Micropower Series Reference in SOT-23

FEATURES

- **3-Lead SOT-23 Package**
- **Low Drift: 20ppm/°C Max**
- **High Accuracy: 0.2% Max**
- Low Supply Current: 130µA Max
- 20mA Output Current Guaranteed
- Stable with Any Capacitive Load
- Reverse-Battery Protection
- Low PC Board Solder Stress: 0.02% Typ

APPLICATIONS

- Handheld Instruments
- Precision Regulators
- A/D and D/A Converters
- Power Supplies
- Hard Disk Drives

DESCRIPTION

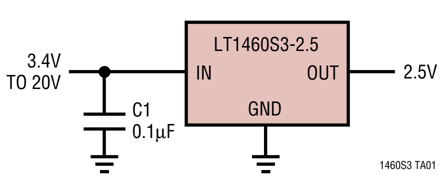
The LT®1460S3-2.5 is a SOT-23 micropower series reference that combines high accuracy and low drift with low power dissipation and small package size. This series reference uses curvature compensation to obtain low temperature coefficient, and laser trimmed precision thin-film resistors to achieve high output accuracy. Furthermore, output shift due to PC board soldering stress has been dramatically reduced. The reference will supply up to 20mA, making it ideal for precision regulator applications, yet it is almost totally immune to input voltage variations.

This series reference provides supply current and power dissipation advantages over shunt references that must idle the entire load current to operate. Additionally, the LT1460S3-2.5 does not require an output compensation capacitor, but is stable with any capacitive load. This feature is important in critical applications where PC board space is a premium or fast settling is demanded. Reverse-battery protection keeps the reference from conducting current.

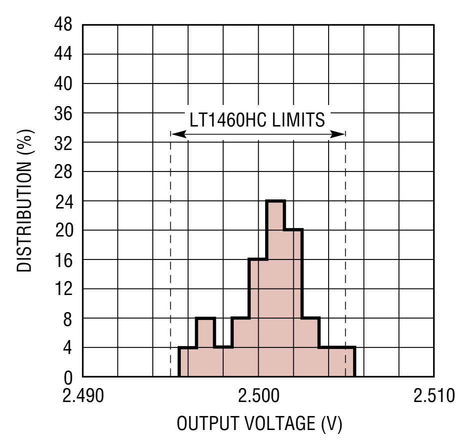
For even tighter tolerance and lower temperature coefficient, the LT1460 is also available in the 8-lead MSOP, SO, PDIP and the 3-lead TO-92 packages.

TYPICAL APPLICATION

Basic Connection



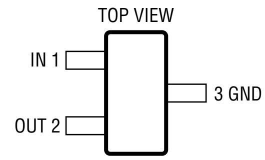
Typical Distribution of SOT-23 LT1460HC V_{OUT} *After* IR Reflow Solder per JEDEC JESD22-A112



ABSOLUTE MAXIMUM RATINGS

Input Voltage 30V
Reverse Voltage .... –15V
Output Short-Circuit Duration, T_A = 25°C
  V_{IN} > 10V .... 5 sec
  V_{IN} ≤ 10V .... Indefinite
Specified Temperature Range .... 0°C to 70°C
Storage Temperature Range (Note 1) ... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PACKAGE/ORDER INFORMATION



