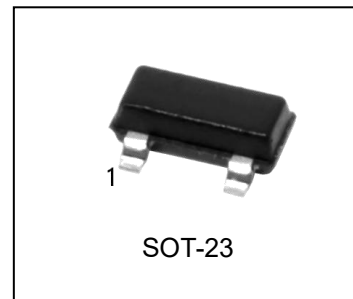


Precision Micropower Shunt Voltage Reference

Features

- Small SOT-23 package
- No output capacitor required
- Tolerates capacitive loads
- Fixed reverse breakdown voltages of 1.225, 2.500V, 4.096V and 5.000V
- Adjustable reverse breakdown version
- Contact Micrel for parts with extended temperature range.



Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
LM4040AIM3-2.5/TR	SOT-23	R2A	REEL	3000pcs/reel
LM4040BIM3-2.5/TR	SOT-23	R2B	REEL	3000pcs/reel
LM4040CIM3-2.5/TR	SOT-23	R2C	REEL	3000pcs/reel
LM4040DIM3-2.5/TR	SOT-23	R2D	REEL	3000pcs/reel
LM4040AIM3-4.1/TR	SOT-23	R4A	REEL	3000pcs/reel
LM4040BIM3-4.1/TR	SOT-23	R4B	REEL	3000pcs/reel
LM4040CIM3-4.1/TR	SOT-23	R4C	REEL	3000pcs/reel
LM4040DIM3-4.1/TR	SOT-23	R4D	REEL	3000pcs/reel
LM4040AIM3-5.0/TR	SOT-23	R5A	REEL	3000pcs/reel
LM4040BIM3-5.0/TR	SOT-23	R5B	REEL	3000pcs/reel
LM4040CIM3-5.0/TR	SOT-23	R5C	REEL	3000pcs/reel
LM4040DIM3-5.0/TR	SOT-23	R5D	REEL	3000pcs/reel
LM4041AIM3-1.2/TR	SOT-23	R1A	REEL	3000pcs/reel
LM4041BIM3-1.2/TR	SOT-23	R1B	REEL	3000pcs/reel
LM4041CIM3-1.2/TR	SOT-23	R1C	REEL	3000pcs/reel
LM4041DIM3-1.2/TR	SOT-23	R1D	REEL	3000pcs/reel
LM4041CIM3-ADJ/TR	SOT-23	RAC	REEL	3000pcs/reel
LM4041DIM3-ADJ/TR	SOT-23	RAD	REEL	3000pcs/reel

General Description

Ideal for space critical applications, the LM4040 and LM4041 precision voltage references are available in the subminiature (3mm × 1.3mm) SOT-23 surface-mount package.

The LM4040 is available in fixed reverse breakdown voltages of 2.500V, 4.096V and 5.000V. The LM4041 is available with a fixed 1.225V or an adjustable reverse breakdown voltage.

The LM4040 and LM4041's advanced design eliminates the need for an external stabilizing capacitor while ensuring stability with any capacitive load, making them easy to use.

The minimum operating current ranges from 60uA for the LM4041-1.2 to 74uA for the LM4040-5.0. LM4040 versions have a maximum operating current of 15mA. LM4041 versions have a maximum operating current of 12mA.

The LM4040 and LM4041 utilizes zener-zap reverse breakdown voltage trim during wafer sort to ensure that the prime parts have an accuracy of better than $\pm 0.1\%$ (A grade) at 25°C. Bandgap reference temperature drift curvature correction and low dynamic impedance ensure stable reverse breakdown voltage accuracy over a wide range of operating temperatures and currents.

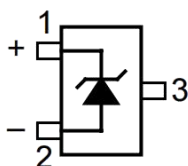
Key Specifications

- Output voltage tolerance (A grade, 25°C) .. $\pm 0.1\%$ (max)
- Low output noise (10Hz to 100Hz)
 - LM4040 35uVRMS (typ)
 - LM4041 20uVRMS (typ)
- Wide operating current range
 - LM4040 60 uA to 15mA
 - LM4041 60 uA to 12mA
- Industrial temperature range -40°C to +85°C
- Low temperature coefficient 100ppm/ °C (max)

Applications

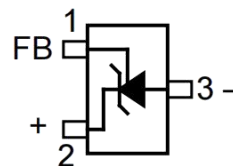
- Battery-Powered Equipment
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management
- Product Testing
- Automotive Electronics
- Precision Audio Components

Pin Configuration



Pin 3 must float or
be connected to pin 2.

Fixed Version
SOT-23 (M3) Package
Top View



Adjustable Version
SOT-23 (M3) Package
Top View

ABSOLUTE MAXIMUM RATINGS

Parameter	Value	Unit
Reverse Current	20	mA
Forward Current	10	mA
Maximum Output Voltage		
LM4041-Adjustable		V
Power Dissipation at TA = 25°C (Note 2)	306	mW
Storage Temperature	65°C to +150	°C
Lead Temperature		
Vapor phase (60 seconds)	+215	°C
Infrared (15 seconds)	+220	°C
ESD Susceptibility		
Human Body Model (Note 3)		kV
Machine Model (Note 3)		V

Operating Ratings (Notes 1 and 2)

Parameter	Temperature Range
(T _{MIN} ≤ TA ≤ T _{MAX})	40°C ≤ TA ≤ +85°C
Reverse Current	
LM4040-2.5	60uA to 15mA
LM4040-4.1	68uA to 15mA
LM4040-5.0	74uA to 15mA
LM4041-1.2	60uA to 12mA
LM4041-ADJ	60uA to 12mA
Output Voltage Range	
LM4041-ADJ	1.24V to 10V

