# LM4041

## PRECISION MICROPOWER SHUNT VOLTAGE REFERENCES

## Description

The LM4041 is a bandgap circuit designed to achieve a precision micro-power voltage reference of 1.225 V. The device is available in the small outline SOT23 and SC70 surface mount packages which are ideal for applications where space saving is important.

Both packages are available to 0.2% B grade for precision applications. 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.

## Features

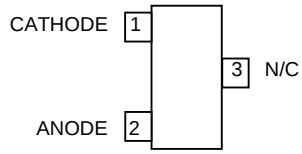
- Small packages: SOT23 and SC70-5
- No Output capacitor required
- Output voltage tolerance
- LM4041B ±0.2% at 25°C
- LM4041C ±0.5% at 25°C
- LM4041D ±1% at 25°C
- Low output noise
- (10 Hz to 10kHz) 20µVrms
- Wide operating current range 60µA to 12mA
- Extended temperature range -40°C to +125°C
- Low temperature coefficient 100ppm/°C (max)

## Applications

- Battery powered equipment
- Precision power supplies
- Portable instrumentation
- Portable communications devices
- Notebook and palmtop computers
- Data acquisition systems

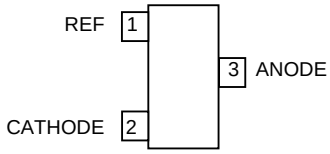
## Pin Connections

**LM4041_F (SOT23)**

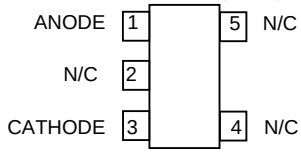



Pin 3 must left floating or connected to pin 2.

**LM4041_ADJF….(SOT23)**

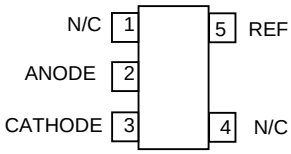



**LM4041_H5 (SC70)**




Pin 2 must be left floating or connected to pin 1

**LM4041_ADJH5 (SC70)**




Order Information

| 25°C Tol | Voltage (V) | ORDER CODE | PACK | PART MARK | STATUS | REEL SIZE | TAPE WIDTH | QUANTITY PER REEL |
|---|---|---|---|---|---|---|---|---|
| 0.2% | 1.225 | **LM4041BFTA** | **SOT23** | **R1B** | Advance | **7", 180mm** | **8mm** | **3000** |
| | | LM4041BH5TA | SC70-5 | R1B | Advance | 7", 180mm | 8mm | 3000 |
| 0.5% | 1.225 | **LM4041CFTA** | **SOT23** | **R1C** | **Active** | **7", 180mm** | **8mm** | **3000** |
| | | LM4041CH5TA | SC70-5 | R1C | Advance | 7", 180mm | 8mm | 3000 |
| | Adj | LM4041CADJFTA | SOT23 | RAC | Advance | 7", 180mm | 8mm | 3000 |
| | | LM4041CADJH5TA | SC70-5 | RAC | Advance | 7", 180mm | 8mm | 3000 |
| 1% | 1.225 | **LM4041DFTA** | **SOT23** | **R1D** | **Active** | **7", 180mm** | **8mm** | **3000** |
| | | LM4041DH5TA | SC70-5 | R1D | Active | 7", 180mm | 8mm | 3000 |
| | Adj | LM4041DADJFTA | SOT23 | RAD | Active | 7", 180mm | 8mm | 3000 |
| | | LM4041DADJH5TA | SC70-5 | RAD | Active | 7", 180mm | 8mm | 3000 |

## ABSOLUTE MAXIMUM RATINGS

Continuous Reverse Current ($I_R$) ..... 20mA
Continuous Forward current ($I_F$) ..... 10mA
Maximum Output voltage (LM4041_ADJ) ..... 15V
Operating Junction Temperature ..... -40 to 150°C
Storage Temperature ..... -55 to 150°C

Operation above the absolute maximum rating may cause device failure. Operation at the absolute maximum ratings, for extended periods, may reduce device reliability.

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.

