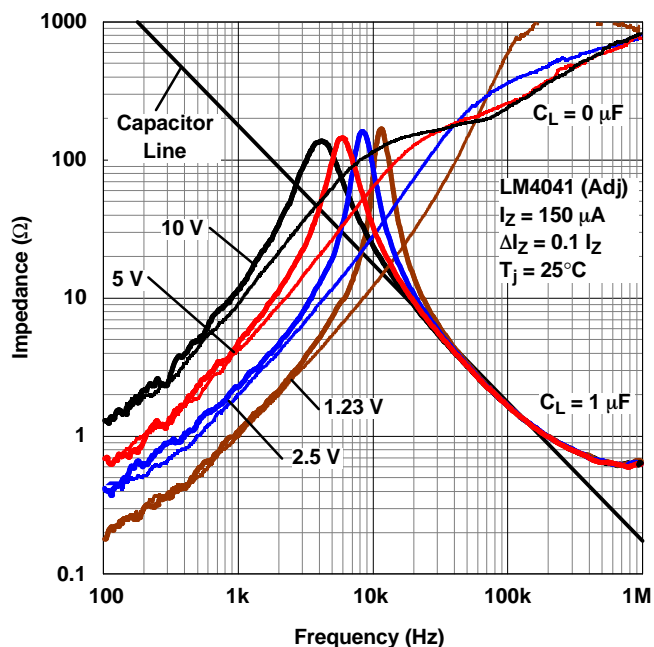


Figure 8. Output Impedance vs Frequency

## TYPICAL CHARACTERISTICS

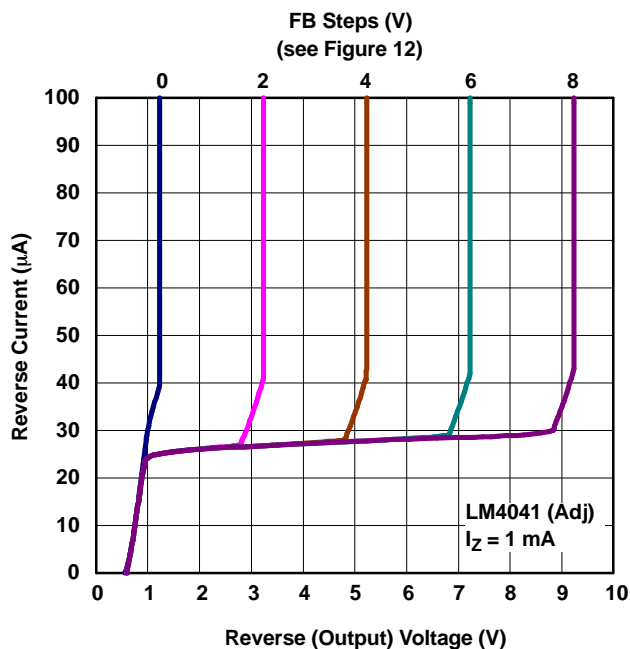


Figure 9. Reverse Characteristics

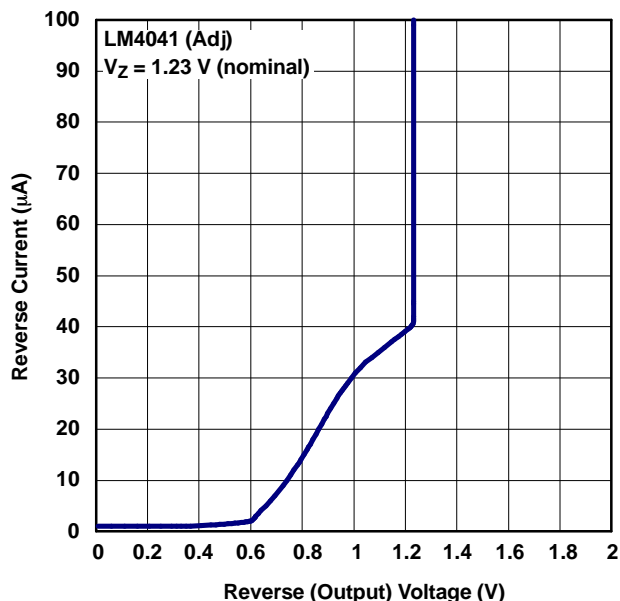


Figure 10. Reverse Characteristics and Minimum Operating Current

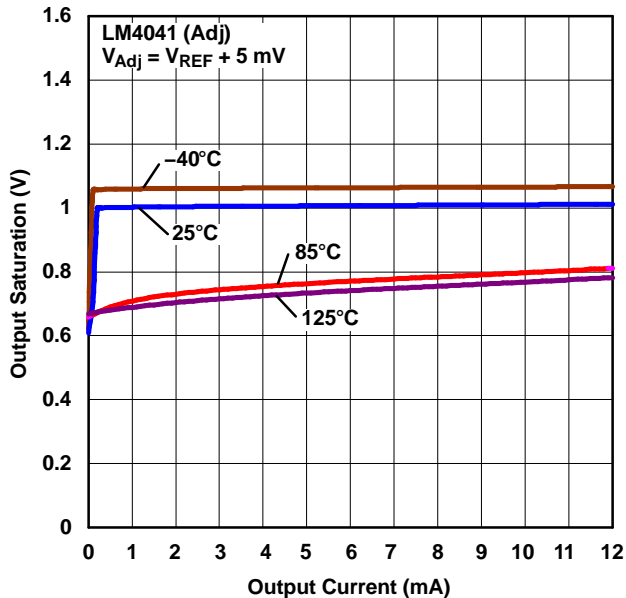
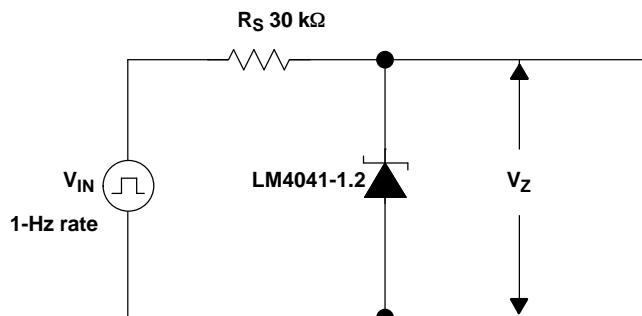
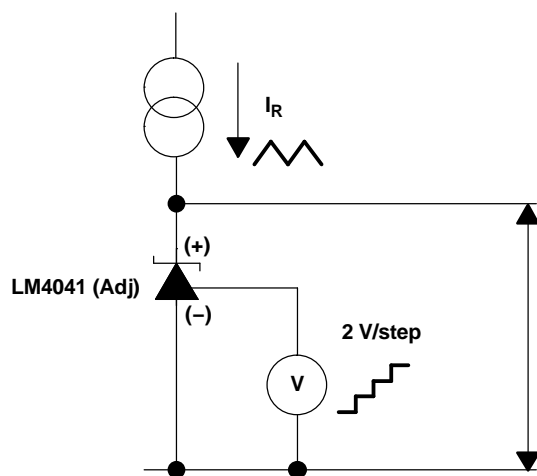


Figure 11. Output Saturation vs Output Current

## APPLICATION INFORMATION



**Figure 12. Startup Characteristics Test Circuit**



**Figure 13. Reverse Characteristics Test Circuit**

### Output Capacitor

The LM4041 does not require an output capacitor across CATHODE and ANODE for stability. However, if an output bypass capacitor is desired, the LM4041 is designed to be stable with all capacitive loads.

### SOT-23 and SC-70 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. Similarly, pin 2 of the SC-70 package also must be left floating or connected to pin 1.

## APPLICATION INFORMATION

### Adjustable Version

The adjustable version allows  $V_Z$  to be set by a user-defined resistor divider. The output voltage,  $V_Z$ , is set according to the equation shown in Figure 14.