Typical Applications

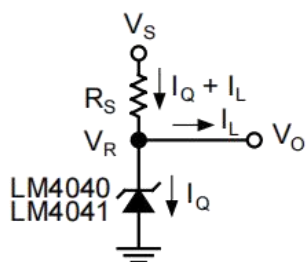


Figure 1. LM4040, LM4041 Fixed Shunt Regulator Application

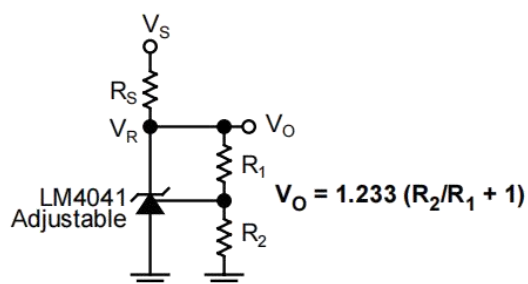
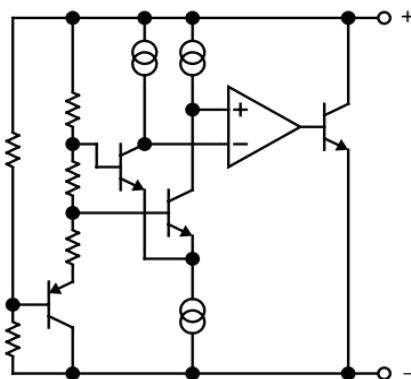
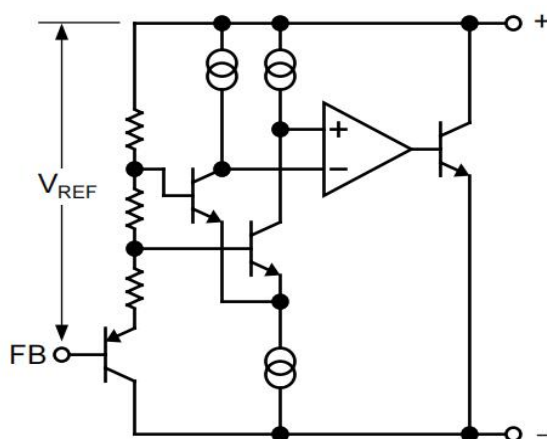


Figure 2. LM4041 Adjustable Shunt Regulator Application

Functional Diagram LM4040, LM4041 Fixed



Functional Diagram LM4041 Adjustable



LM4040-2.5 Electrical Characteristics

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX} ; all other limits $T_A = T_J = 25^\circ\text{C}$. The grades A, B, C, and D designate initial Reverse Breakdown Voltage tolerance of $\pm 0.1\%$, $\pm 0.2\%$, $\pm 0.5\%$, and ± 1.0 respectively.

Symbol	Parameter	Conditions	Typical (Note4)	LM4040AIM3 Limits (Note 5)	LM4040BIM3 Limits (Note 5)	LM4040CIM3 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	2.500				V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 2.5 ± 19	± 5.0 ± 21	± 12 ± 29	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		45	60 65	60 65	60 65	μA μA (max) μA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$	20 15 15	100	100	100	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.3	0.8 1.0	0.8 1.0	0.8 1.0	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	2.5	0.6 8.0	0.6 8.0	0.6 8.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.3	0.8	0.8	0.9	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	35				μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120				ppm

Symbol	Parameter	Conditions	Typical (Note4)	LM4040DIM3 Limits (Note 5)	Units (Limit)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	2.500		V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 25 ± 49	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		45	65 70	μA μA (max) μA (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$	20 15 15	150	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.3	1.0 1.2	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	2.5	8.0 10.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.3	1.1	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	35		μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120		ppm

LM4040-4.1 Electrical Characteristics

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX} ; all other limits $T_A = T_J = 25^\circ\text{C}$. The grades A, B, C, and D designate initial Reverse Breakdown Voltage tolerance of $\pm 0.1\%$, $\pm 0.2\%$, $\pm 0.5\%$, and $\pm 1.0\%$ respectively.

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040AIM3 Limits (Note 5)	LM4040BIM3 Limits (Note 5)	Units(Limit)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	4.096			V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 4.1 ± 31	± 8.2 ± 35	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		50	68 73	68 73	A A (max) A (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{m}$ $I_R = 1\text{m}$ $I_R = 100\mu\text{A}$	30 20 20	100	100	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.5	0.9 1.2	0.9 1.2	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	3.5	7.0 10.0	7.0 10.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.5	1.0	1.0	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	80			μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120			ppm

Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CIM3 Limits (Note 5)	LM4040DIM3 Limits (Note 5)	Units (Limits)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	4.096			V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 20 ± 47	± 41 ± 81	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		50	68 73	73 78	A A (max) A (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$	30 20 20	100	150	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.5	0.9 1.2	1.2 1.5	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	3.0	7.0 10.0	9.0 13.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.5	1.0	1.3	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	80			μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120			ppm

LM4040-5.0 Electrical Characteristics

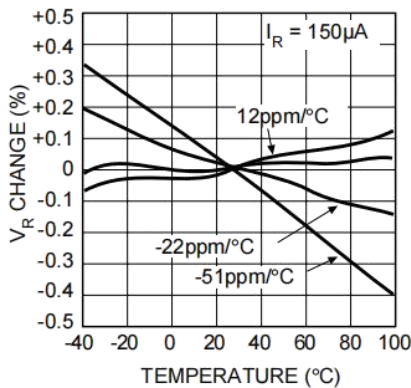
Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX} ; all other limits $T_A = T_J = 25^\circ\text{C}$. The grades A, B, C, and D designate initial Reverse Breakdown Voltage tolerance of $\pm 0.1\%$, $\pm 0.2\%$, $\pm 0.5\%$, and $\pm 1.0\%$ respectively.