S3 PACKAGE
3-LEAD PLASTIC SOT-23
T_{JMAX} = 125°C, θ_{JA} = 325°C/W

ORDER PART NUMBER	S3 PART MARKING
LT1460HCS3-2.5	LTAC
LT1460JCS3-2.5	LTAD
LT1460KCS3-2.5	LTAE

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS

V_{IN} = V_{OUT} + 2.5V, I_{OUT} = 0, T_A = 25°C unless otherwise specified.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage (Note 2)	LT1460HCS3		2.495 –0.2	2.500	2.505 0.2	V %
	LT1460JCS3		2.490 –0.4	2.500	2.510 0.4	V %
	LT1460KCS3		2.4875 –0.5	2.500	2.5125 0.5	V %
Output Voltage Temperature Coefficient (Note 3)	T_{MIN} ≤ T_J ≤ T_{MAX} LT1460HCS3 LT1460JCS3 LT1460KCS3	 ● ● ●		 10 10 25	 20 20 50	 ppm/°C ppm/°C ppm/°C
Line Regulation	3.4V ≤ V_{IN} ≤ 5V	 ●		150	800 1000	ppm/V ppm/V
	5V ≤ V_{IN} ≤ 20V	 ●		50	100 130	ppm/V ppm/V
Load Regulation Sourcing (Note 4)	I_{OUT} = 100µA	 ●		4300	6000 8000	ppm/mA ppm/mA
	I_{OUT} = 10mA	 ●		280	400 500	ppm/mA ppm/mA
	I_{OUT} = 20mA 0°C ≤ T_A ≤ 70°C	 ●		220	300 380	ppm/mA ppm/mA
Thermal Regulation (Note 5)	ΔP = 200mW			2.5	10	ppm/mW
Dropout Voltage (Note 6)	V_{IN} – V_{OUT}, ΔV_{OUT} ≤ 0.2%, I_{OUT} = 0	●			0.9	V
	V_{IN} – V_{OUT}, ΔV_{OUT} ≤ 0.2%, I_{OUT} = 10mA	 ●			1.3 1.4	V V
Output Current	Short V_{OUT} to GND			40		mA
Reverse Leakage	V_{IN} = –15V	●		0.5	10	µA

ELECTRICAL CHARACTERISTICS

$V_{IN} = V_{OUT} + 2.5V$, $I_{OUT} = 0$, $T_A = 25°C$ unless otherwise specified.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Current				100	130	μA
		●			165	μA
Output Voltage Noise (Note 7)	0.1Hz ≤ f ≤ 10Hz			10		$μV_{P-P}$
	10Hz ≤ f ≤ 1kHz			10		$μV_{RMS}$
Long-Term Stability of Output Voltage (Note 8)				70		ppm/√kHr
Hysteresis (Note 9)	ΔT = 0°C to 70°C			100		ppm

The ● denotes specifications which apply over the full specified temperature range.

Note 1: If the part is stored outside of the specified temperature range, the output may shift due to hysteresis.

Note 2: ESD (Electrostatic Discharge) sensitive device. Extensive use of ESD protection devices are used internal to the LT1460S3-2.5, however, high electrostatic discharge can damage or degrade the device. Use proper ESD handling precautions.

Note 3: Temperature coefficient is measured by dividing the change in output voltage by the specified temperature range. Incremental slope is also measured at 25°C.

Note 4: Load regulation is measured on a pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.

Note 5: Thermal regulation is caused by die temperature gradients created by load current or input voltage changes. This effect must be added to normal line or load regulation. This parameter is not 100% tested.

Note 6: Excludes load regulation errors.

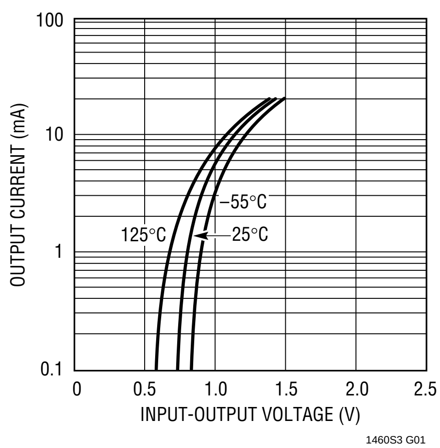
Note 7: Peak-to-peak noise is measured with a single highpass filter at 0.1Hz and 2-pole lowpass filter at 10Hz. The unit is enclosed in a still-air environment to eliminate thermocouple effects on the leads. The test time is 10 sec. RMS noise is measured with a single highpass filter at 10Hz and a 2-pole lowpass filter at 1kHz. The resulting output is full wave rectified and then integrated for a fixed period, making the final reading an average as opposed to RMS. A correction factor of 1.1 is used to convert from average to RMS and a second correction of 0.88 is used to correct for the nonideal bandpass of the filters.

Note 8: Long-term stability typically has a logarithmic characteristic and therefore, changes after 1000 hours tend to be much smaller than before that time. Total drift in the second thousand hours is normally less than one third that of the first thousand hours with a continuing trend toward reduced drift with time. Significant improvement in long-term drift can be realized by preconditioning the IC with a 100 hour to 200 hour, 125°C burn-in. Long-term stability will also be effected by differential stresses between the IC and the board material created during board assembly.

