

## SOT-23 Precision Micropower Series Voltage Reference

Check for Samples: [SM74601](#)

### FEATURES

- Renewable Energy Grade
- Output Voltage Initial Accuracy 0.5%
- Low Temperature Coefficient 100ppm/°C
- Low Supply Current, 60  $\mu$ A
- Enable Pin Allowing a 3  $\mu$ A Shutdown Mode
- Up to 20 mA Output Current
- Voltage Options 1.8V, 2.048V, 2.5V, 3.0V, 3.3V, 4.096V
- Custom Voltage Options Available (1.8V to 4.096V)
- $V_{IN}$  Range of  $V_{REF} + 400$  mV to 5.5V @ 10 mA
- Stable with Low ESR Ceramic Capacitors
- SOT23-5 Package
- $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  Junction Temperature Range

### DESCRIPTION

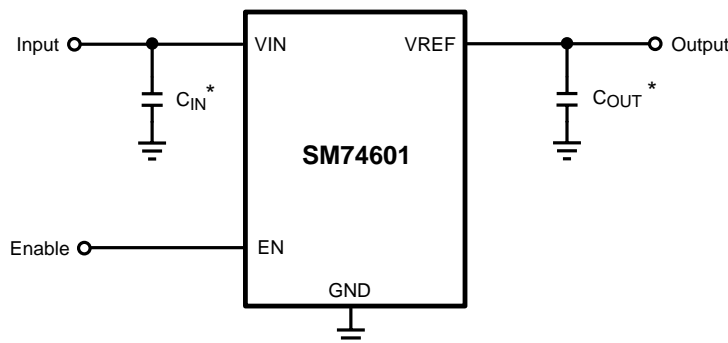
Ideal for space critical applications, the SM74601 precision voltage reference is available in the SOT-23 surface-mount package. The SM74601's advanced design eliminates the need for an external stabilizing capacitor while ensuring stability with capacitive loads up to 10  $\mu$ F, thus making the SM74601 easy to use.

Series references provide lower power consumption than shunt references, since they do not have to idle the maximum possible load current under no load conditions. This advantage, the low quiescent current (60  $\mu$ A), and the low dropout voltage (400 mV) make the SM74601 ideal for battery-powered solutions.

### APPLICATIONS

- Photovoltaic
- Instrumentation & Process Control
- Test Equipment
- Data Acquisition Systems
- Base Stations
- Servo Systems
- Portable, Battery Powered Equipment
- Automotive & Industrial Electronics
- Precision Regulators
- Battery Chargers
- Communications
- Medical Equipment

### Typical Application Circuit



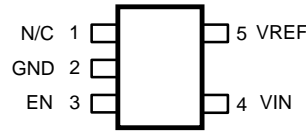
\*Note: The capacitor  $C_{IN}$  is required and the capacitor  $C_{OUT}$  is optional.



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.

All trademarks are the property of their respective owners.

## Connection Diagram



**Figure 1. SOT23-5 Package  
Package Number DBV0005A  
Top View**

### PIN DESCRIPTIONS

Pin #	Name	Function
1	N/C	No connect pin, leave floating
2	GND	Ground
3	EN	Enable pin
4	VIN	Input supply
5	VREF	Reference output



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### Absolute Maximum Ratings <sup>(1)(2)</sup>

Maximum Voltage on any input	-0.3 to 6V
Output short circuit duration	Indefinite
Power Dissipation ( $T_A = 25^\circ\text{C}$ ) <sup>(3)</sup>	350 mW
Storage Temperature Range	$-65^\circ\text{C}$ to $150^\circ\text{C}$
Lead Temperature (soldering, 10sec)	$260^\circ\text{C}$
Vapor Phase (60 sec)	$215^\circ\text{C}$
Infrared (15sec)	$220^\circ\text{C}$
ESD Susceptibility <sup>(4)</sup> Human Body Model	2 kV

- (1) Absolute Maximum Ratings indicate limits beyond which damage may occur to the device. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications, see Electrical Characteristics.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) Without PCB copper enhancements. The maximum power dissipation must be de-rated at elevated temperatures and is limited by  $T_{JMAX}$  (maximum junction temperature),  $\theta_{J-A}$  (junction to ambient thermal resistance) and  $T_A$  (ambient temperature). The maximum power dissipation at any temperature is:  $P_{DissMAX} = (T_{JMAX} - T_A) / \theta_{J-A}$  up to the value listed in the Absolute Maximum Ratings.  $\theta_{J-A}$  for SOT23-5 package is  $220^\circ\text{C}/\text{W}$ ,  $T_{JMAX} = 125^\circ\text{C}$ .
- (4) The human body model is a 100 pF capacitor discharged through a 1.5 k $\Omega$  resistor into each pin.

### Operating Ratings

Maximum Input Supply Voltage	5.5V
Maximum Enable Input Voltage	$V_{IN}$
Maximum Load Current	20mA
Junction Temperature Range ( $T_J$ )	$-40^\circ\text{C}$ to $+125^\circ\text{C}$

## Electrical Characteristics SM74601-1.8 (V<sub>OUT</sub> = 1.8V)

Limits in standard type are for T<sub>J</sub> = 25°C only, and limits in **boldface type** apply over the junction temperature (T<sub>J</sub>) range of -40°C to +125°C unless otherwise specified. Minimum and Maximum limits are ensured through test, design, or statistical correlation. Typical values represent the most likely parametric norm at T<sub>J</sub> = 25°C, and are provided for reference purposes only. Unless otherwise specified V<sub>IN</sub> = 5V and I<sub>LOAD</sub> = 0A.