Symbol	Parameter	Conditions	Typical (Note4)	LM4040AIM3 Limits (Note5)	LM4040BIM3 Limits (Note5)	Units(Limit)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	5000			V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 5.0 ± 38	± 10 ± 43	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		54	74 80	74 80	A A (max) A (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$	30 20 20	100	100	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.5	1.0 1.4	1.0 1.4	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	3.5	8.0 12.0	8.0 12.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.5	1.1	1.1	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	80			μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120			ppm

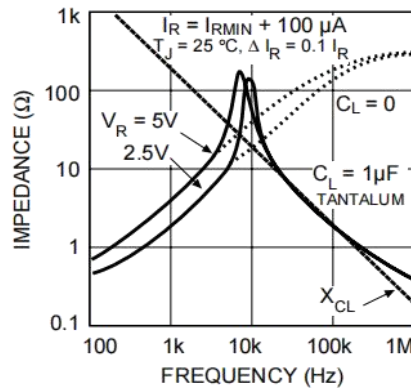
Symbol	Parameter	Conditions	Typical (Note 4)	LM4040CIM3 Limits (Note 5)	LM4040DIM3 Limits (Note 5)	Units (Limits)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	5000			V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 5.0 ± 38	± 10 ± 43	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		54	74 80	74 80	A A (max) A (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$	30 20 20	100	100	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.5	1.0 1.4	1.0 1.4	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	3.5	8.0 12.0	8.0 12.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.5	1.1	1.1	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	80			μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120			ppm

LM4040 Typical Characteristics

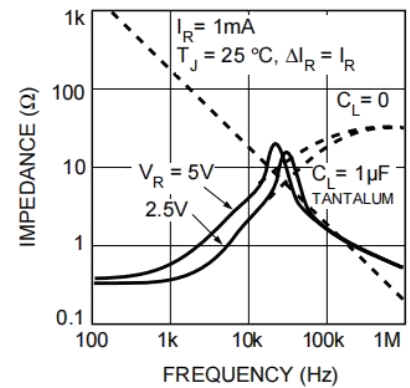
Temperature Drift for Different Average Temperature Coefficient



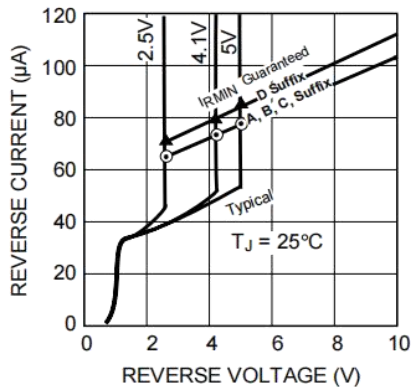
Output Impedance vs. Frequency



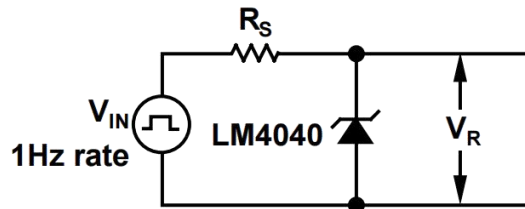
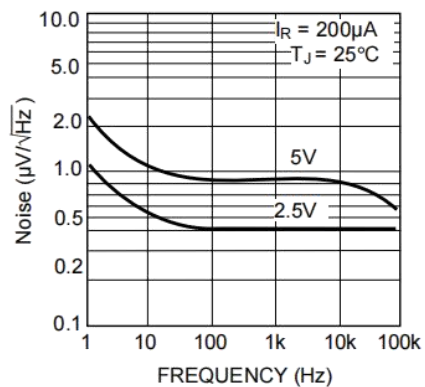
Output Impedance vs. Frequency



Reverse Characteristics and Minimum Operating Current

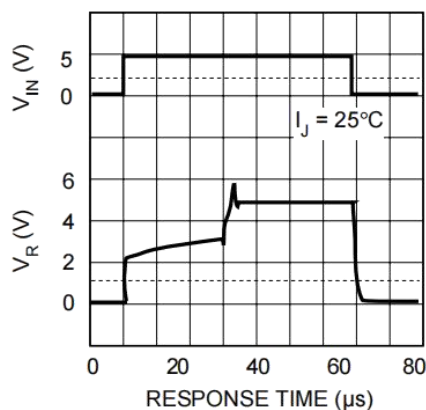


Noise Voltage vs. Frequency

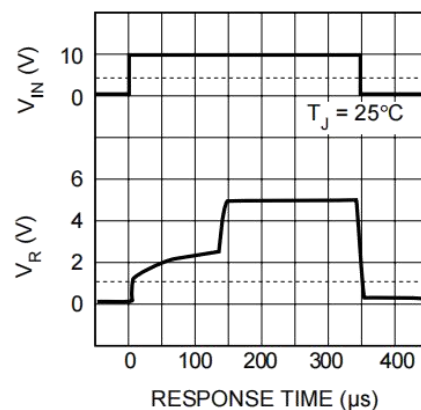


Test Circuit

LM4040-2.5 $R_S = 30k$



LM4040-5.0 $R_S = 30k$



LM4041-1.2 Electrical Characteristics

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX} ; all other limits $T_A = T_J = 25^\circ\text{C}$. The grades A, B, C, and D designate initial Reverse Breakdown Voltage tolerance of $\pm 0.1\%$, $\pm 0.2\%$, $\pm 0.5\%$, and $\pm 1.0\%$ respectively.