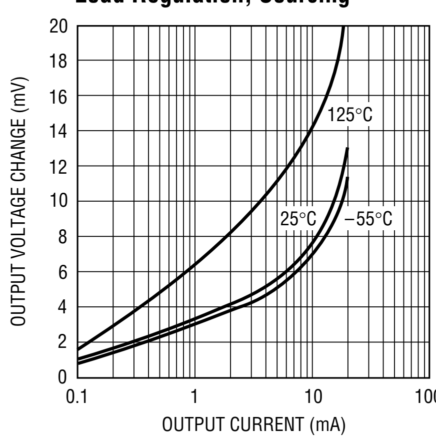
Note 9: Hysteresis in output voltage is created by package stress that differs depending on whether the IC was previously at a higher or lower temperature. Output voltage is always measured at 25°C, but the IC is cycled to 70°C or 0°C before successive measurements. Hysteresis is roughly proportional to the square of the temperature change. Hysteresis is not normally a problem for operational temperature excursions where the instrument might be stored at high or low temperature.

TYPICAL PERFORMANCE CHARACTERISTICS

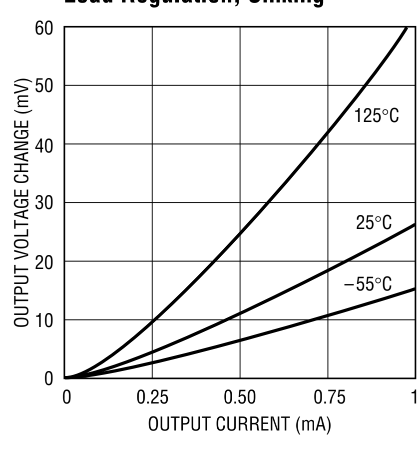
Minimum Input-Output Voltage Differential