Symbol	Parameter	Conditions	Min (1)	Typ (2)	Max (1)	Unit
V <sub>REF</sub>	Output Voltage Initial Accuracy					
TCV <sub>REF</sub> /°C (Note 6)	Temperature Coefficient				100	ppm/°C
I <sub>Q</sub>	Supply Current			60	<b>100</b>	μA
I <sub>Q_SD</sub>	Supply Current in Shutdown	EN = 0V		3	<b>7</b>	μA
ΔV <sub>REF</sub> /ΔV <sub>IN</sub>	Line Regulation	V <sub>REF</sub> + 400 mV ≤ V <sub>IN</sub> ≤ 5.5V		30		ppm / V
ΔV <sub>REF</sub> /ΔI <sub>LOAD</sub>	Load Regulation	0 mA ≤ I <sub>LOAD</sub> ≤ 20 mA		25	<b>120</b>	ppm / mA
ΔV <sub>REF</sub>	Long Term Stability (Note 7)	1000 Hrs		50		ppm
	Thermal Hysteresis (Note 8)	-40°C ≤ T <sub>J</sub> ≤ +125°C		75		
V <sub>IN</sub> - V <sub>REF</sub>	Dropout Voltage (Note 9)	I <sub>LOAD</sub> = 10 mA		200	<b>400</b>	mV
V <sub>N</sub>	Output Noise Voltage	0.1 Hz to 10 Hz		170		μV <sub>PP</sub>
I <sub>SC</sub>	Short Circuit Current				<b>75</b>	mA
V <sub>IL</sub>	Enable Pin Maximum Low Input Level				<b>35</b>	%V
V <sub>IH</sub>	Enable Pin Minimum High Input Level		<b>65</b>			%V

- (1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control.  
 (2) Typical numbers are at 25°C and represent the most likely parametric norm.

## Electrical Characteristics SM74601-2.0 (V<sub>OUT</sub> = 2.048V)

Limits in standard type are for T<sub>J</sub> = 25°C only, and limits in **boldface type** apply over the junction temperature (T<sub>J</sub>) range of -40°C to +125°C unless otherwise specified. Minimum and Maximum limits are ensured through test, design, or statistical correlation. Typical values represent the most likely parametric norm at T<sub>J</sub> = 25°C, and are provided for reference purposes only. Unless otherwise specified V<sub>IN</sub> = 5V and I<sub>LOAD</sub> = 0A.

Symbol	Parameter	Conditions	Min (1)	Typ (2)	Max (1)	Unit
V <sub>REF</sub>	Output Voltage Initial Accuracy					
TCV <sub>REF</sub> /°C (Note 6)	Temperature Coefficient				100	ppm/°C
I <sub>Q</sub>	Supply Current			60	<b>100</b>	μA
I <sub>Q_SD</sub>	Supply Current in Shutdown	EN = 0V		3	<b>7</b>	μA
ΔV <sub>REF</sub> /ΔV <sub>IN</sub>	Line Regulation	V <sub>REF</sub> + 400 mV ≤ V <sub>IN</sub> ≤ 5.5V		30		ppm / V
ΔV <sub>REF</sub> /ΔI <sub>LOAD</sub>	Load Regulation	0 mA ≤ I <sub>LOAD</sub> ≤ 20 mA		25	<b>120</b>	ppm / mA
ΔV <sub>REF</sub>	Long Term Stability (Note 7)	1000 Hrs		50		ppm
	Thermal Hysteresis (Note 8)	-40°C ≤ T <sub>J</sub> ≤ +125°C		75		
V <sub>IN</sub> - V <sub>REF</sub>	Dropout Voltage (Note 9)	I <sub>LOAD</sub> = 10 mA		175	<b>400</b>	mV
V <sub>N</sub>	Output Noise Voltage	0.1 Hz to 10 Hz		190		μV <sub>PP</sub>
I <sub>SC</sub>	Short Circuit Current				<b>75</b>	mA
V <sub>IL</sub>	Enable Pin Maximum Low Input Level				<b>35</b>	%V
V <sub>IH</sub>	Enable Pin Minimum High Input Level		<b>65</b>			%V

- (1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control.  
 (2) Typical numbers are at 25°C and represent the most likely parametric norm.

## Electrical Characteristics

### SM74601-2.5 (V<sub>OUT</sub> = 2.5V)

Limits in standard type are for T<sub>J</sub> = 25°C only, and limits in **boldface type** apply over the junction temperature (T<sub>J</sub>) range of -40°C to +125°C unless otherwise specified. Minimum and Maximum limits are ensured through test, design, or statistical correlation. Typical values represent the most likely parametric norm at T<sub>J</sub> = 25°C, and are provided for reference purposes only. Unless otherwise specified V<sub>IN</sub> = 5V and I<sub>LOAD</sub> = 0A.