Symbol	Parameter	Conditions	Typical (Note4)	LM4041AIM3 Limits (Note5)	LM4041BIM3 Limits (Note5)	LM4041CIM3 Limits (Note5)	Units (Limit)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	1.225				V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 1.9 ± 9.2	± 2.4 ± 10.4	± 6 ± 14	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		45	60 65	60 65	60 65	A A (max) A (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$	20 15 15	± 100	± 100	± 100	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.7	1.5 2.0	1.5 2.0	1.5 2.0	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	4.0	6.0 8.0	6.0 8.0	6.0 8.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.5	1.5	1.5	1.5	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	20				μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120				ppm

Symbol	Parameter	Conditions	Typical (Note 4)	LM4041DIM3 Limits (Note 5)	LM4041EIM3 Limits (Note 5)	Units (Limits)
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$	1.225			V
	Reverse Breakdown Voltage Tolerance	$I_R = 100\mu\text{A}$		± 14 ± 24	± 25 ± 36	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		45	65 70	65 70	A A (max) A (max)
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	$I_R = 10\text{mA}$ $I_R = 1\text{mA}$ $I_R = 100\mu\text{A}$	20 15 15	± 150	± 150	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
$\Delta V_R/\Delta I_R$	Reverse Breakdown Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$	0.3	2.0 2.5	2.0 2.5	mV mV (max) mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$	2.5	8.0 12.0	8.0 12.0	mV mV (max) mV (max)
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$	0.3	2.0	2.0	Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	35			μV_{RMS}
ΔV_R	Reverse Breakdown Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120			ppm

LM4041-Adjustable Electrical Characteristics

Boldface limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX} ; all other limits $T_J = 25^\circ\text{C}$ unless otherwise specified (SOT-23, see Note 7), $I_{RMIN} \leq I_R < 12\text{mA}$, $V_{REF} \leq V_{OUT} \leq 10\text{V}$. The grades C and D designate initial Reverse Breakdown Voltage tolerance of $\pm 0.5\%$ and $\pm 1\%$, respectively for $V_{OUT} = 5\text{V}$.

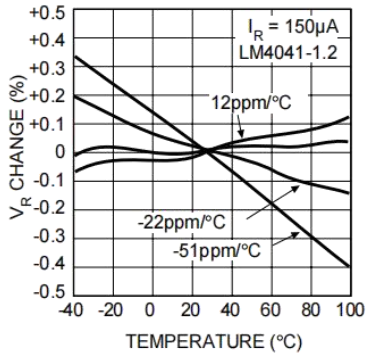
Symbol	Parameter	Conditions	Typical I(Note 4)	LM4041CIM3 Limits (Note 5)	LM4041DIM3 Limits (Note 5)	Units(Limit)
V_{REF}	Reference Breakdown Voltage	$I_R = 100\mu\text{A}$ $V_{OUT} = 5\text{V}$	1.233			V
	Reference Breakdown Voltage Tolerance (Note 8)	$I_R = 100\mu\text{A}$		6.2 14	12 24	mV (max) mV (max)
I_{RMIN}	Minimum Operating Current		45	60 65	65 70	μA μA (max) μA (max)
$\Delta V_{REF}/\Delta I_R$	Reference Voltage Change with Operating Current Change	$I_{RMIN} \leq I_R 1\text{mA}$ SOT-23: $V_{OUT} \geq 1.6\text{V}$ (Note 7)	0.7	1.5 2.0	2.0 2.5	mV mV (max)mV (max)
		$1\text{mA} \leq I_R 15\text{mA}$ SOT-23: $V_{OUT} \geq 1.6\text{V}$ (Note 7)	2	4 6	6 8	mV mV (max) mV (max)
$\Delta V_{REF}/\Delta V_O$	Reference Voltage Change with Output Voltage Change	$I_R = 1\text{mA}$	-1.3	-2.0 -2.5	-2.5 -3.0	mV/V mV/V(max) mV/V (max)
I_{FB}	Feedback Current		60	100 120	150 200	nA nA (max) nA (max)
$\Delta V_{REF}/\Delta T_O$	Average Reference Voltage Temperature Coefficient (Note 8)	$V_{OUT} = 5\text{V}$ $I_R = 10\text{mA}$ $A_{IR} = 1\text{mA}$ $I_R = 100\mu\text{A}$	20 15 15	100	150	ppm/ $^\circ\text{C}$ ppm/ $^\circ\text{C}$ (max) ppm/ $^\circ\text{C}$ (max)
Z_{OUT}	Dynamic Output Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$ $I_{AC} = 0.1 I_R$ $V_{OUT} = V_{REF}$ $V_{OUT} = 10\text{V}$	0.3 2			Ω Ω (max)
e_N	Wideband Noise	$I_R = 100\mu\text{A}$ $10\text{Hz} \leq f \leq 10\text{kHz}$	20			μV_{RMS}
ΔV_{REF}	Reference Voltage Long Term Stability	$t = 1000\text{hrs}$ $T = 25^\circ\text{C} \pm 0.1^\circ\text{C}$ $I_R = 100\mu\text{A}$	120			ppm

LM4040 and LM4041 Electrical Characteristic Notes

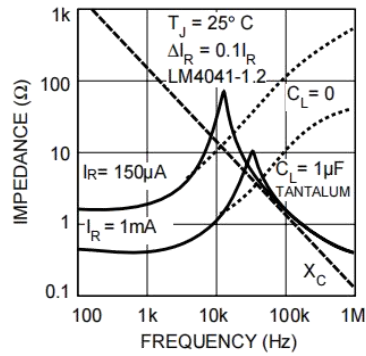
1. Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specification and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
2. The maximum power dissipation must be derated at elevated temperatures and is dictated by TJMAX (maximum junction temperature), θ_{JA} (junction to ambient thermal resistance), and TA (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{D_{MAX}} = (T_{J_{MAX}} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4040 and LM4041, TJMAX = 125°C, and the typical thermal resistance (θ_{JA}), when board mounted, is 326°C/W for the SOT-23 package.
3. The human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin. The machine model is a 200pF capacitor discharged directly into each pin.
4. Typicals are at TJ = 25°C and represent most likely parametric norm.
5. Limits are 100% production tested at 25°C. Limits over temperature are guaranteed through correlation using Statistical Quality Control (SQL) methods.
6. The boldface (over temperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance $[(\Delta V_R/\Delta T)(65^\circ\text{C})(V_R)]$. $\Delta V_R/\Delta T$ is the VR temperature coefficient, 65°C is the temperature range from -40°C to the reference point of 25°C, and VR is the reverse breakdown voltage. The total over temperature tolerance for the different grades follows:
 - A. grade: $\pm 0.75\% = \pm 0.1\%$ 100ppm/°C 65°C
 - B. grade: $\pm 0.85\% = \pm 0.2\%$ 100ppm/°C 65°C
 - C. grade: $\pm 1.15\% = \pm 0.5\%$ 100ppm/°C 65°C
 - D. grade: $\pm 1.98\% = \pm 1.0\%$ 150ppm/°C 65°C
 - E. example: The A-grade LM4040-2.5 has an over temperature Reverse Breakdown Voltage tolerance of $\pm 2.5 \times 0.75\% = \pm 19\text{mV}$.
7. When $V_{OUT} \leq 1.6\text{V}$, the LM4041-ADJ must operate at reduced IR. This is caused by the series resistance of the die attach between the die (-) output and the package (-) output pin. See the Output Saturation curve in the Typical Performance Characteristics section.
8. Reference voltage and temperature coefficient will change with output voltage. See Typical Performance Characteristics curves.