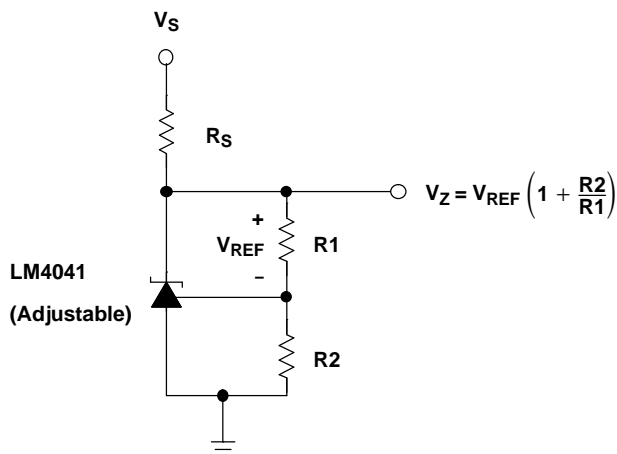


Figure 14. Adjustable Shunt Regulator

### Cathode and Load Currents

In a typical shunt regulator configuration (see Figure 15), an external resistor,  $R_S$ , is connected between the supply and the cathode of the LM4041.  $R_S$  must be set properly, as it sets the total current available to supply the load ( $I_L$ ) and bias the LM4041 ( $I_Z$ ). 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 recommended rating of 12 mA.

$R_S$  is calculated as shown in Equation 1.

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

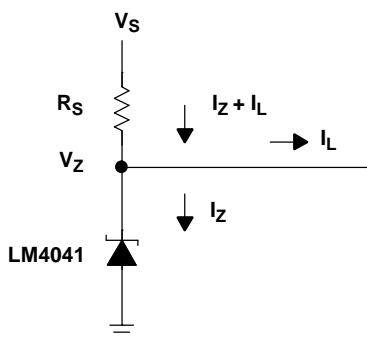


Figure 15. Shunt Regulator

**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>
LM4041A12IDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041A12IDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041A12IDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041A12IDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041A12IDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041A12IDCKRE4	ACTIVE	SC70	DCK	5	3000	TBD	Call TI	Call TI
LM4041A12ILP	PREVIEW	TO-92	LP	3	1000	TBD	Call TI	Call TI
LM4041B12IDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041B12IDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041B12IDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041B12IDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041B12IDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041B12IDCKRE4	ACTIVE	SC70	DCK	5	3000	TBD	Call TI	Call TI
LM4041B12ILP	PREVIEW	TO-92	LP	3	1000	TBD	Call TI	Call TI
LM4041BIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041BIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041BIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041BIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041BIDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041BIDCKRE4	ACTIVE	SC70	DCK	5	3000	TBD	Call TI	Call TI
LM4041BIDCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041BIDCKTE4	ACTIVE	SC70	DCK	5	250	TBD	Call TI	Call TI
LM4041BILP	PREVIEW	TO-92	LP	3	1000	TBD	Call TI	Call TI
LM4041BILPR	PREVIEW	TO-92	LP	3	2000	TBD	Call TI	Call TI
LM4041C12IDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041C12IDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041C12IDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041C12IDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM



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>
LM4041C12IDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041C12IDCKRE4	ACTIVE	SC70	DCK	5	3000	TBD	Call TI	Call TI
LM4041C12ILP	PREVIEW	TO-92	LP	3	1000	TBD	Call TI	Call TI
LM4041C12QDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041C12QDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041C12QDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041C12QDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDCKRE4	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CIDCKTE4	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CILP	PREVIEW	TO-92	LP	3	1000	TBD	Call TI	Call TI
LM4041CILPR	PREVIEW	TO-92	LP	3	2000	TBD	Call TI	Call TI
LM4041CQDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CQDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CQDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041CQDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12IDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12IDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12IDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12IDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12IDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12IDCKRE4	ACTIVE	SC70	DCK	5	3000	TBD	Call TI	Call TI
LM4041D12QDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

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>
LM4041D12QDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12QDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041D12QDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDBZTG4	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDCKRE4	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DIDCKTE4	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
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LM4041DILPR	PREVIEW	TO-92	LP	3	2000	TBD	Call TI	Call TI
LM4041DQDBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DQDBZRG4	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DQDBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM4041DQDBZTG4	ACTIVE	SOT-23	DBZ	3	250	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) 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.