Symbol	Parameter	Conditions	Min (1)	Typ (2)	Max (1)	Unit
V <sub>REF</sub>	Output Voltage Initial Accuracy					
TCV <sub>REF</sub> /°C (Note 6)	Temperature Coefficient				100	ppm/°C
I <sub>Q</sub>	Supply Current			60	<b>100</b>	μA
I <sub>Q_SD</sub>	Supply Current in Shutdown	EN = 0V		3	<b>7</b>	μA
ΔV <sub>REF</sub> /ΔV <sub>IN</sub>	Line Regulation	V <sub>REF</sub> + 400 mV ≤ V <sub>IN</sub> ≤ 5.5V		50		ppm / V
ΔV <sub>REF</sub> /ΔI <sub>LOAD</sub>	Load Regulation	0 mA ≤ I <sub>LOAD</sub> ≤ 20 mA		25	<b>120</b>	ppm / mA
ΔV <sub>REF</sub>	Long Term Stability (Note 7)	1000 Hrs		50		ppm
	Thermal Hysteresis (Note 8)	-40°C ≤ T <sub>J</sub> ≤ +125°C		75		
V <sub>IN</sub> - V <sub>REF</sub>	Dropout Voltage (Note 9)	I <sub>LOAD</sub> = 10 mA		175	<b>400</b>	mV
V <sub>N</sub>	Output Noise Voltage	0.1 Hz to 10 Hz		275		μV <sub>PP</sub>
I <sub>SC</sub>	Short Circuit Current				<b>75</b>	mA
V <sub>IL</sub>	Enable Pin Maximum Low Input Level				<b>35</b>	%V
V <sub>IH</sub>	Enable Pin Minimum High Input Level		<b>65</b>			%V

- (1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control.  
(2) Typical numbers are at 25°C and represent the most likely parametric norm.

## Electrical Characteristics

### SM74601-3.0 (V<sub>OUT</sub> = 3.0V)

Limits in standard type are for T<sub>J</sub> = 25°C only, and limits in **boldface type** apply over the junction temperature (T<sub>J</sub>) range of -40°C to +125°C unless otherwise specified. Minimum and Maximum limits are ensured through test, design, or statistical correlation. Typical values represent the most likely parametric norm at T<sub>J</sub> = 25°C, and are provided for reference purposes only. Unless otherwise specified V<sub>IN</sub> = 5V and I<sub>LOAD</sub> = 0A.

Symbol	Parameter	Conditions	Min (1)	Typ (2)	Max (1)	Unit
V <sub>REF</sub>	Output Voltage Initial Accuracy					
TCV <sub>REF</sub> /°C (Note 6)	Temperature Coefficient				100	ppm/°C
I <sub>Q</sub>	Supply Current			60	<b>100</b>	μA
I <sub>Q_SD</sub>	Supply Current in Shutdown	EN = 0V		3	<b>7</b>	μA
ΔV <sub>REF</sub> /ΔV <sub>IN</sub>	Line Regulation	V <sub>REF</sub> + 400 mV ≤ V <sub>IN</sub> ≤ 5.5V		70		ppm / V
ΔV <sub>REF</sub> /ΔI <sub>LOAD</sub>	Load Regulation	0 mA ≤ I <sub>LOAD</sub> ≤ 20 mA		25	<b>120</b>	ppm / mA
ΔV <sub>REF</sub>	Long Term Stability (Note 7)	1000 Hrs		50		ppm
	Thermal Hysteresis (Note 8)	-40°C ≤ T <sub>J</sub> ≤ +125°C		75		
V <sub>IN</sub> - V <sub>REF</sub>	Dropout Voltage (Note 9)	I <sub>LOAD</sub> = 10 mA		175	<b>400</b>	mV
V <sub>N</sub>	Output Noise Voltage	0.1 Hz to 10 Hz		285		μV <sub>PP</sub>
I <sub>SC</sub>	Short Circuit Current				<b>75</b>	mA
V <sub>IL</sub>	Enable Pin Maximum Low Input Level				<b>35</b>	%V
V <sub>IH</sub>	Enable Pin Minimum High Input Level		<b>65</b>			%V

- (1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control.  
(2) Typical numbers are at 25°C and represent the most likely parametric norm.

## Electrical Characteristics SM74601-3.3 (V<sub>OUT</sub> = 3.3V)

Limits in standard type are for T<sub>J</sub> = 25°C only, and limits in **boldface type** apply over the junction temperature (T<sub>J</sub>) range of -40°C to +125°C unless otherwise specified. Minimum and Maximum limits are ensured through test, design, or statistical correlation. Typical values represent the most likely parametric norm at T<sub>J</sub> = 25°C, and are provided for reference purposes only. Unless otherwise specified V<sub>IN</sub> = 5V and I<sub>LOAD</sub> = 0A.