Load Regulation, Sourcing

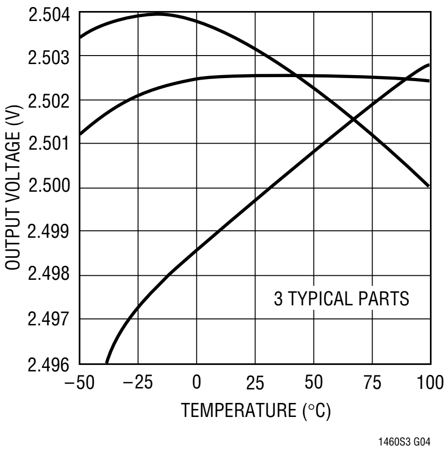


Load Regulation, Sinking

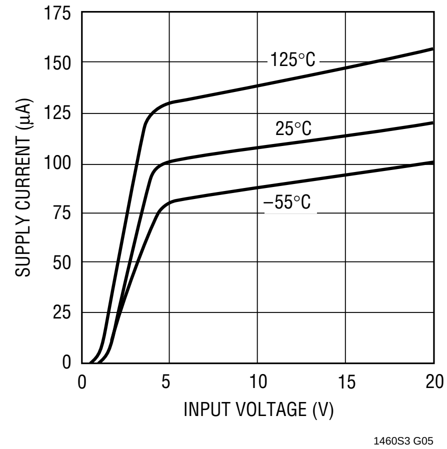


TYPICAL PERFORMANCE CHARACTERISTICS

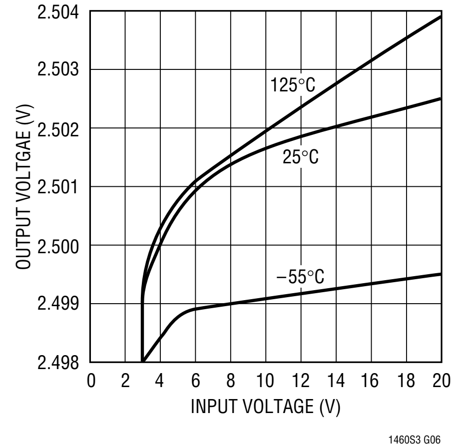
Output Voltage Temperature Drift



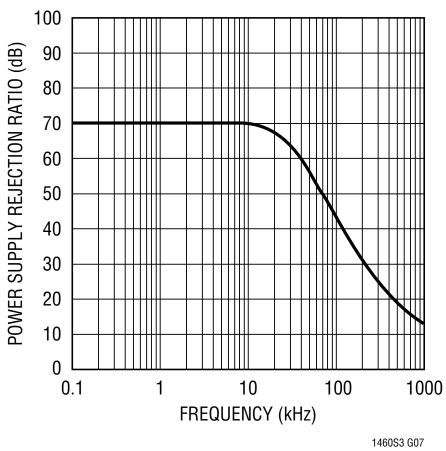
Supply Current vs Input Voltage



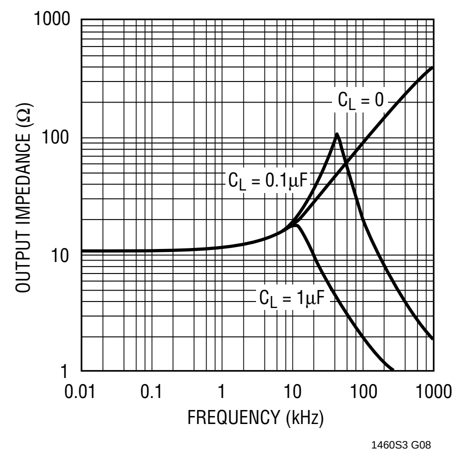
Line Regulation



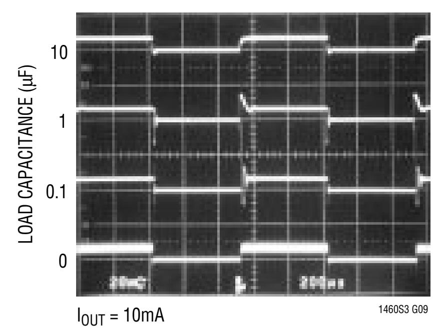
Power Supply Rejection Ratio vs Frequency



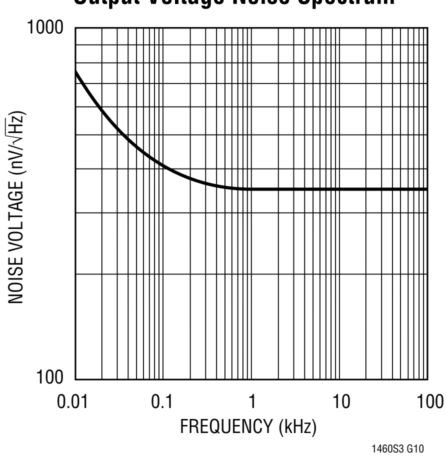
Output Impedance vs Frequency



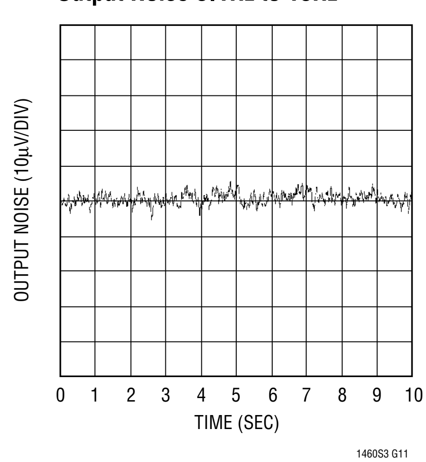
Transient Response



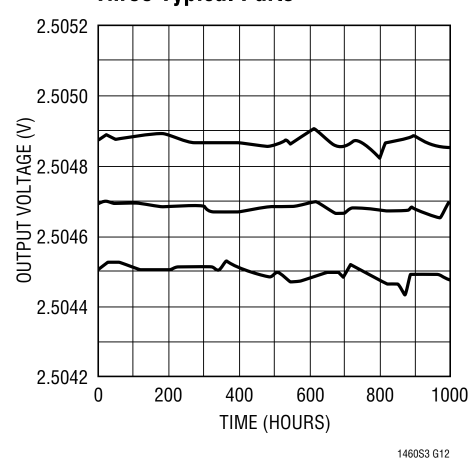
Output Voltage Noise Spectrum



Output Noise 0.1Hz to 10Hz



Long-Term Drift— Three Typical Parts



APPLICATIONS INFORMATION

Longer Battery Life

Series references have a large advantage over older shunt style references. Shunt references require a resistor from the power supply to operate. This resistor must be chosen to supply the maximum current that can ever be demanded by the circuit being regulated. When the circuit being controlled is not operating at this maximum current, the shunt reference must always sink this current, resulting in high dissipation and short battery life.