LM4041 Typical Characteristics

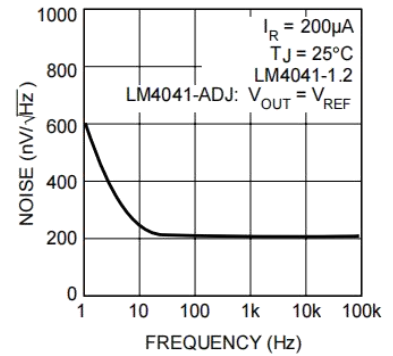
Temperature Drift for Different Average Temperature Coefficient



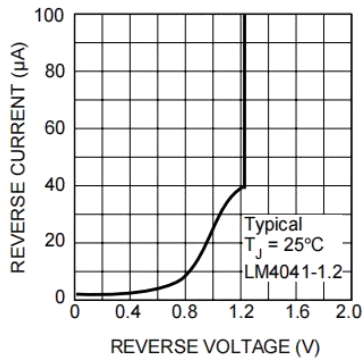
Output Impedance vs. Frequency



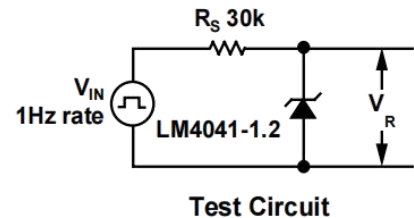
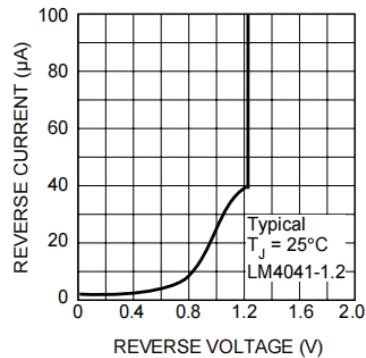
Voltage Impedance



Reverse Characteristics and Minimum Operating Current

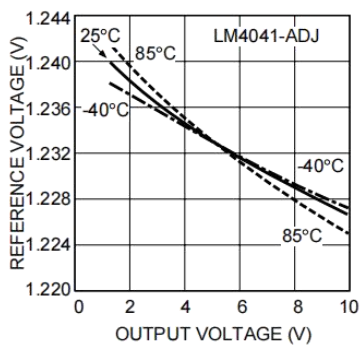


Reverse Characteristics and Minimum Operating Current

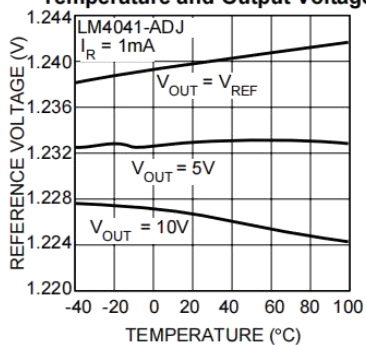


LM4041 Typical Characteristics

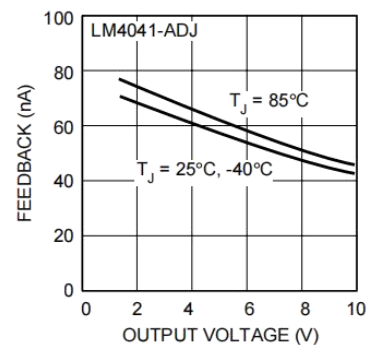
Reference Voltage vs. Output Voltage and Temperature



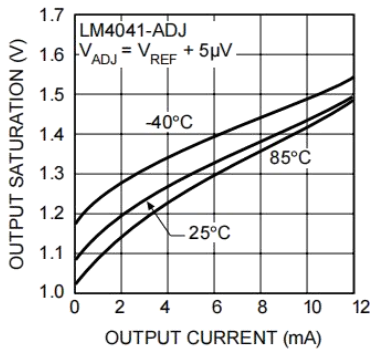
Reference Voltage vs. Temperature and Output Voltage



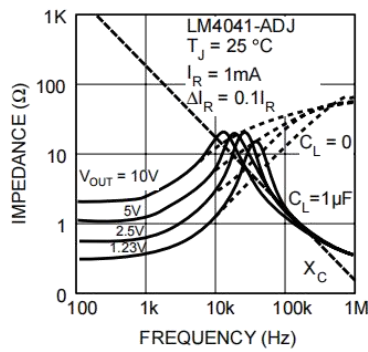
Feedback Current vs. Output Voltage and Temperature