Symbol	Parameter	Conditions	Min (1)	Typ (2)	Max (1)	Unit
V <sub>REF</sub>	Output Voltage Initial Accuracy					
TCV <sub>REF</sub> /°C (Note 6)	Temperature Coefficient				100	ppm/°C
I <sub>Q</sub>	Supply Current			60	<b>100</b>	μA
I <sub>Q_SD</sub>	Supply Current in Shutdown	EN = 0V		3	<b>7</b>	μA
ΔV <sub>REF</sub> /ΔV <sub>IN</sub>	Line Regulation	V <sub>REF</sub> + 400 mV ≤ V <sub>IN</sub> ≤ 5.5V		85		ppm / V
ΔV <sub>REF</sub> /ΔI <sub>LOAD</sub>	Load Regulation	0 mA ≤ I <sub>LOAD</sub> ≤ 20 mA		25	<b>120</b>	ppm / mA
ΔV <sub>REF</sub>	Long Term Stability (Note 7)	1000 Hrs		50		ppm
	Thermal Hysteresis (Note 8)	-40°C ≤ T <sub>J</sub> ≤ +125°C		75		
V <sub>IN</sub> - V <sub>REF</sub>	Dropout Voltage (Note 9)	I <sub>LOAD</sub> = 10 mA		175	<b>400</b>	mV
V <sub>N</sub>	Output Noise Voltage	0.1 Hz to 10 Hz		310		μV <sub>PP</sub>
I <sub>SC</sub>	Short Circuit Current				<b>75</b>	mA
V <sub>IL</sub>	Enable Pin Maximum Low Input Level				<b>35</b>	%V
V <sub>IH</sub>	Enable Pin Minimum High Input Level		<b>65</b>			%V

- (1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control.
- (2) Typical numbers are at 25°C and represent the most likely parametric norm.

## Electrical Characteristics SM74601-4.1 (V<sub>OUT</sub> = 4.096V)

Limits in standard type are for T<sub>J</sub> = 25°C only, and limits in **boldface type** apply over the junction temperature (T<sub>J</sub>) range of -40°C to +125°C unless otherwise specified. Minimum and Maximum limits are ensured through test, design, or statistical correlation. Typical values represent the most likely parametric norm at T<sub>J</sub> = 25°C, and are provided for reference purposes only. Unless otherwise specified V<sub>IN</sub> = 5V and I<sub>LOAD</sub> = 0A.

Symbol	Parameter	Conditions	Min (1)	Typ (2)	Max (1)	Unit
V <sub>REF</sub>	Output Voltage Initial Accuracy					
TCV <sub>REF</sub> /°C (Note 6)	Temperature Coefficient				100	ppm/°C
I <sub>Q</sub>	Supply Current			60	<b>100</b>	μA
I <sub>Q_SD</sub>	Supply Current in Shutdown	EN = 0V		3	<b>7</b>	μA
ΔV <sub>REF</sub> /ΔV <sub>IN</sub>	Line Regulation	V <sub>REF</sub> + 400 mV ≤ V <sub>IN</sub> ≤ 5.5V		100		ppm / V
ΔV <sub>REF</sub> /ΔI <sub>LOAD</sub>	Load Regulation	0 mA ≤ I <sub>LOAD</sub> ≤ 20 mA		25	<b>120</b>	ppm / mA
ΔV <sub>REF</sub>	Long Term Stability (Note 7)	1000 Hrs		50		ppm
	Thermal Hysteresis (Note 8)	-40°C ≤ T <sub>J</sub> ≤ +125°C		75		
V <sub>IN</sub> - V <sub>REF</sub>	Dropout Voltage (Note 9)	I <sub>LOAD</sub> = 10 mA		175	<b>400</b>	mV
V <sub>N</sub>	Output Noise Voltage	0.1 Hz to 10 Hz		350		μV <sub>PP</sub>
I <sub>SC</sub>	Short Circuit Current				<b>75</b>	mA
V <sub>IL</sub>	Enable Pin Maximum Low Input Level				<b>35</b>	%V
V <sub>IH</sub>	Enable Pin Minimum High Input Level		<b>65</b>			%V

- (1) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control.
- (2) Typical numbers are at 25°C and represent the most likely parametric norm.

### Typical Performance Characteristics for 2.5V

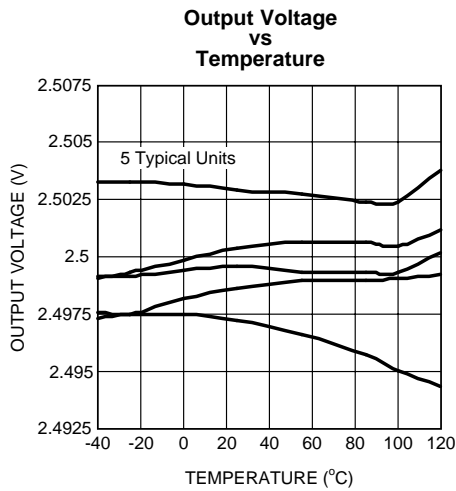


Figure 2.

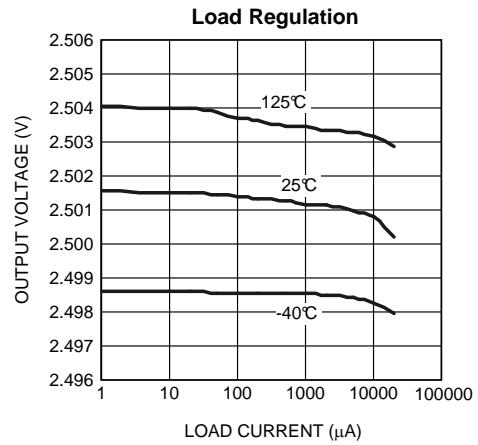


Figure 3.

