

## 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 SC70-5 surface mount packages which are ideal for applications where space saving is important.

Both packages are available to 0.5% C grade and 1% D 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

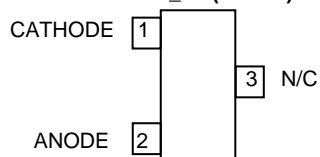
- Small packages: SOT23, SC70-5
- No output capacitor required
- Output voltage tolerance
- LM4041C: ±0.5% at 25°C
- LM4041D: ±1% at 25°C
- Low output noise: 20µVrms (10Hz to 10kHz)
- Wide operating current range: 60µA to 12mA
- Extended temperature range: -40°C to +125°C
- Low temperature coefficient : 100ppm/°C (max)
- All parts AEC-Q100 Grade1 qualified

## Applications

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

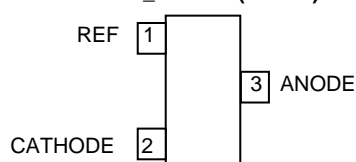
## Pin Assignments

**LM4041\_F (SOT23)**

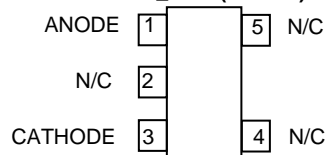


Pin 3 must left floating or connected to pin 2.

**LM4041\_ADJF....(SOT23)**

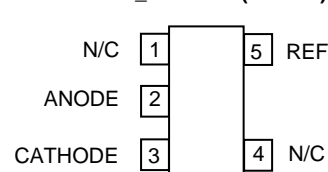


**LM4041\_H5 (SC70-5)**



Pin 2 must be left floating or connected to pin 1

**LM4041\_ADJH5 (SC70-5)**



### 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   |
| <b>ESD Ratings</b>                   |            |      |
| Human Body Model                     | 4000       | V    |
| Machine Model                        | 200        | V    |

These are stress ratings only. Operation outside the absolute maximum ratings may cause device failure. Operation at the absolute maximum rating, 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.

### Package Thermal Data

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

### 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

#### LM4041-1.2

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

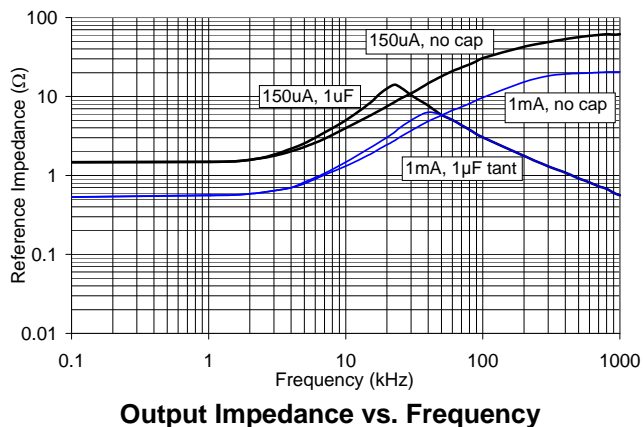
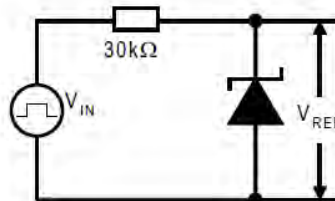
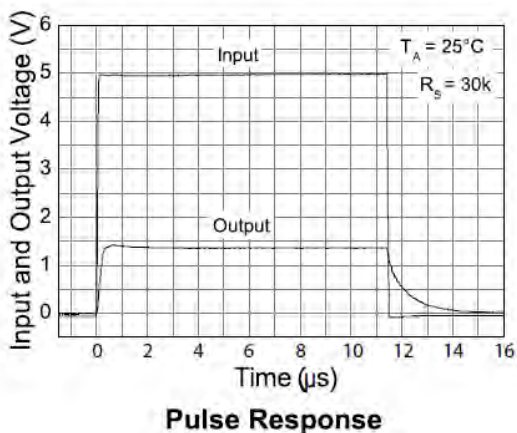
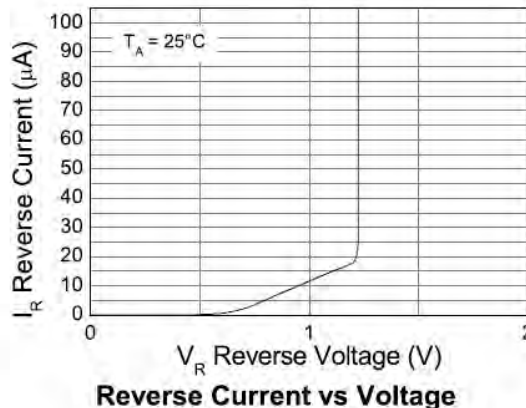
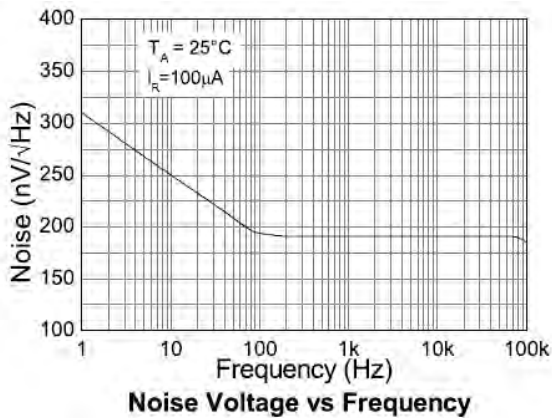
| Symbol                  | Parameter   | Conditions  |              | Typ   | LM4041C Limits | LM4041D Limits | Units             |
|-------------------------|---|---|--------------|-------|----------------|----------------|-------------------|
|                         |   |   | $T_A$        |       |                |                |                   |
| $V_{REF}$               | Reverse Breakdown Voltage                                 | $I_R = 100 \mu\text{A}$                                       | 25°C         | 1.225 |                |                | V                 |
|                         | Reverse Breakdown Voltage Tolerance                       |   | 25°C         |       | ±6             | ±12            | mV                |
|                         |   |   | -40 to 85°C  |       | ±14            | ±24            |                   |
|                         |   |   | -40 to 125°C |       | ±18.4          | ±31            |                   |
| $I_{RMIN}$              | 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 | $I_R = 10 \text{ mA}$   | -40 to 125°C | ±20   | ±100           | ±150           | ppm/°C            |
|                         |   | $I_R = 1 \text{ mA}$ ,  |              | ±15   |                |                |                   |
|                         |   | $I_R = 100 \mu\text{A}$                                       |              | ±15   |                |                |                   |
| $\Delta V_R/\Delta I_R$ | Reverse Breakdown Change With Current                     | $I_{RMIN} < I_R < 1 \text{ mA}$                               | 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            |                   |
|                         |   | $1 \text{ mA} < I_R < 12 \text{ mA}$                          | 25°C         | 2.5   | 6.0            | 8.0            |                   |
|                         |   |   | -40 to 85°C  |       | 8.0            | 10.0           |                   |
|                         |   |   | -40 to 125°C |       | 8.0            | 10.0           |                   |
| $Z_R$                   | Dynamic Output Impedance                                  | $I_R = 1 \text{ mA}$ , $f = 120\text{Hz}$ , $I_{AC} = 0.1I_R$ |              | 0.5   | 1.5            | 2.0            | Ω                 |
| $e_n$                   | Noise Voltage   | $I_R = 100\mu\text{A}$ $10\text{Hz} < f < 10\text{kHz}$       |              | 20    |                |                | μV <sub>RMS</sub> |
| $\Delta V_R$            | Long Term Stability (Non cumulative)                      | $t = 1000\text{Hrs}$ $I_R = 100\mu\text{A}$                   |              | 120   |                |                | ppm               |