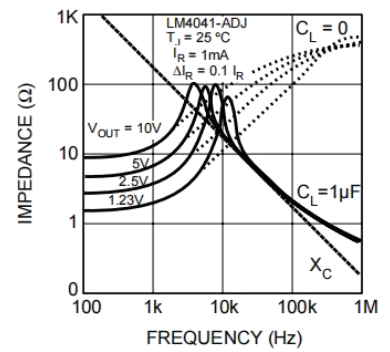
Output Saturation



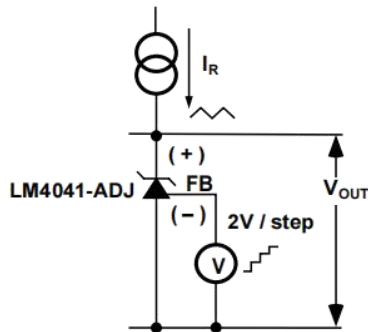
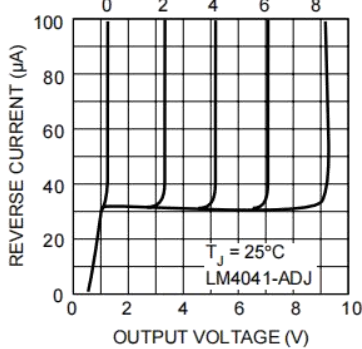
Output Impedance vs. Frequency *



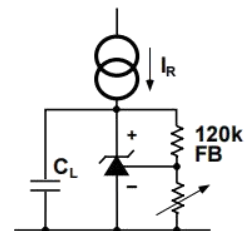
Output Impedance vs. Frequency *



Reverse Characteristics †

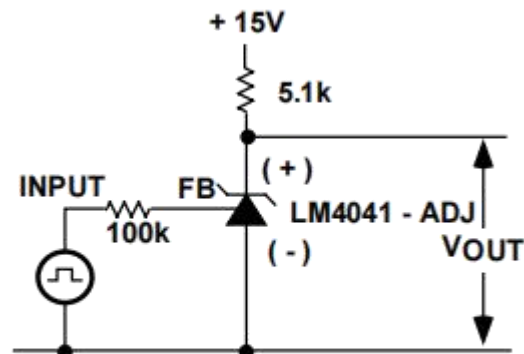
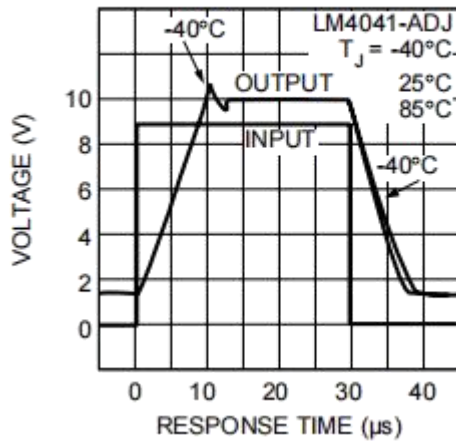


† Reverse Characteristics Test Circuit



* Output Impedance vs. Freq. Test Circuit

Large Signal Response ‡



‡ Large Signal Response Test Circuit

Applications Information

The LM4040 and LM4041 have been designed for stable operation without the need of an external capacitor connected between the (+) and (–) pins. If a bypass capacitor is used, the references remain stable.

Schottky Diode

LM4040-x.x and LM4041-1.2 in the SOT-23 package have a parasitic Schottky diode between pin 2 (–) and pin 3 (die attach interface connect). Pin 3 of the SOT-23 package must float or be connected to pin 1. LM4041-ADJs use pin 3 as the (–) output.

Conventional Shunt Regulator

In a conventional shunt regulator application (see Figure 1), an external series resistor (RS) is connected between the supply voltage and the LM4040-x.x or LM4041-1.2 reference. RS determines the current that flows through the load (IL) and the reference (IQ). Since load current and supply voltage may vary, RS should be small enough to supply at least the minimum acceptable IQ to the reference even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and IL is at its minimum, RS should be large enough so that the current flowing through the LM4040-x.x is less than 15mA, and the current flowing through the LM4041-1.2 or LM4041-ADJ is less than 12mA.

RS is determined by the supply voltage (VS), the load and operating current, (IL and IQ), and the reference's reverse breakdown voltage (VR).

$$R_s = (V_s - V_R) / (I_L + I_Q)$$

Adjustable Regulator

The LM4041-ADJ's output voltage can be adjusted to any value in the range of 1.24V through 10V. It is a function of the internal reference voltage (VREF) and the ratio of the external feedback resistors as shown in Figure 2. The output is found using the equation

$$(1) \quad V_O = V_{REF}' [(R_2/R_1) + 1]$$

where VO is the desired output voltage. The actual value of the internal VREF is a function of VO. The "corrected" VREF is determined by

$$(2) \quad V_{REF}' = V_O (\Delta V_{REF} / \Delta V_O) + V_Y$$

where VO is the desired output voltage. $\Delta V_{REF} / \Delta V_O$ is found in the Electrical Characteristics and is typically –1.3mV/V and VY is equal to 1.233V. Replace the value of VREF' in equation (1) with the value found using equation (2).

Note that actual output voltage can deviate from that predicted using the typical $\Delta V_{REF} / \Delta V_O$ in equation (2); for C- grade parts, the worst-case $\Delta V_{REF} / \Delta V_O$ is –2.5mV/V and VY = 1.248V.

The following example shows the difference in output voltage resulting from the typical and worst case values of $\Delta V_{REF} / \Delta V_O$:

Let VO = +9V. Using the typical values of $\Delta V_{REF} / \Delta V_O$, VREF is 1.223V. Choosing a value of R1 = 10k Ω , R2 = 63.272k Ω . Using the worst case $\Delta V_{REF} / \Delta V_O$ for the C-grade and D-grade parts, the output voltage is actually 8.965V and 8.946V respectively. This results in possible errors as large as 0.39% for the C-grade parts and 0.59% for the D-grade parts. Once again, resistor values found using the typical value of $\Delta V_{REF} / \Delta V_O$ will work in most cases, requiring no further adjustment.

