AUTOMOTIVE GRADE 1.225V AND ADJUSTABLE PRECISION REFERENCE

Description

The LM4041 is a bandgap circuit designed to achieve a precision micro-power voltage reference of 1.225 V; it is also available in an adjustable version. The device is available in the small outline SOT23 surface mount package which is ideal for applications where space saving is important.

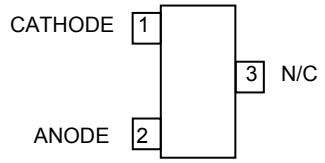
The fixed output version is available in 0.5% C grade and 1% D grade while the adjustable is only available in D grade. Excellent performance is maintained over the 60µA to 12mA operating current range with a typical temperature coefficient of only 20ppm/°C. The device has been designed to be highly tolerant of capacitive loads so maintaining excellent stability.

This device offers a pin for pin compatible alternative to the LM4041 voltage reference in both adjustable and 1.225V output variants for automotive applications.

The LM4041Q has been qualified to AEC-Q100 Grade 1 and is Automotive Grade supporting PPAPs.

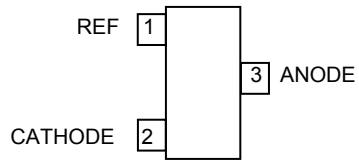
Pin Assignments

LM4041_QF (SOT23)



Pin 3 must left floating or connected to pin 2.

LM4041_ADJQF….(SOT23)



Features

- No output capacitor required
- Output voltage tolerance
  - LM4041CQ: ±0.5% at +25°C
  - LM4041DQ: ±1.0% at +25°C
- Low output noise:
  - 10Hz to 10kHz 20µVrms
- Wide operating current range: 60µA to 12mA
- Extended temperature range: -40°C to +125°C
- Low temperature coefficient: 100ppm/°C (max)
- Green Molding in small package SOT23
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- Automotive Grade
- **Qualified to AEC-Q100 Standards for High Reliability**
- **PPAP Capable (Note 4)**

Applications

- Battery powered equipment
- Precision power supplies

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
4. Automotive products are AEC-Q100 qualified and are PPAP capable. Automotive, AEC-Q100 and standard products are electrically and thermally the same, except where specified. For more information, please refer to http://www.diodes.com/quality/product_compliance_definitions/.

Absolute Maximum Ratings

Description		Rating	Unit
Continuous Reverse Current (I_R)		20	mA
Continuous Forward Current (I_F)		10	mA
Maximum Output Voltage (LM4041_ADJ)		15	V
Junction Temperature		-40 to +155	°C
Storage Temperature		-55 to +150	°C
ESD Ratings			
HBM	Human Body Model	4000	V
MM	Machine Model	200	V
CDM	Charged Device Model	TBD	V

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at conditions between maximum recommended operating conditions and absolute maximum ratings is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

(Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.)

Unless otherwise stated voltages specified are relative to the ANODE pin.

Package Thermal Data

Package	θ_{JA}	P_{DIS} T_A = +25°C, T_J = +150°C
SOT23	380°C/W	330mW

Recommended Operating Conditions

Parameter	Min	Max	Units
Reverse Current	0.06	12	mA
Output Voltage Range	1.24	10	V
Operating Ambient Temperature Range	-40	+125	°C

Electrical Characteristics

LM4041_Q (Fixed 1.225V)

Electrical characteristics over recommended operating conditions, T_A = +25°C, unless otherwise stated, $I_{RMIN} \leq I_R \leq 12mA$, $V_{REF} \leq V_{OUT} \leq 10V$. LM4041CQ and LM4041DQ have initial tolerances of 0.5% and 1% respectively.