#### LM4041-Adj

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

**Typical Characteristics LM4041 1.225**



## Application Information

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.

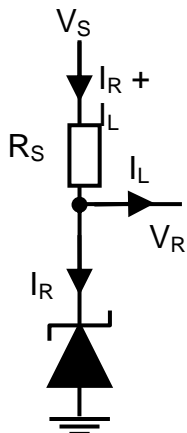


Figure 1

$R_S$  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.

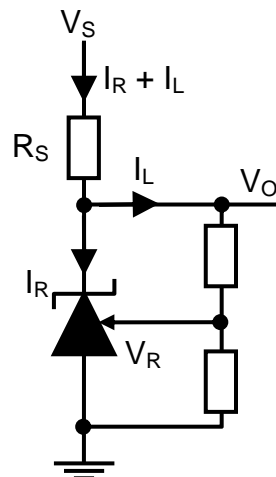


Figure 2

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 pin 1.

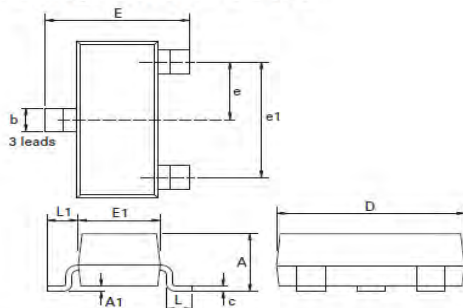
**Ordering Information**

| 25°C Tol | Voltage (V) | ORDER CODE     | QUALIFICATION† | PACK   | PART MARK | REEL SIZE | TAPE WIDTH | QUANTITY PER REEL |
|----------|-------------|----------------|----------------|--------|-----------|-----------|------------|-------------------|
| 0.5%     | 1.225       | LM4041CFTA     | Commercial     | SOT23  | R1C       | 7", 180mm | 8mm        | 3000              |
|          |             | LM4041CQFTA    | Automotive     | SOT23  | R1C       | 7", 180mm | 8mm        | 3000              |
|          |             | LM4041CH5TA    | Commercial     | SC70-5 | R1C       | 7", 180mm | 8mm        | 3000              |
| 1%       | 1.225       | LM4041DFTA     | Commercial     | SOT23  | R1D       | 7", 180mm | 8mm        | 3000              |
|          |             | LM4041DQFTA    | Automotive     | SOT23  | R1D       | 7", 180mm | 8mm        | 3000              |
|          |             | LM4041DH5TA    | Commercial     | SC70-5 | R1D       | 7", 180mm | 8mm        | 3000              |
|          | Adj         | LM4041DADJFTA  | Commercial     | SOT23  | RAD       | 7", 180mm | 8mm        | 3000              |
|          |             | LM4041DADJH5TA | Commercial     | SC70-5 | RAD       | 7", 180mm | 8mm        | 3000              |

† All parts AEC-Q100 grade 1 qualified

**Package Outline Information**

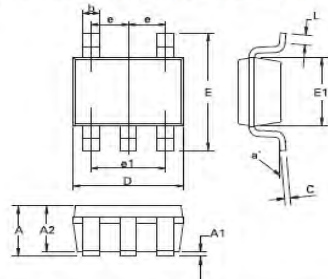
**Package outline - SOT23**



| 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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