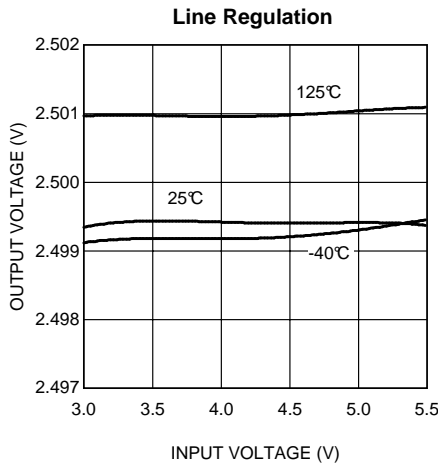


Figure 4.

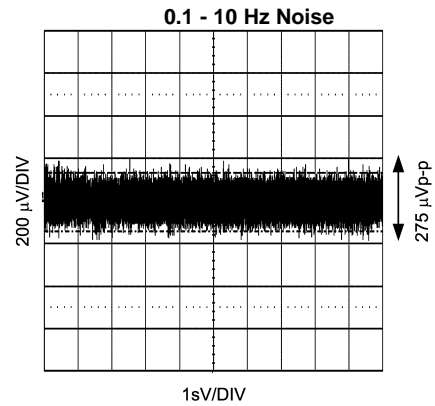


Figure 5.

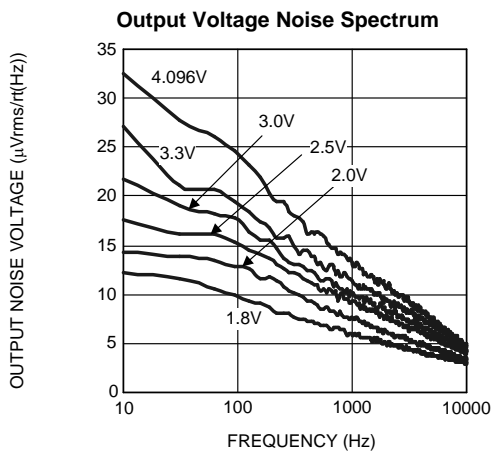


Figure 6.

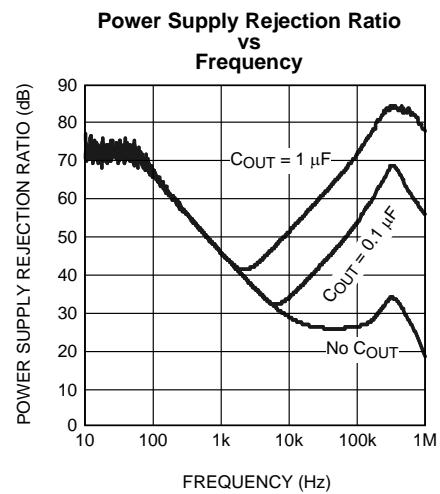


Figure 7.

Typical Performance Characteristics for 2.5V (continued)

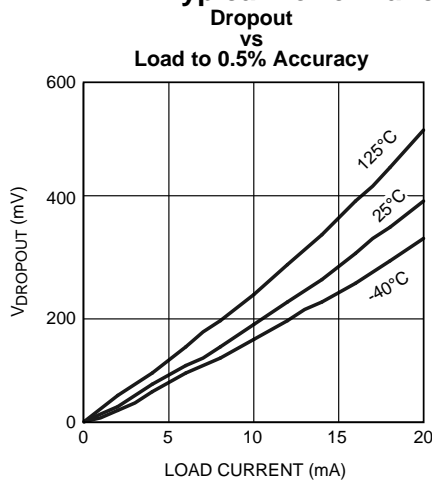


Figure 8.

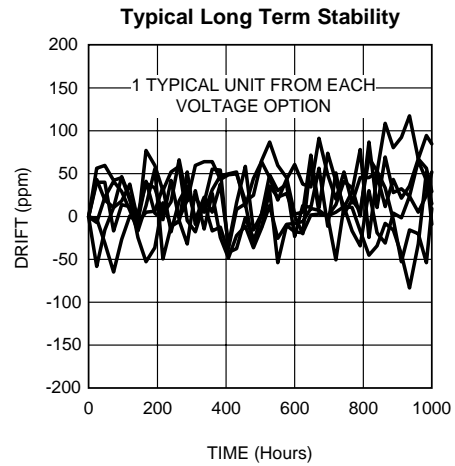


Figure 9.

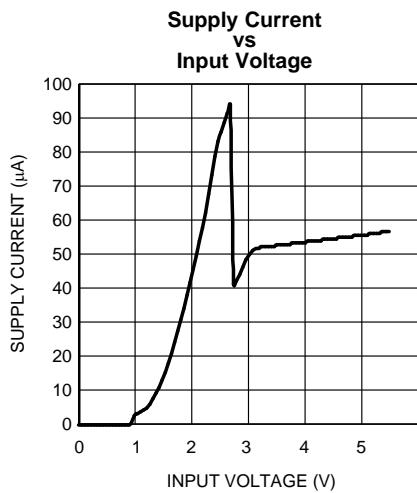


Figure 10.