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**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.

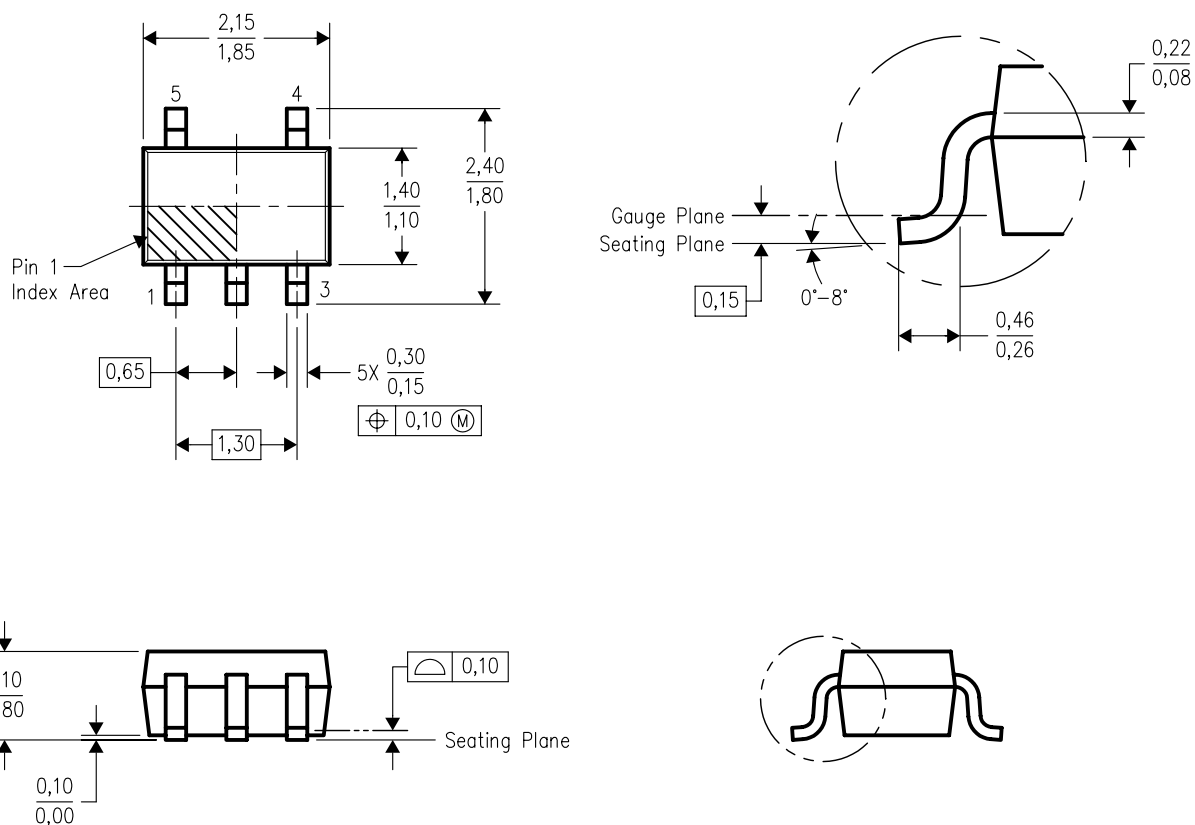
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## DCK (R-PDSO-G5)