ESD susceptibility

| | |
|---|---|
| Human body model | 4000 V |
| Machine model | 200 V |

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

Package Thermal Data

| Package | $\theta_{JA}$ | $P_{DIS}$ $T_A$ =25°C, $T_J$ = 150°C |
|---|---|---|
| SOT23 | 380°C/W | 330 mW |
| SC70-5 | 420°C/W | 300 mW |

**Recommended Operating Conditions**

| | 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

### LM4041-1.2

Electrical characteristics over recommended operating conditions, $T_A$ = 25°C, unless otherwise stated, $I_{RMIN} \leq I_R \leq 12mA$, $V_{REF} \leq V_{OUT} \leq 10V$. LM4041B, LM4041C and LM4041D have initial tolerances of 0.2%, 0.5% and 1% respectively.

| Symbol | Parameter | Conditions | | Typ | LM4041B Limits | LM4041C Limits | LM4041D Limits | Units |
|---|---|---|---|---|---|---|---|---|
| | | | $T_A$ | | | | | |
| $V_{REF}$ | Reverse Breakdown Voltage | $I_R$ = 100 µA | 25°C | 1.225 | | | | V |
| | Reverse Breakdown Voltage Tolerance | | 25°C | | ±2.4 | ±6 | ±12 | mV |
| | | | -40 to 85°C | | ±10.4 | ±14 | ±24 | |
| | | | -40 to 125°C | | ±14.8 | ±18.4 | ±31 | |
| $I_{RMIN}$ | Minimum Operating Current | | 25°C | 45 | 60 | 60 | 65 | µA |
| | | | -40 to 85°C | | 65 | 65 | 70 | |
| | | | -40 to 125°C | | 68 | 68 | 73 | |
| $\Delta V_R/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient | $I_R$ = 10 mA | -40 to 125°C | ±20 | | | | ppm/°C |
| | | $I_R$ = 1 mA, | | ±15 | ±100 | ±100 | ±150 | |
| | | $I_R$ = 100 µA | | ±15 | | | | |
| $\Delta V_R/\Delta I_R$ | Reverse Breakdown Change With Current | $I_{RMIN} < I_R < 1mA$ | 25°C | 0.7 | 1.5 | 1.5 | 2.0 | mV |
| | | | -40 to 85°C | | 2.0 | 2.0 | 2.5 | |
| | | | -40 to 125°C | | 2.0 | 2.0 | 2.5 | |
| | | 1mA < $I_R$ < 12 mA | 25°C | 2.5 | 6.0 | 6.0 | 8.0 | |
| | | | -40 to 85°C | | 8.0 | 8.0 | 10.0 | |
| | | | -40 to 125°C | | 8.0 | 8.0 | 10.0 | |
| $Z_R$ | Dynamic Output Impedance | $I_R$ = 1mA, f = 120Hz $I_{AC} = 0.1I_R$ | | 0.5 | 1.5 | 1.5 | 2.0 | Ω |
| $e_n$ | Noise Voltage | $I_R$ = 100µA 10Hz < f < 10kHz | | 20 | | | | $\mu V_{RMS}$ |
| $\Delta V_R$ | Long Term Stability (Non cumulative) | t = 1000Hrs $I_R$ = 100µA | | 120 | | | | ppm |

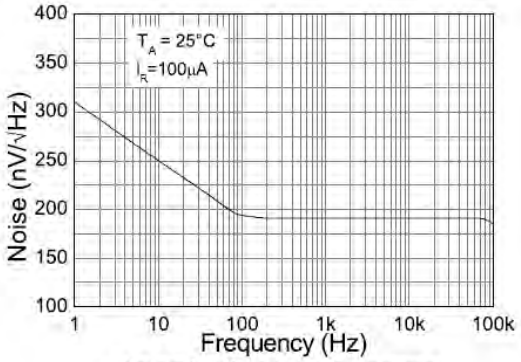
## ELECTRICAL CHARACTERISTICS

### LM4041-Adj

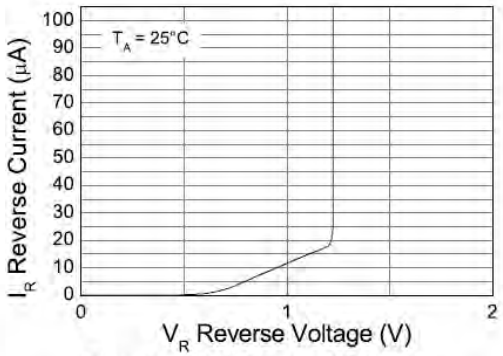
Electrical characteristics over recommended operating conditions, $T_A$ = 25°C, $I_{RMIN}$ . $I_R$ . 12 mA, $V_{REF}$ . $V_{OUT}$ . 10V unless otherwise stated. The grades C and D designate initial Reference Voltage Tolerances of ±0.5% and ±1% and are measured at an output/cathode voltage of 5V.