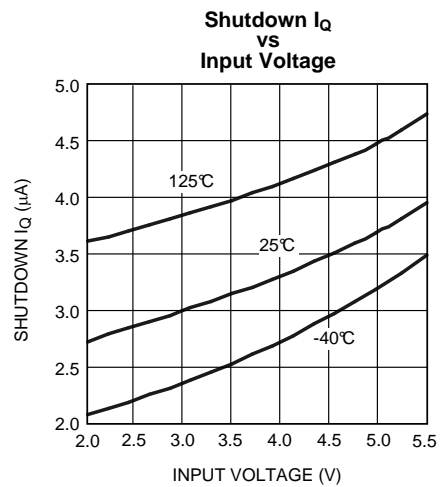


Figure 11.

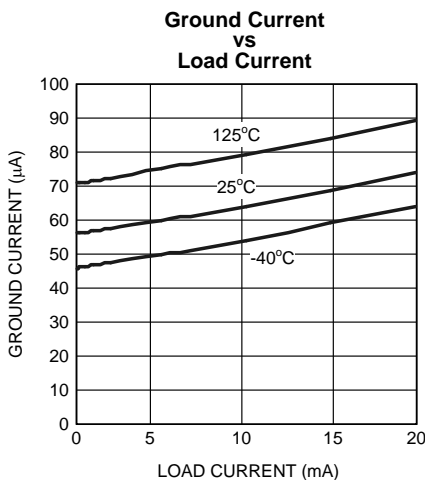


Figure 12.

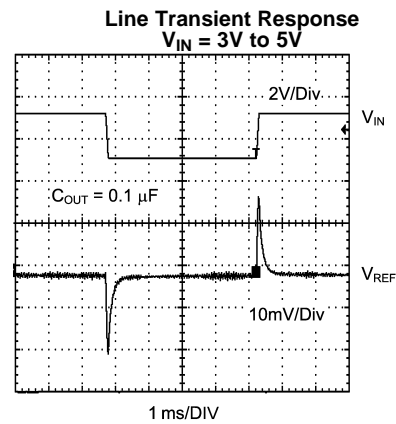


Figure 13.

**Typical Performance Characteristics for 2.5V (continued)**

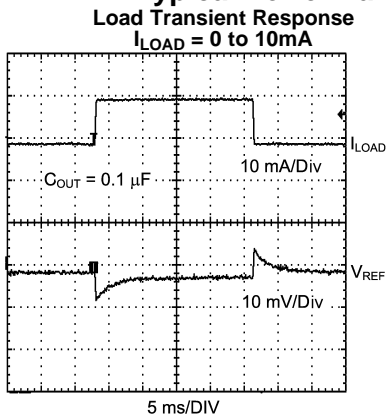


Figure 14.

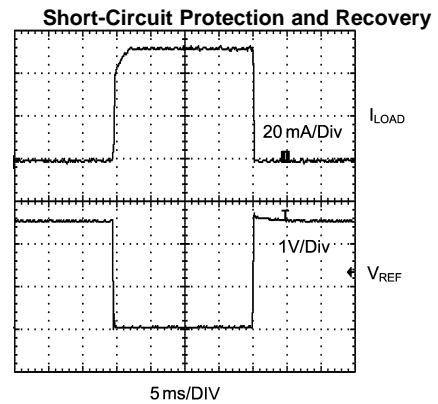


Figure 15.

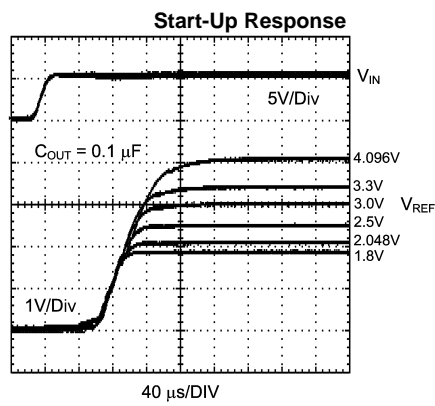


Figure 16.



## APPLICATION INFORMATION

### THEORY OF OPERATION

The foundation of any voltage reference is the band-gap circuit. While the reference in the SM74601 is developed from the gate-source voltage of transistors in the IC, principles of the band-gap circuit are easily understood using a bipolar example. For a detailed analysis of the bipolar band-gap circuit, please refer to Application Note AN-56 [SNVA514](#).

### SUPPLY AND ENABLE VOLTAGES

To ensure proper operation,  $V_{EN}$  and  $V_{IN}$  must be within a specified range. An acceptable range of input voltages is

$$V_{IN} > V_{REF} + 400 \text{ mV} \quad (I_{LOAD} \leq 10 \text{ mA}) \quad (1)$$

The enable pin uses an internal pull-up current source ( $I_{PULL\_UP} \approx 2 \mu\text{A}$ ) that may be left floating or triggered by an external source. If the part is not enabled by an external source, it may be connected to  $V_{IN}$ . An acceptable range of enable voltages is given by the enable transfer characteristics. See the Electrical Characteristics section and Enable Transfer Characteristics figure for more detail. Note, the part will not operate correctly for  $V_{EN} > V_{IN}$ .