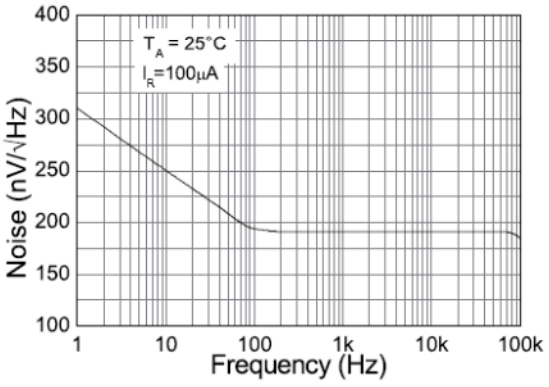
Symbol	Parameter	Conditions		Typ	LM4041C Limits	LM4041D Limits	Units
		—	T_A				
V_{REF}	Reverse Breakdown Voltage	I_R = 100µA	+25°C	1.225	—	—	V
	Reverse Breakdown Voltage Tolerance		+25°C	—	±6	±12	mV
			-40°C to +85°C	—	±14	±24	
			-40°C to +125°C	—	±18.4	±31	
I_{RMIN}	Minimum Operating Current	—	+25°C	45	60	65	µA
			-40°C to +85°C		65	70	
			-40°C to +125°C		68	73	
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 10mA	-40°C to +125°C	±20	—	—	ppm/°C
		I_R = 1mA,		±15	±100	±150	
		I_R = 100µA		±15	—	—	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Change With Current	$I_{RMIN} < I_R < 1mA$	+25°C	0.7	1.5	2.0	mV
			-40°C to +85°C		2.0	2.5	
			-40°C to +125°C		2.0	2.5	
		1mA < I_R < 12mA	+25°C	2.5	6.0	8.0	
			-40°C to +85°C		8.0	10.0	
			-40°C to +125°C		8.0	10.0	
Z_R	Dynamic Output Impedance	I_R = 1mA, f = 120Hz, I_{AC} = 0.1I_R		0.5	1.5	2.0	Ω
e_n	Noise Voltage	I_R = 100µA 10Hz < f < 10kHz		20	—	—	μV_{RMS}
ΔV_R	Long Term Stability (Non cumulative)	t = 1000Hrs I_R = 100µA		120	—	—	ppm

LM4041DADJQ (Adjustable)

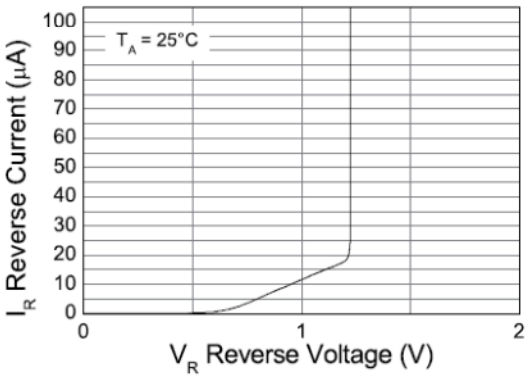
Electrical characteristics over recommended operating conditions, T_A = +25°C, $I_{RMIN} \leq I_R \leq 12$ mA, $V_{REF} \leq V_{OUT} \leq 10V$ unless otherwise stated. The grade D designates initial reference voltage tolerance of ±1% and is measured at an output/cathode voltage of 5V.

Symbol	Parameter	Conditions		Typ	LM4041D Limits	Units
		—	T_A			
V_{REF}	Reverse Breakdown Voltage	I_R = 100 µA, V_{KA} = 5V	+25°C	1.233	—	V
	Reverse Breakdown Voltage Tolerance		+25°C	—	±12	mV
			-40°C to +85°C	—	±24	
			-40°C to +125°C	—	±30	
I_{RMIN}	Minimum Operating Current	—	+25°C	45	65	µA
			-40°C to +85°C		70	
			-40°C to +125°C		73	
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient	I_R = 10mA	-40°C to +125°C	±20	—	ppm/°C
		I_R = 1mA,		±15	±150	
		I_R = 100µA		±15	—	
$\Delta V_R/\Delta V_K$	Reference voltage change with cathode voltage change	I_R = 1mA	+25°C	-1.55	-2.5	mV/V
			-40°C to +85°C		-3.0	
			-40°C to +125°C		-4.0	
I_{REF}	Reference input current	—	+25°C	60	150	nA
			-40°C to +85°C		200	
			-40°C to +125°C		200	
$\Delta V_R/\Delta I_R$	Reverse Breakdown Change With Current	$I_{RMIN} < I_R < 1mA$ $V_{OUT} > 1.6V$	+25°C	0.7	2.0	mV
			-40°C to +85°C		2.5	
			-40°C to +125°C		2.5	
		1mA < I_R < 12 mA $V_{OUT} > 1.6V$	+25°C	2	6.0	
			-40°C to +85°C		8.0	
			-40°C to +125°C		10.0	
Z_R	Dynamic Output Impedance	I_R = 1mA, f = 120Hz I_{AC} = 0.1I_R	V_{KA} = V_{REF}	0.5	—	Ω
			V_{KA} = 10V	2	—	Ω
e_n	Noise Voltage	I_R = 100µA, 10Hz < f < 10kHz		20	—	μV_{RMS}
ΔV_R	Long Term Stability (Non cumulative)	t = 1000Hrs, I_R = 100µA		120	—	ppm