## PLASTIC SMALL-OUTLINE PACKAGE

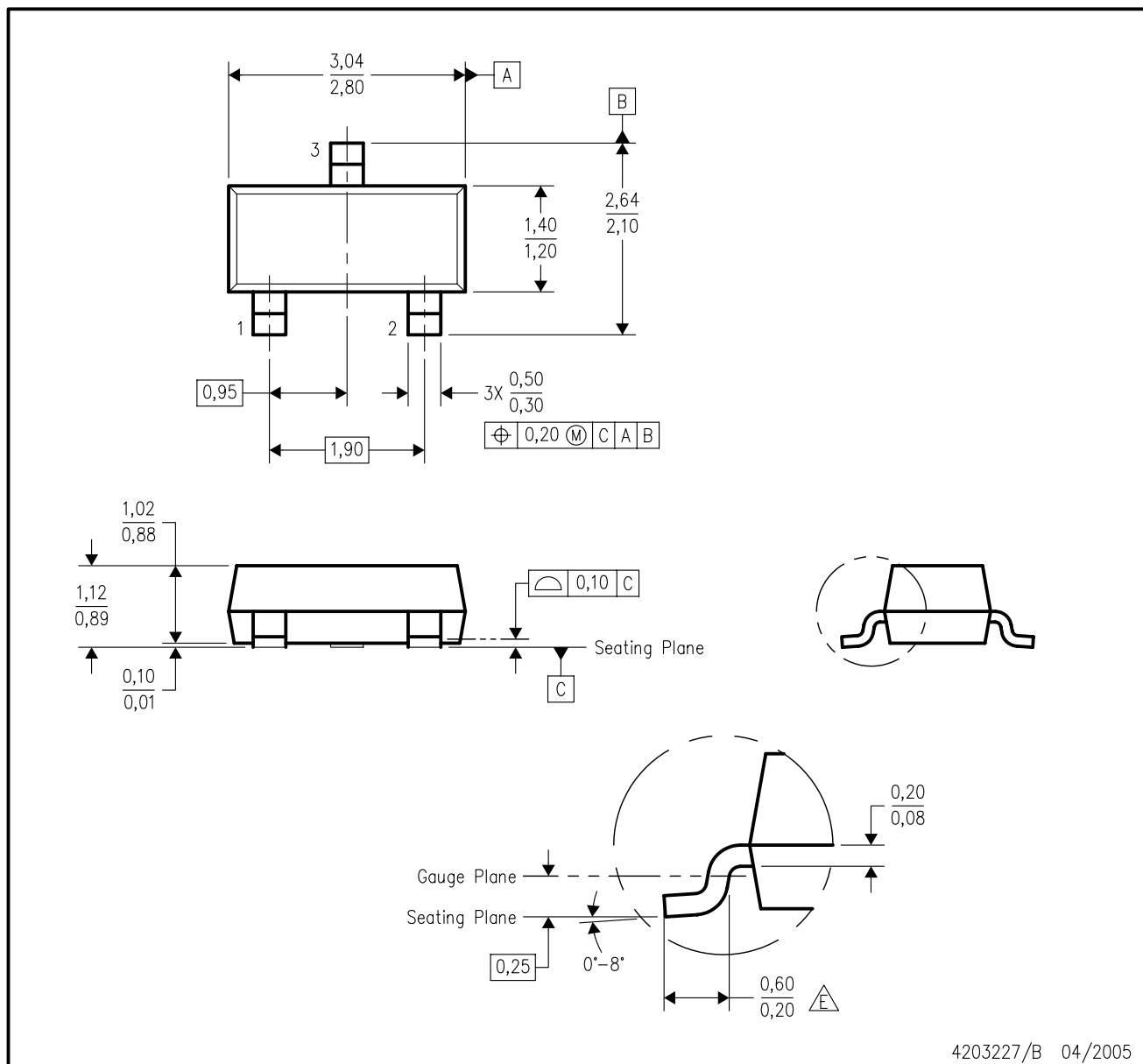


4093553-2/E 10/2005

- 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