The LT1460S3-2.5 series reference does not require a current setting resistor and can operate with any supply voltage from V_{OUT} + 0.9V to 20V. When the circuitry being regulated does not demand current, the LT1460S3-2.5 reduces its dissipation and battery life is extended. If the reference is not delivering load current it dissipates only 500µW on a 5V supply, yet the same connection can deliver 20mA of load current when demanded.

Capacitive Loads

The LT1460S3-2.5 is designed to be stable with any capacitive load. With no capacitive load, the reference is ideal for fast settling or applications where PC board space is a premium. The test circuit shown in Figure 1 is used to measure the response time for various load currents and load capacitors. The 1V step from 2.5V to 1.5V produces a current step of 1mA or 100µA for R_L = 1k or R_L = 10k. Figure 2 shows the response of the reference with no load capacitance.

The reference settles to 5mV (0.2%) in 1µs for a 100µA pulse and to 0.2% in 2µs with a 1mA step. When load capacitance is greater than 0.01µF, the reference has a small amount of ringing due to the pole formed with the output impedance. Figure 3 shows the response of the reference to a 1mA and 100µA load with a 0.01µF load capacitor. Figure 4 shows the response with a 1µF and 10µF load capacitance.

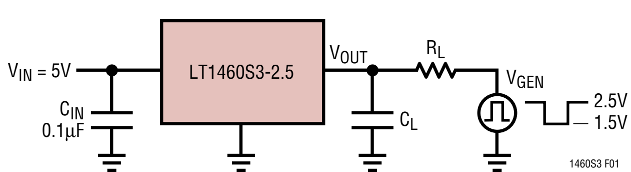


Figure 1. Response Time Test Circuit

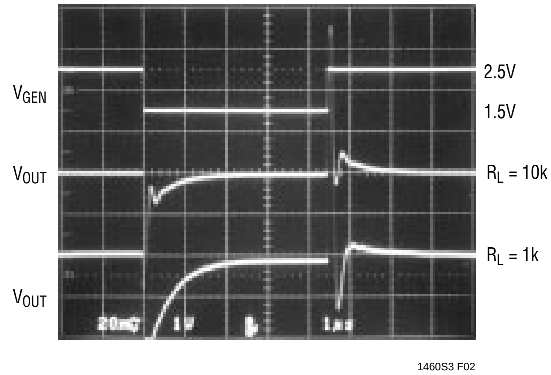


Figure 2. C_L = 0

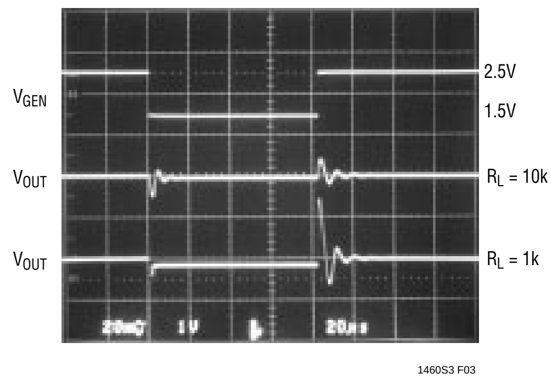


Figure 3. C_L = 0.01µF

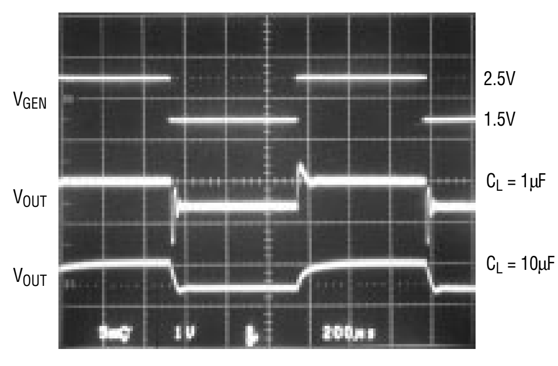


Figure 4. I_{OUT} = 1mA

APPLICATIONS INFORMATION

Fast Turn-On