### COMPONENT SELECTION

A small ceramic (X5R or X7R) capacitor on the input must be used to ensure stable operation. The value of  $C_{IN}$  must be sized according to the output capacitor value. The value of  $C_{IN}$  must satisfy the relationship  $C_{IN} \geq C_{OUT}$ . When no output capacitor is used,  $C_{IN}$  must have a minimum value of 0.1  $\mu\text{F}$ . Noise on the power-supply input may affect the output noise. Larger input capacitor values (typically 4.7  $\mu\text{F}$  to 22  $\mu\text{F}$ ) may help reduce noise on the output and significantly reduce overshoot during startup. Use of an additional optional bypass capacitor between the input and ground may help further reduce noise on the output. With an input capacitor, the SM74601 will drive any combination of resistance and capacitance up to  $V_{REF}/20 \text{ mA}$  and 10  $\mu\text{F}$  respectively.

The SM74601 is designed to operate with or without an output capacitor and is stable with capacitive loads up to 10  $\mu\text{F}$ . Connecting a capacitor between the output and ground will significantly improve the load transient response when switching from a light load to a heavy load. The output capacitor should not be made arbitrarily large because it will effect the turn-on time as well as line and load transients.

While a variety of capacitor chemistry types may be used, it is typically advisable to use low esr ceramic capacitors. Such capacitors provide a low impedance to high frequency signals, effectively bypassing them to ground. Bypass capacitors should be mounted close to the part. Mounting bypass capacitors close to the part will help reduce the parasitic trace components thereby improving performance.

### SHORT CIRCUITED OUTPUT

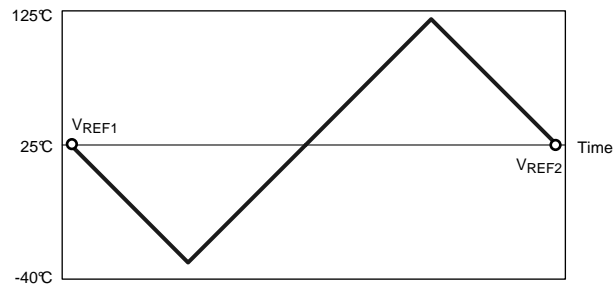
The SM74601 features indefinite short circuit protection. This protection limits the output current to 75 mA when the output is shorted to ground.

### TURN ON TIME

Turn on time is defined as the time taken for the output voltage to rise to 90% of the preset value. The turn on time depends on the load. The turn on time is typically 33.2  $\mu\text{s}$  when driving a 1  $\mu\text{F}$  load and 78.8  $\mu\text{s}$  when driving a 10  $\mu\text{F}$  load. Some users may experience an extended turn on time (up to 10 ms) under brown out conditions and low temperatures (-40°C).

### THERMAL HYSTERESIS

Thermal hysteresis is defined as the change in output voltage at 25°C after some deviation from 25°C. This is to say that thermal hysteresis is the difference in output voltage between two points in a given temperature profile. An illustrative temperature profile is shown in [Figure 17](#).



**Figure 17. Illustrative Temperature Profile**

This may be expressed analytically as the following:

$$V_{HYS} = \frac{|V_{REF1} - V_{REF2}|}{V_{REF}} \times 10^3 \text{ mV}$$

where

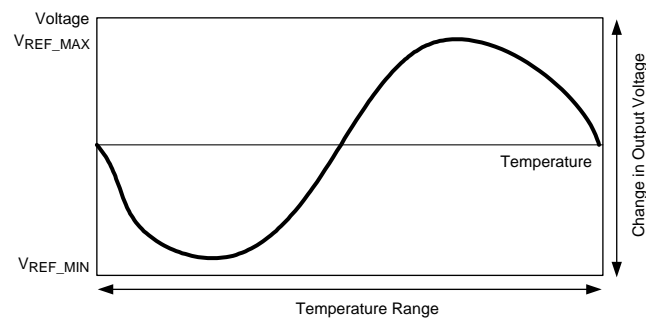
- $V_{HYS}$  = Thermal hysteresis expressed in ppm
- $V_{REF}$  = Nominal preset output voltage
- $V_{REF1} = V_{REF}$  before temperature fluctuation
- $V_{REF2} = V_{REF}$  after temperature fluctuation.

(2)

The SM74601 features a low thermal hysteresis of 190  $\mu\text{V}$  from  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

## TEMPERATURE COEFFICIENT

Temperature drift is defined as the maximum deviation in output voltage over the operating temperature range. This deviation over temperature may be illustrated as shown in [Figure 18](#).



**Figure 18. Illustrative Temperature Coefficient Profile**

Temperature coefficient may be expressed analytically as the following:

$$T_D = \frac{(V_{REF\_MAX} - V_{REF\_MIN})}{V_{REF} \times \Delta T} \times 10^6 \text{ ppm}$$

- $T_D$  = Temperature drift
- $V_{REF}$  = Nominal preset output voltage
- $V_{REF\_MIN}$  = Minimum output voltage over operating temperature range
- $V_{REF\_MAX}$  = Maximum output voltage over operating temperature range
- $\Delta T$  = Operating temperature range.