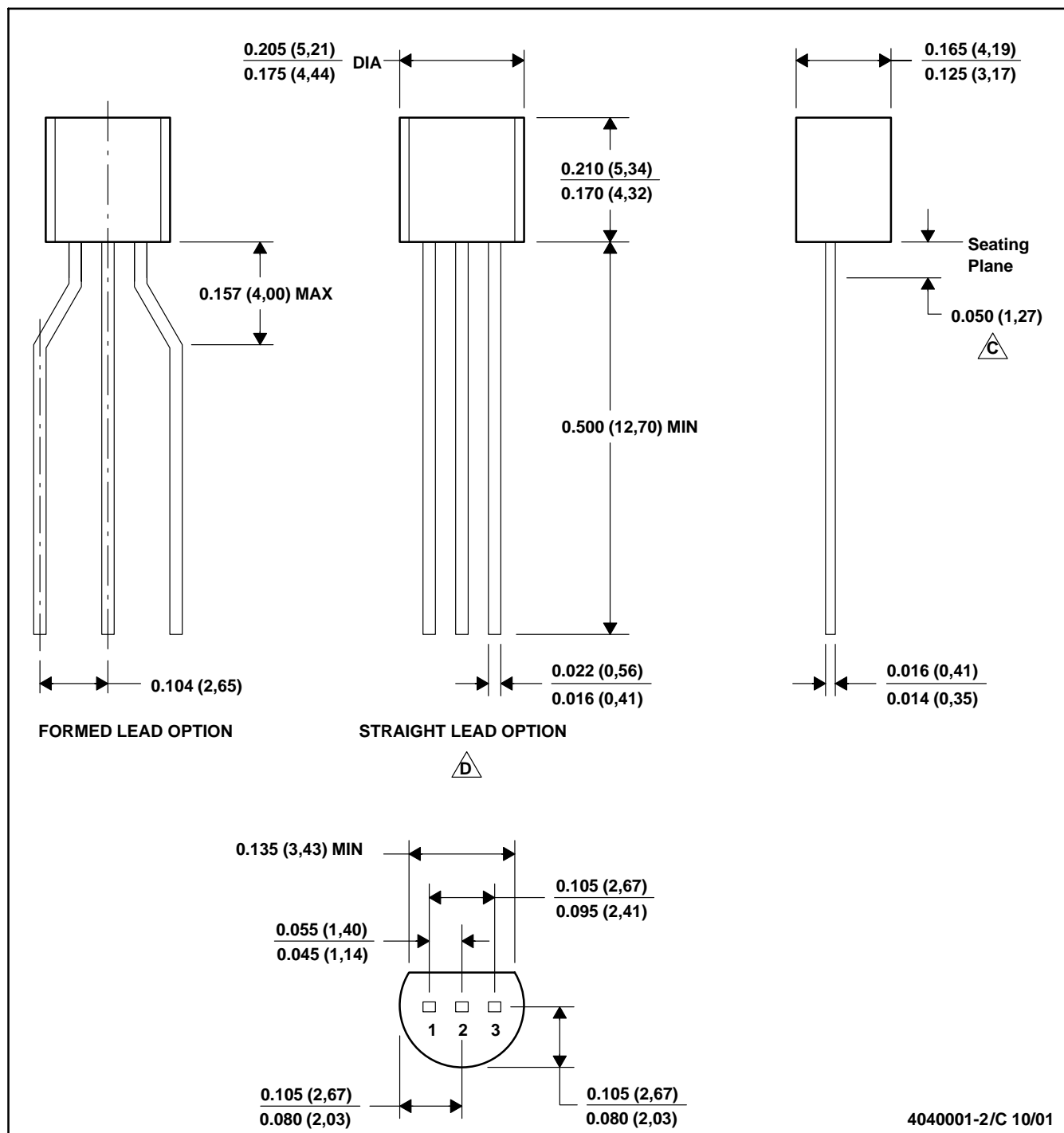
4203227/B 04/2005

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.
- E. Falls within JEDEC TO-236 variation AB, except minimum foot length.