It is recommended to add a 0.1µF or larger bypass capacitor to the input pin of the LT1460S3-2.5. Although this can help stability with large load currents, the main reason is for proper start-up. The LT1460S3-2.5 can start in 2µs, but it is important to limit the dv/dt of the input. Under light load conditions and with a very fast input, internal nodes overslew and this requires finite recovery time. Figure 5 shows the result of no bypass capacitance on the input and no output load. In this case the supply dv/dt is 5V in 30ns which causes internal overslew, and the output does not bias to 2.5V until 500µs. Figure 6 shows the effect of a 0.1µF bypass capacitor which limits the input dv/dt to approximately 5V in 2µs and the output settles quickly.

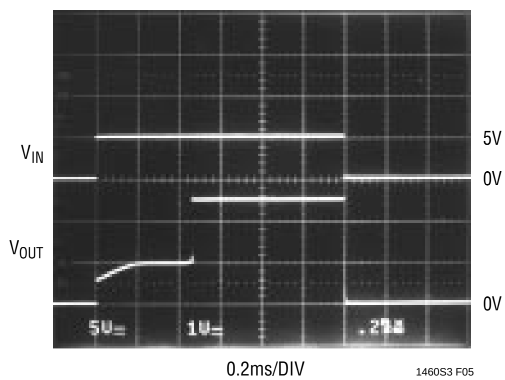


Figure 5. C_{BYPASS} = 0

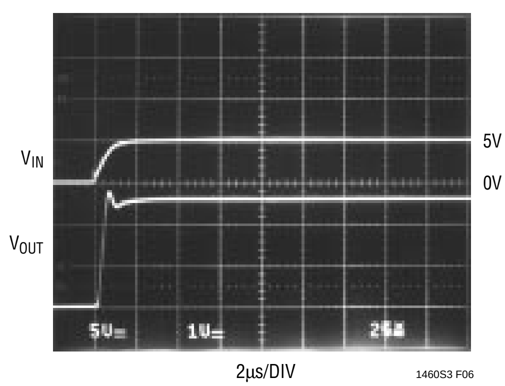


Figure 6. C_{BYPASS} = 0.1µF

Output Accuracy

Like all references, either series or shunt, the error budget of the LT1460S3-2.5 is made up of primarily three components: initial accuracy, temperature coefficient and load regulation. Line regulation is neglected because it typically contributes only 150ppm/V, or 150µV for a 1V input change. The LT1460S3-2.5 typically shifts 0.02% when soldered into a PCB, so this is also neglected. The output errors are calculated as follows for a 100µA load and 0°C to 70°C temperature range:

LT1460HCS3
Initial Accuracy = 0.2%

For I_{OUT} = 100µA
ΔV_{OUT} = (8000ppm/mA)(0.1mA)(2.5V) = 2.0mV
which is 0.08%

For Temperature 0°C to 70°C the maximum ΔT = 70°C
ΔV_{OUT} = (20ppm/°C)(70°C)(2.5V) = 3.5mV
which is 0.14%

Total worst-case output error is:
0.2% + 0.08% + 0.14% = 0.420%

Table 1 gives the worst-case accuracy for LT1460HCS3, LT1460JCS3 and LT1460KCS3 from 0°C to 70°C, and shows that if the LT1460HCS3 is used as a reference instead of a regulator, it is capable of 8 bits of absolute accuracy over temperature without a system calibration.

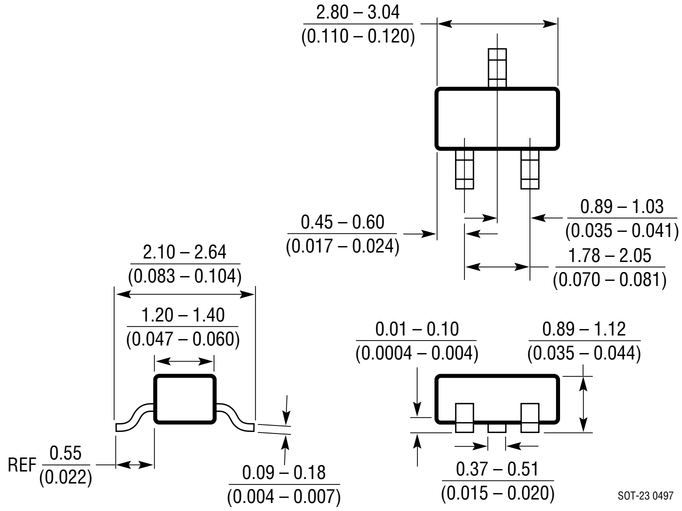
Table 1. Worst-Case Output Accuracy over Temperature