| Symbol | Parameter | Conditions | | Typ | LM4041C Limits | 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 | | ±6.2 | ±12 | mV |
| | | | -40 to 85°C | | ±14 | ±24 | |
| | | | -40 to 125°C | | ±18 | ±30 | |
| $I_{RMIN}$ | Minimum Operating Current | | 25°C | 45 | 60 | 65 | µA |
| | | | -40 to 85°C | | 65 | 70 | |
| | | | -40 to 125°C | | 68 | 73 | |
| $\Delta V_R/\Delta T$ | Average Reverse Breakdown Voltage Temperature Coefficient | $I_R$ = 10 mA | -40 to 125°C | ±20 | | | ppm/°C |
| | | $I_R$ = 1 mA, | | ±15 | ±100 | ±150 | |
| | | $I_R$ = 100 µA | | ±15 | | | |
| $\Delta V_R/\Delta V_K$ | Reference voltage change with cathode voltage change | $I_R$ = 1mA | 25°C | -1.55 | -2.0 | -2.5 | mV/V |
| | | | -40 to 85°C | | -2.5 | -3.0 | |
| | | | -40 to 125°C | | -3.0 | -4.0 | |
| $I_{REF}$ | Reference input current | | 25°C | 60 | 100 | 150 | nA |
| | | | -40 to 85°C | | 120 | 200 | |
| | | | -40 to 125°C | | 120 | 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 | 1.5 | 2.0 | mV |
| | | | -40 to 85°C | | 2.0 | 2.5 | |
| | | | -40 to 125°C | | 2.0 | 2.5 | |
| | | 1mA < $I_R$ < 12 mA $V_{OUT}$ > 1.6V | 25°C | 2 | 4.0 | 6.0 | |
| | | | -40 to 85°C | | 6.0 | 8.0 | |
| | | | -40 to 125°C | | 8.0 | 10.0 | |
| $Z_R$ | Dynamic Output Impedance | $I_R$ = 1mA, f = 120Hz $I_{AC}$ = 0.1$I_R$ | $V_{KA}$ = $V_{REF}$ | 0.5 | | | Ω |
| | | | $V_{KA}$ = 10V | 2 | | | |
| $e_n$ | Noise Voltage | $I_R$ = 100µA 10Hz < f < 10kHz | | 20 | | | $\mu V_{RMS}$ |
| $\Delta V_R$ | Long Term Stability (Non cumulative) | t = 1000Hrs | $I_R$ = 100µA | 120 | | | ppm |

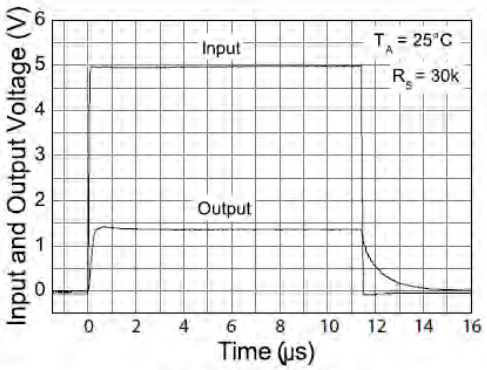
## LM4041 1.225 Typical characteristics



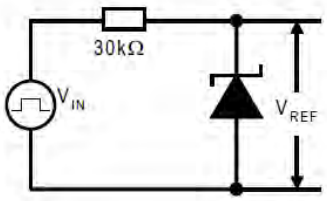

**Noise Voltage vs Frequency**

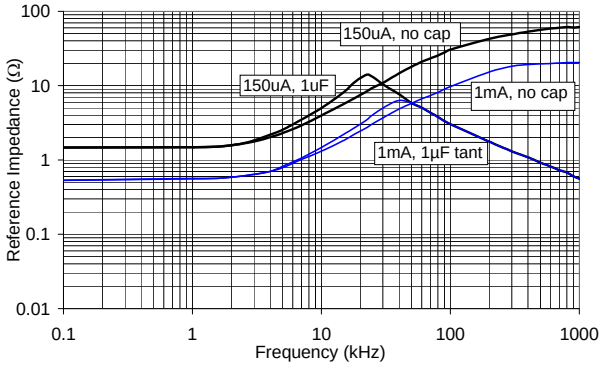



**Reverse Current vs Voltage**




**Pulse Response**




Output impedance Vs frequency

## Application information

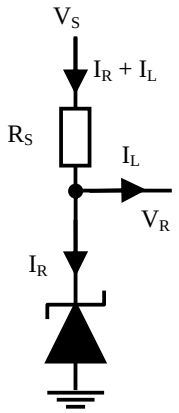



Figure 1

In a conventional shunt regulator application (*Figure 1*), an external series resistor ($R_S$) is connected between the supply voltage, $V_S$, and the LM4041.