## LP (O-PBCY-W3)

## PLASTIC CYLINDRICAL PACKAGE

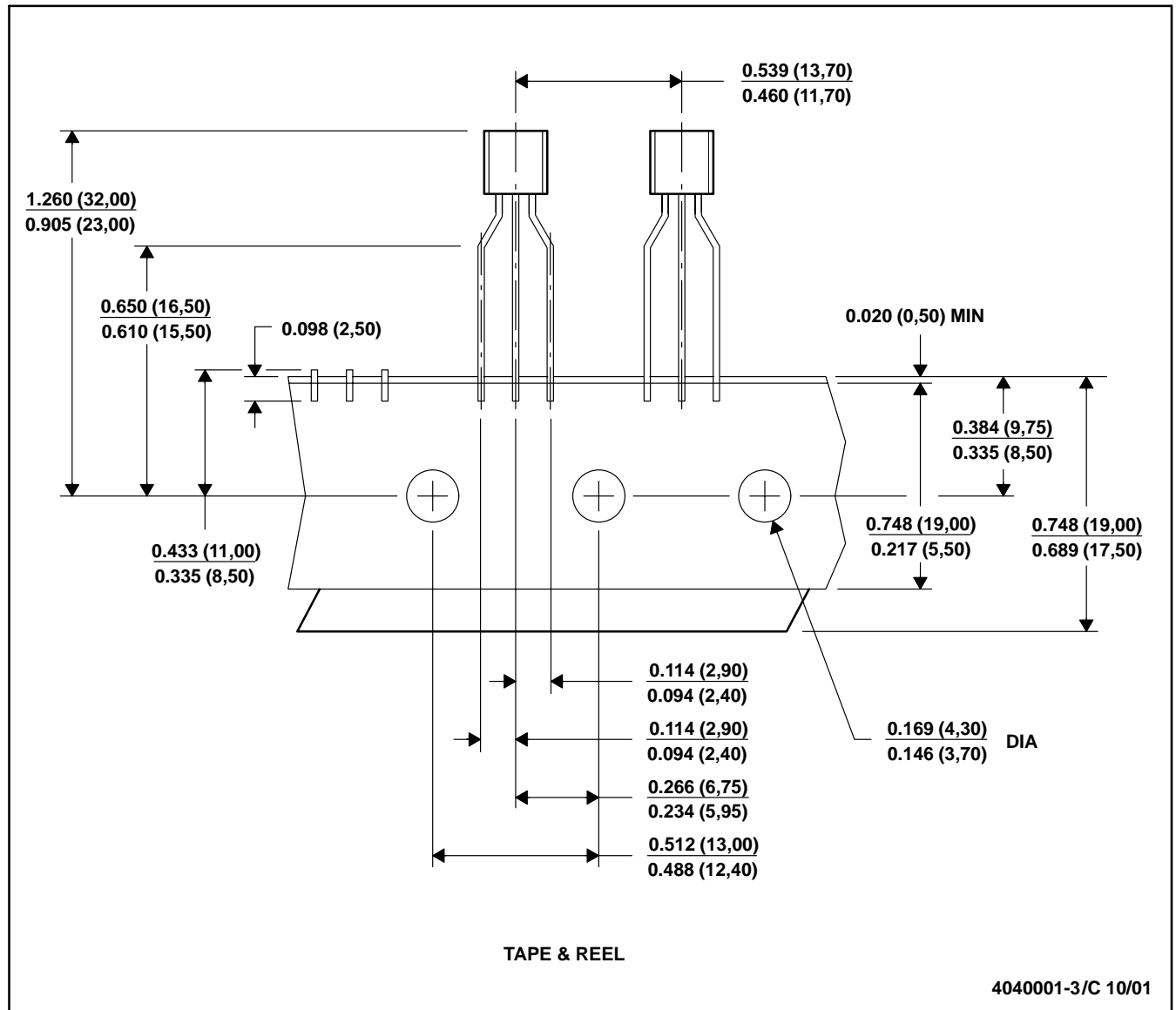


# MECHANICAL DATA

MSOT002A – OCTOBER 1994 – REVISED NOVEMBER 2001

LP (O-PBCY-W3)

PLASTIC CYLINDRICAL PACKAGE



- NOTES: A. All linear dimensions are in inches (millimeters).  
B. This drawing is subject to change without notice.  
C. Tape and Reel information for the Format Lead Option package.

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