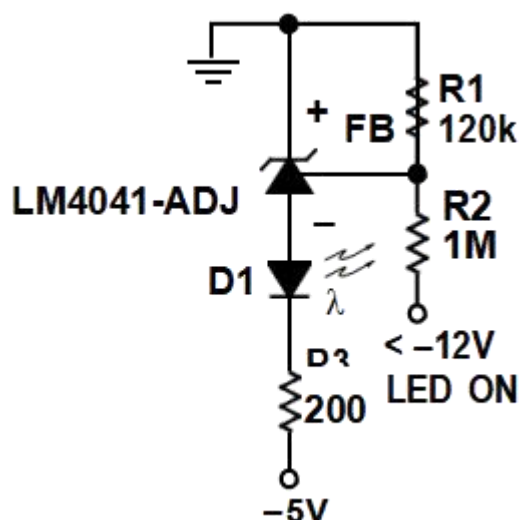


Figure 3. Voltage Level Detector

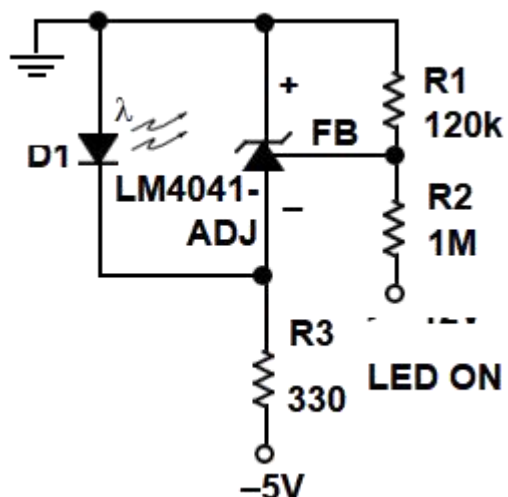


Figure 4. Voltage Level Detector

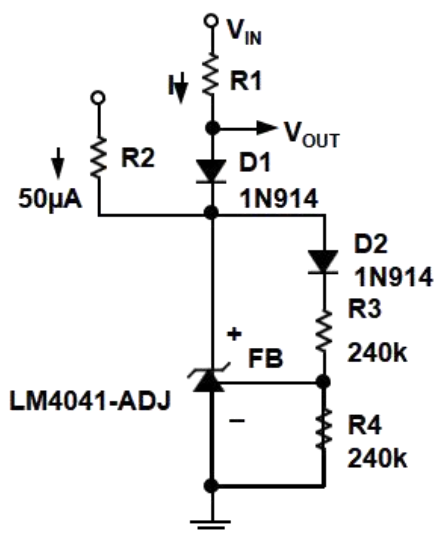


Figure 7. Bidirectional Adjustable Clamp $\pm 18V$ to $\pm 2.4V$

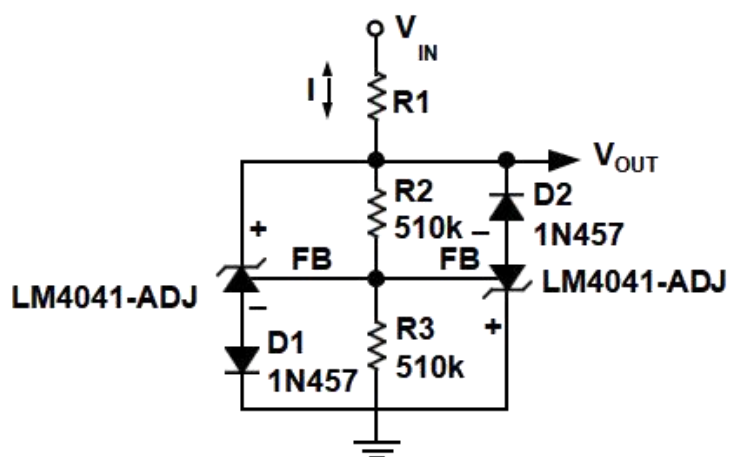


Figure 8. Bidirectional Adjustable Clamp ± 2.4 to $\pm 6V$

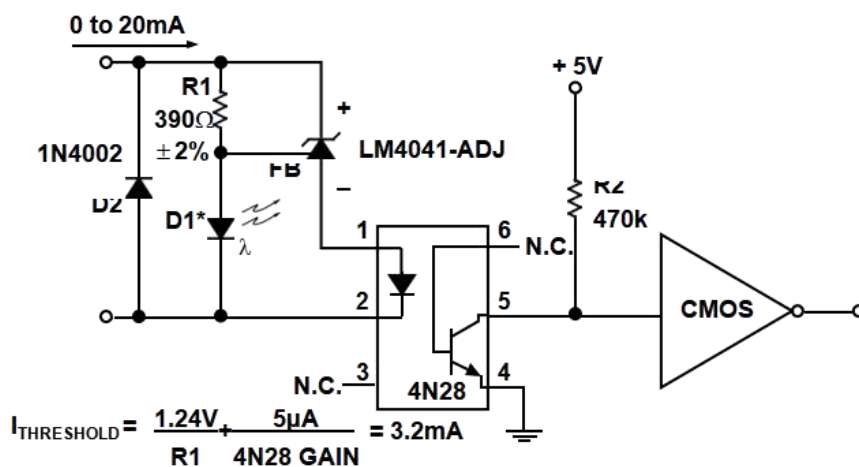


Figure 9. Floating Current Detector

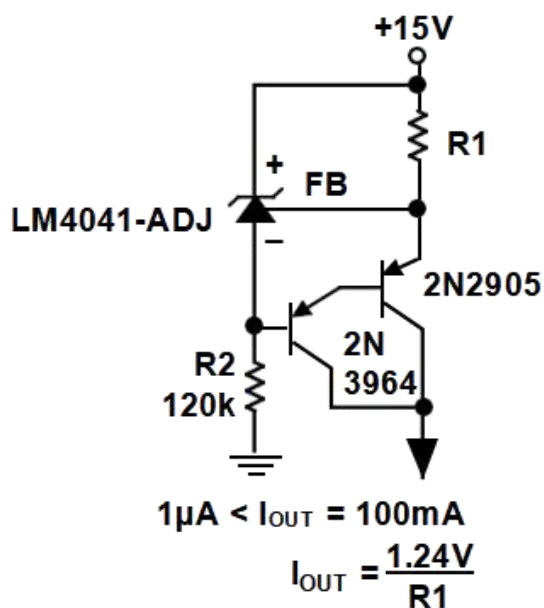


Figure 10. Current Source

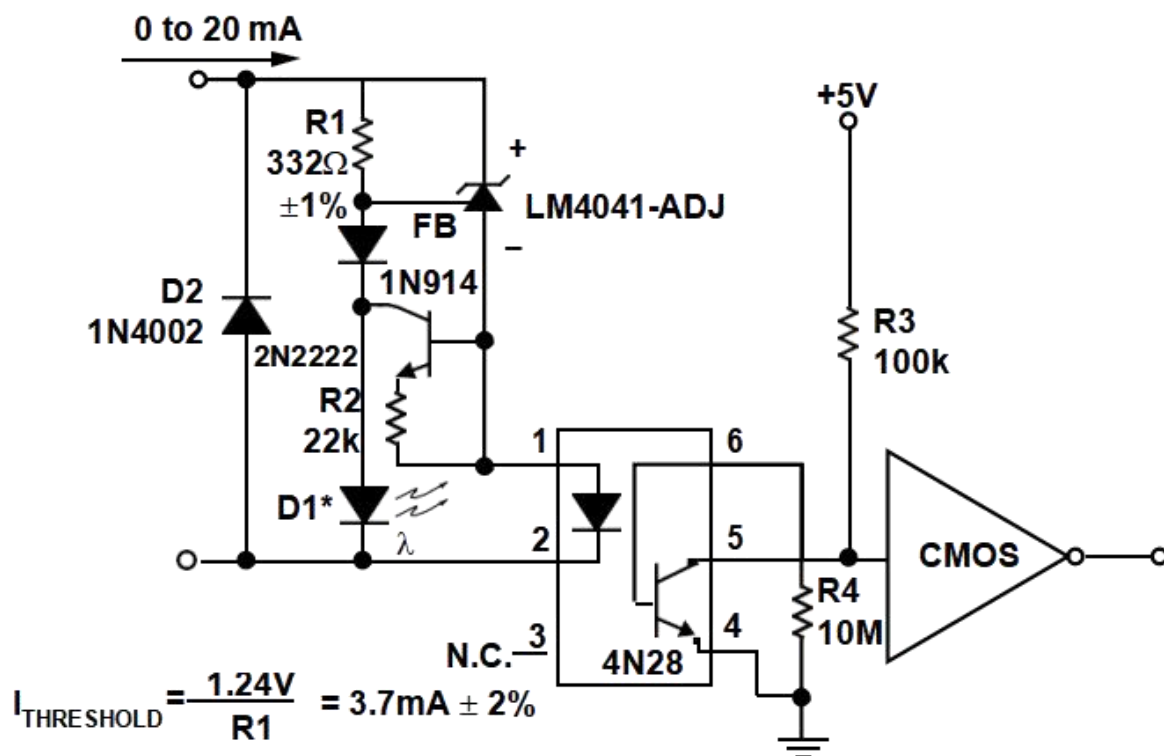