(3)

The SM74601 features a low temperature drift of 100 ppm (max), from  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

## LONG TERM STABILITY

Long-term stability refers to the fluctuation in output voltage over a long period of time (1000 hours). The SM74601 features a typical long-term stability of 50 ppm over 1000 hours. The measurements are made using 5 units of each voltage option, at a nominal input voltage (5V), with no load, at room temperature.

## EXPRESSION OF ELECTRICAL CHARACTERISTICS

Electrical characteristics are typically expressed in mV, ppm, or a percentage of the nominal value. Depending on the application, one expression may be more useful than the other. To convert one quantity to the other one may apply the following:

ppm to mV error in output voltage:

$$\frac{V_{REF} \times \text{ppm}_{ERROR}}{10^3} = V_{ERROR}$$

where

- $V_{REF}$  is in volts (V)
- $V_{ERROR}$  is in milli-volts (mV).

(4)

Bit error (1 bit) to voltage error (mV):

$$\frac{V_{REF}}{2^n} \times 10^3 = V_{ERROR}$$

- $V_{REF}$  is in volts (V)
- $V_{ERROR}$  is in milli-volts (mV)
- n is the number of bits

(5)

mV to ppm error in output voltage:

$$\frac{V_{ERROR}}{V_{REF}} \times 10^3 = \text{ppm}_{ERROR}$$

where

- $V_{REF}$  is in volts (V)
- $V_{ERROR}$  is in milli-volts (mV)

(6)

Voltage error (mV) to percentage error (percent):

$$\frac{V_{ERROR}}{V_{REF}} \times 0.1 = \text{Percent\_Error}$$

where

- $V_{REF}$  is in volts (V)
- $V_{ERROR}$  is in milli-volts (mV)

(7)

## PRINTED CIRCUIT BOARD and LAYOUT CONSIDERATIONS

To minimize the mechanical stress due to PC board mounting that can cause the output voltage to shift from its initial value, mount the reference on a low flex area of the PC board, such as near the edge or a corner.

The part may be isolated mechanically by cutting a U shape slot on the PCB for mounting the device. This approach also provides some thermal isolation from the rest of the circuit.

Bypass capacitors must be mounted close to the part. Mounting bypass capacitors close to the part will reduce the parasitic trace components thereby improving performance.

Typical Application Circuits

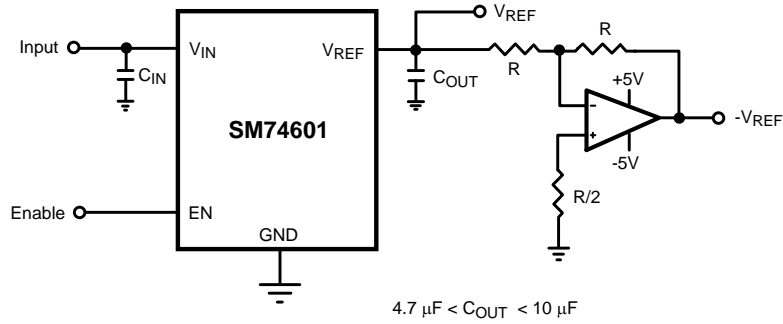


Figure 19. Voltage Reference with Complimentary Output

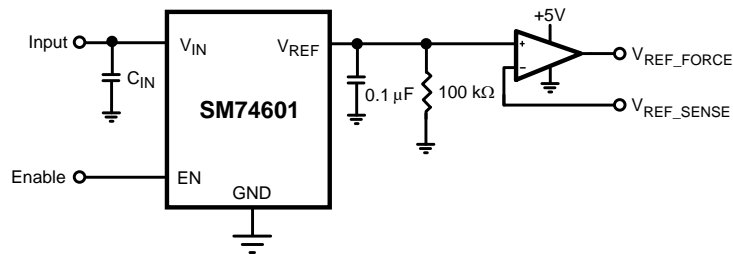


Figure 20. Precision Voltage Reference with Force and Sense Output

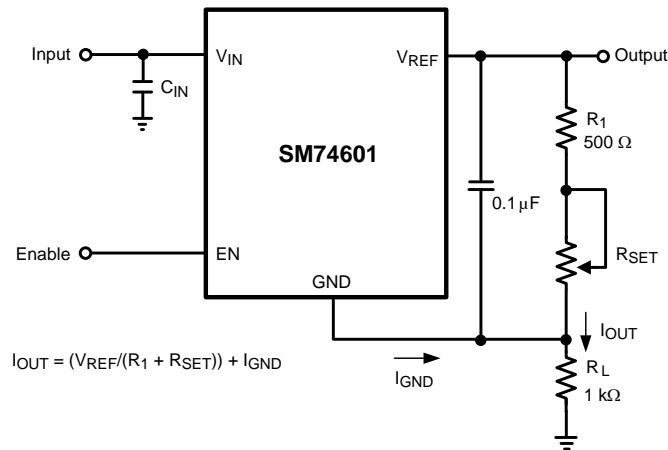


Figure 21. Programmable Current Source

---

**REVISION HISTORY**

<b>Changes from Original (April 2013) to Revision A</b>	<b>Page</b>
• Changed layout of National Data Sheet to TI format .....	<a href="#">12</a>

---

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)