I_{OUT}	LT1460HCS3	LT1460JCS3	LT1460KCS3
0µA	0.340%	0.540%	0.85%
100µA	0.420%	0.620%	0.93%
10mA	0.840%	1.040%	1.35%
20mA	1.100%	1.300%	1.61%

PACKAGE DESCRIPTION

Dimensions in millimeters (inches) unless otherwise noted.

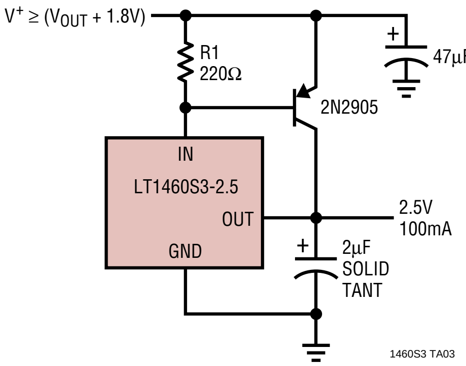
S3 Package
3-Lead Plastic SOT-23
(LTC DWG # 05-08-1631)



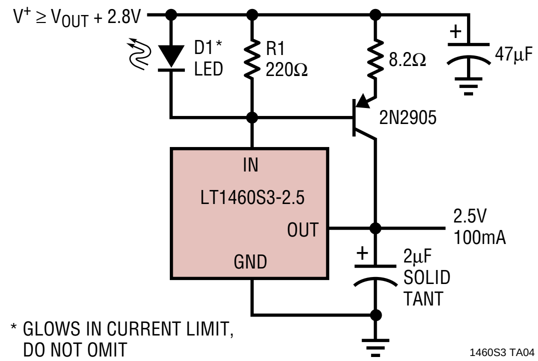
NOTE: GOVERNING DIMENSION IN MILLIMETERS
DIMENSIONS ARE INCLUSIVE OF PLATING
DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
MOLD FLASH SHALL NOT EXCEED 0.254mm

TYPICAL APPLICATIONS

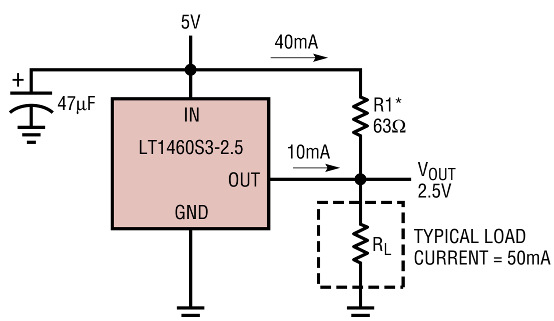
Boosted Output Current with No Current Limit



Boosted Output Current with Current Limit



Handling Higher Load Currents



*SELECT R1 TO DELIVER 80% OF TYPICAL LOAD CURRENT. LT1460 WILL THEN SOURCE AS NECESSARY TO MAINTAIN PROPER OUTPUT. DO NOT REMOVE LOAD AS OUTPUT WILL BE DRIVEN UNREGULATED HIGH. LINE REGULATION IS DEGRADED IN THIS APPLICATION

1460S3 TA05

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1019	Precision Bandgap Reference	0.05% Max, 5ppm/°C Max
LT1027	Precision 5V Reference	0.02%, 2ppm/°C Max
LT1236	Precision Low Noise Reference	0.05% Max, 5ppm/°C Max, SO Package
LT1634	Micropower Precision Shunt Reference 1.25V, 2.5V Output	0.05%, 25ppm/°C Max

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417 • (408) 432-1900
FAX: (408) 434-0507 • TELEX: 499-3977 • www.linear-tech.com

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