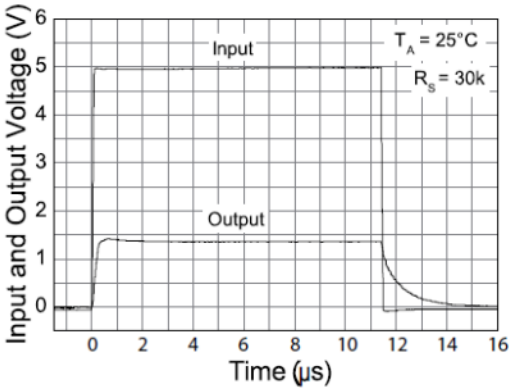
Typical Characteristics LM4041Q - 1.225



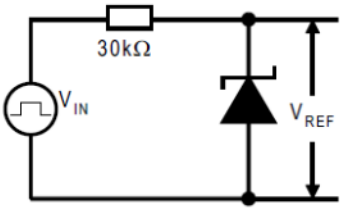
Noise Voltage vs Frequency

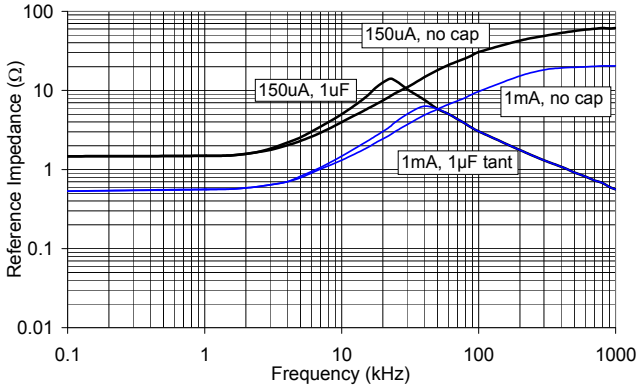


Reverse Current vs Voltage



Pulse Response





Output Impedance vs. Frequency

Application Information

The LM4041Q comes in two variants:

- LM4041_Q with fixed 1.225V output
- LM4041DADJQ with variable output voltage.

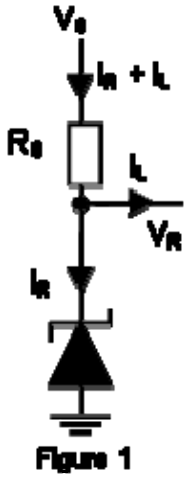


Figure 1

In a conventional shunt reference (2-terminal, fixed output device) application (*Figure 1*), an external series resistor (R_S) is connected between the supply voltage, V_S, and the LM4041Q.

R_S determines the current that flows through the load (I_L) and the LM4041Q (I_R). Since load current and supply voltage may vary, R_S should be small enough to supply at least the minimum acceptable I_R to the LM4041Q 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 I_L is at its minimum, R_S should be large enough so that the current flowing through the LM4041Q is less than 12 mA.

R_S is determined by the supply voltage, (V_S), the load and operating current, (I_L and I_Q), and the LM4041Q's reverse breakdown voltage, V_R.

$$R_S = \frac{V_S - V_R}{I_L + I_R}$$

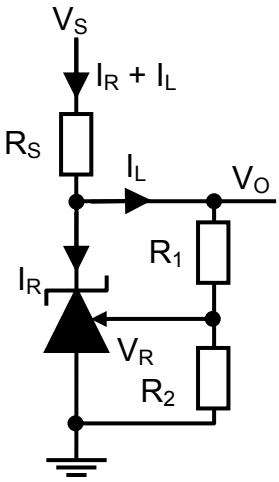


Figure 2

For the adjustable device 3-terminals are used

The LM4041Q-ADJ's output voltage can be adjusted to any value in the range of 1.24V through 10V. The output voltage is set by the ratio of two external feedback resistors as shown in Figure 2 and the internal reference voltage (V_R).