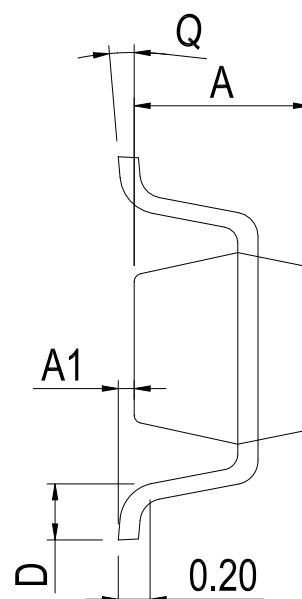
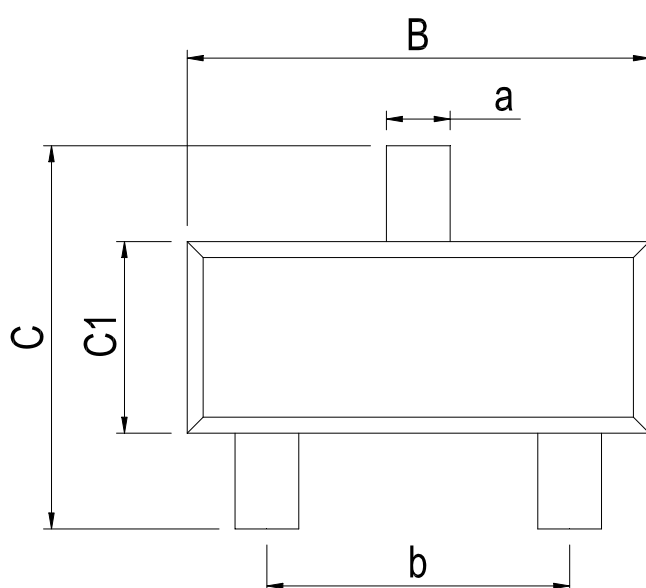


Figure 11. Precision Floating Current Detector

* D1 can be any LED, $V_F = 1.5\text{V}$ to 2.2V at 3mA . D1 may act as an indicator. D1 will be on if $I_{\text{THRESHOLD}}$ falls below the threshold current, except with $I = 0$.

Package Information

SOT-23



Dimensions In Millimeters(SOT-23)									
Symbol:	A	A1	B	C	C1	D	Q	a	b
Min:	0.90	0.00	2.80	2.25	1.20	0.13	0°	0.30	1.90 BSC
Max:	1.05	0.15	3.00	2.55	1.40	0.41	8°	0.50	

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