$R_S$ determines the current that flows through the load ($I_L$) and the LM4041 ($I_R$). 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 LM4040 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 LM4040 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 LM4040's reverse breakdown voltage, $V_R$.

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

The LM4041 comes in two variants:

- LM4041 with fixed 1.225V output
- LM4041_ADJ with variable output voltage.

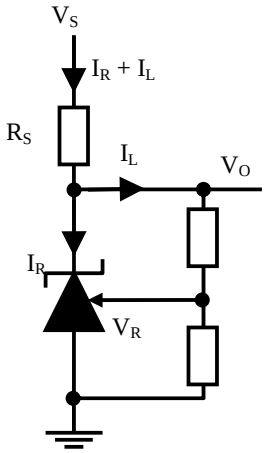



Figure 2

The LM4041-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:

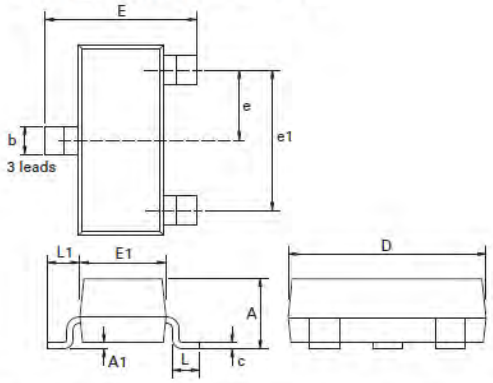
$$V_O = V_R \times \left(1 + \frac{R_2}{R_1}\right)$$

### PRINTED CIRCUIT BOARD LAYOUT CONSIDERATIONS

LM4041 with fixed output voltage in the SOT23 package has the die attached to pin 1, which results in an electrical contact between pin 2 and pin 1. Therefore, pin 1 of the SOT23 package must be left floating or connected to pin 2.

LM4041 with fixed output voltage in the SC70-5 package have the die attached to pin 2, which results in an electrical contact between pin 2 and pin 1. Therefore, pin 2 must be left floating or connected to pin1.

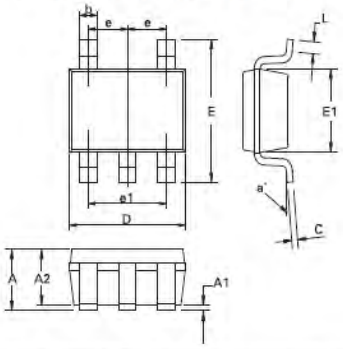
## Package outline - SOT23




| Dim. | Millimeters | | Inches | | Dim. | Millimeters | | Inches | |
|---|---|---|---|---|---|---|---|---|---|
| | Min. | Max. | Min. | Max. | | Min. | Max. | Max. | Max. |
| A | - | 1.12 | - | 0.044 | e1 | 1.90 NOM | | 0.075 NOM | |
| A1 | 0.01 | 0.10 | 0.0004 | 0.004 | E | 2.10 | 2.64 | 0.083 | 0.104 |
| b | 0.30 | 0.50 | 0.012 | 0.020 | E1 | 1.20 | 1.40 | 0.047 | 0.055 |
| C | 0.085 | 0.120 | 0.003 | 0.008 | L | 0.25 | 0.62 | 0.018 | 0.024 |
| D | 2.80 | 3.04 | 0.110 | 0.120 | L1 | 0.45 | 0.62 | 0.018 | 0.024 |
| e | 0.95 NOM | | 0.0375 NOM | | - | - | - | - | - |

**Note:** Controlling dimensions are in millimeters. Approximate dimensions are provided in inches

## Package outline SC-70-5




| Dim. | Millimeters | | Inches | | Dim. | Millimeters | | Inches | |
|---|---|---|---|---|---|---|---|---|---|
| | Min. | Max. | Min. | Max. | | Min. | Max. | Max. | Max. |
| A | 0.80 | 1.10 | 0.0315 | 0.0433 | E | 2.10 BSC | | 0.0826 BSC | |
| A1 | - | 0.10 | - | 0.0039 | E1 | 1.25 BSC | | 0.0492 BSC | |
| A2 | 0.80 | 1.00 | 0.0315 | 0.0394 | e | 0.65 BSC | | 0.0255 BSC | |
| b | 0.15 | 0.30 | 0.006 | 0.0118 | e1 | 1.30 BSC | | 0.0511 BSC | |
| C | 0.08 | 0.25 | 0.0031 | 0.0098 | L | 0.26 | 0.46 | 0.0102 | 0.0181 |
| D | 2.00 BSC | | 0.0787 BSC | | a° | 0 | 8 | 0 | 8 |

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