The output voltage is found using the equation:

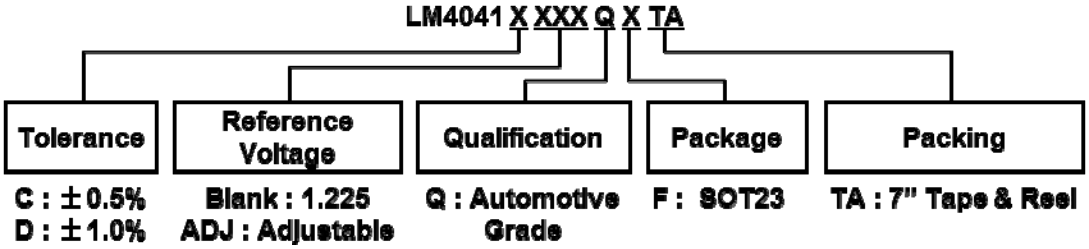
$$V_O = V_R \times \left(1 + \frac{R_2}{R_1}\right)$$

Printed Circuit Board Layout Considerations

LM4041Q with fixed output voltage in the SOT23 package has the die attached to pin 3, which results in an electrical contact between pin 2 and pin 3.

Therefore, pin 3 of the SOT23 package must be left floating or connected to pin 2.

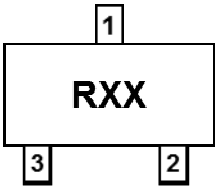
Ordering Information



Order Code	+25°C Tol	Voltage (V)	Package (Note 5)	Package Code	Identification Code	Packing: 7" Tape and Reel			Qualification Grade (Note 6)
						Quantity	Tape width	Part Number Suffix	
LM4041CQFTA	0.5%	1.225	SOT23	F	R1C	3000	8mm	TA	Automotive Grade
LM4041DQFTA	1%	1.225	SOT23	F	R1D	3000	8mm	TA	Automotive Grade
LM4041DADJQFTA	1%	Adj	SOT23	F	RAD	3000	8mm	TA	Automotive Grade

Note: 5. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf
6. LM4041Q has been been qualified to AEC-Q100 grade 1 and is classified as "Automotive Grade" supporting PPAP documentation. See LM4041 datasheet for commercial qualified versions.

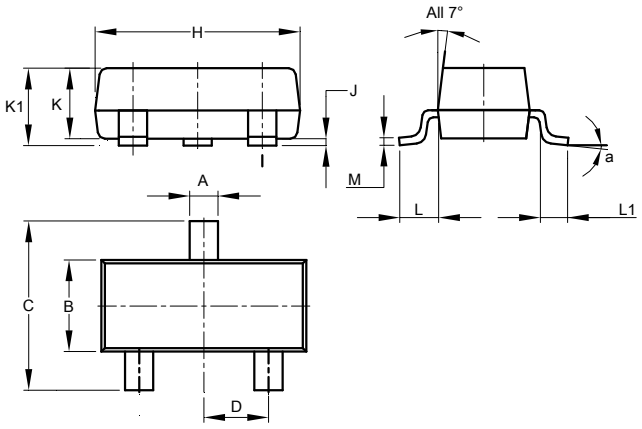
Marking Information



RXX : Identification code

Package Outline Information

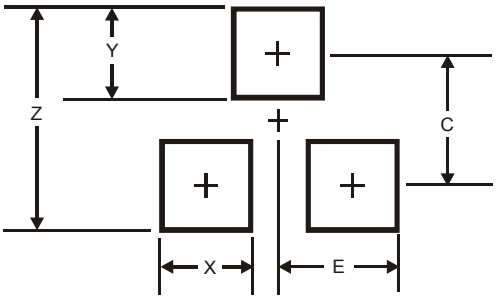
Please see AP02001 at http://www.diodes.com/datasheets/ap02002.pdf for latest version



SOT23			
Dim	Min	Max	Typ
A	0.37	0.51	0.40
B	1.20	1.40	1.30
C	2.30	2.50	2.40
D	0.89	1.03	0.915
F	0.45	0.60	0.535
G	1.78	2.05	1.83
H	2.80	3.00	2.90
J	0.013	0.10	0.05
K	0.890	1.00	0.975
K1	0.903	1.10	1.025
L	0.45	0.61	0.55
L1	0.25	0.55	0.40
M	0.085	0.150	0.110
a	8°		
All Dimensions in mm			

Suggested Pad Layout

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for latest version.



Dimensions	Value (in mm)
Z	2.9
X	0.8
Y	0.9
C	2.0
E	1.35