National Semiconductor

November 2003

LM4125
Precision Micropower Low Dropout Voltage Reference

General Description

The LM4125 is a precision low power low dropout bandgap voltage reference with up to 5 mA output current source and sink capability.

This series reference operates with input voltages as low as 2V and up to 6V consuming 160 µA (Typ.) supply current. In power down mode, device current drops to less than 2 µA.

The LM4125 comes in two grades (A and Standard) and three voltage options for greater flexibility. The best grade devices (A) have an initial accuracy of 0.2%, while the standard have an initial accuracy of 0.5%, both with a tempco of 50ppm/˚C guaranteed from −40˚C to +125˚C.

The very low dropout voltage, low supply current and power-down capability of the LM4125 makes this product an ideal choice for battery powered and portable applications.

The device performance is guaranteed over the industrial temperature range (−40˚C to +85˚C), while certain specs are guaranteed over the extended temperature range (−40˚C to +125˚C). Please contact National for full specifications over the extended temperature range. The LM4125 is available in a standard 5-pin SOT-23 package.

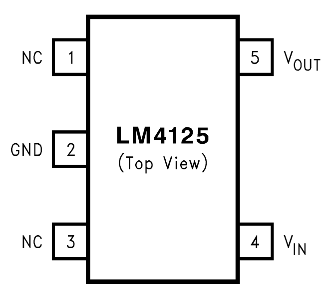
Features

- Small SOT23-5 package
- Low dropout voltage: 120 mV Typ @ 1 mA
- High output voltage accuracy: 0.2%
- Source and Sink current output: ±5 mA
- Supply current: 160 µA Typ.
- Low Temperature Coefficient: 50 ppm/˚C
- Fixed output voltages: 2.048, 2.5,and 4.096
- Industrial temperature Range: −40˚C to +85˚C
- (For extended temperature range, −40˚C to 125˚C, contact National Semiconductor)

Applications

- Portable, battery powered equipment
- Instrumentation and process control
- Automotive & Industrial
- Test equipment
- Data acquisition systems
- Precision regulators
- Battery chargers
- Base stations
- Communications
- Medical equipment

Connection Diagram



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Refer to the Ordering Information Table in this Data Sheet for Specific Part Number

SOT23-5 Surface Mount Package

Ordering Information

Industrial Temperature Range (−40˚C to + 85˚C)

Initial Output Voltage Accuracy at 25˚C And Temperature Coefficient	LM4125 Supplied as 1000 Units, Tape and Reel	LM4125 Supplied as 3000 Units, Tape and Reel	Top Marking
0.2%, 50 ppm/˚C max (A grade)	LM4125AIM5-2.0	LM4125AIM5X-2.0	R80A
	LM4125AIM5-2.5	LM4125AIM5X-2.5	R81A
	LM4125AIM5-4.1	LM4125AIM5X-4.1	R82A
0.5%, 50 ppm/˚C max	LM4125IM5-2.0	LM4125IM5X-2.0	R80B
	LM4125IM5-2.5	LM4125IM5X-2.5	R81B
	LM4125IM5-4.1	LM4125IM5X-4.1	R82B

SOT-23 Package Marking Information

Only four fields of marking are possible on the SOT-23's small surface. This table gives the meaning of the four fields.

Field Information
First Field:
R = Reference
Second and third Field:
80 = 2.048V Voltage Option
81 = 2.500V Voltage Option
82 = 4.096V Voltage Option
Fourth Field:
A-B = Initial Reference Voltage Tolerance
A = ±0.2%
B = ±0.5%

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Maximum Voltage on input or enable pins	−0.3V to 8V
Output Short-Circuit Duration	Indefinite
Power Dissipation (T_A = 25˚C) (Note 2):	
MA05B package – θ_{JA}	280˚C/W
Power Dissipation	350 mW
ESD Susceptibility (Note 3)	
Human Body Model	2 kV
Machine Model	200V
Lead Temperature:	
Soldering, (10 sec.)	+260˚C
Vapor Phase (60 sec.)	+215˚C
Infrared (15 sec.)	+220˚C

Operating Range (Note 1)

Storage Temperature Range	−65˚C to +150˚C
Ambient Temperature Range	−40˚C to +85˚C
Junction Temperature Range	−40˚C to +125˚C

Electrical Characteristics

LM4125-2.048V and 2.5V

Unless otherwise specified V_{IN} = 3.3V, I_{LOAD} = 0, C_{OUT} = 0.01µF, T_A = T_j = 25˚C. Limits with standard typeface are for T_j = 25˚C, and limits in **boldface type** apply over the −40˚C ≤ T_A ≤ +85˚C temperature range.

Symbol	Parameter	Conditions	Min (Note 5)	Typ (Note 4)	Max (Note 5)	Units
V_{OUT}	Output Voltage Initial Accuracy LM4125A-2.048 LM4125A-2.500				±0.2	%
	LM4125-2.048 LM4125-2.500				±0.5	%
TCV_{OUT}/˚C	Temperature Coefficient	−40˚C ≤ T_A ≤ +125˚C		14	50	ppm/˚c
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	3.3V ≤ V_{IN} ≤ 6V		0.0007	0.008 **0.01**	%/V
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load Regulation	0 mA ≤ I_{LOAD} ≤ 1 mA		0.03	0.08 **0.17**	%/mA
		1 mA ≤ I_{LOAD} ≤ 5 mA		0.01	0.04 **0.1**	
		−1 mA ≤ I_{LOAD} ≤ 0 mA		0.04	0.12	
		−5 mA ≤ I_{LOAD} ≤ −1 mA		0.01		
V_{IN}–V_{OUT}	Dropout Voltage (Note 6)	I_{LOAD} = 0 mA		45	65 **100**	mV
		I_{LOAD} = +1 mA		120	150 **200**	
		I_{LOAD} = +5 mA		180	210 **300**	
V_N	Output Noise Voltage (Note 8)	0.1 Hz to 10 Hz		20		μV_{PP}
		10 Hz to 10 kHz		36		μV_{PP}
I_S	Supply Current			160	257 **290**	µA
I_{SC}	Short Circuit Current	V_{IN} = 3.3V, V_{OUT} = 0		15		mA
			6		**30**	
		V_{IN} = 6V, V_{OUT} = 0		17		
			6		**30**	
Hyst	Thermal Hysteresis (Note 7)	−40˚C ≤ T_A ≤ 125˚C		0.5		mV/V

Electrical Characteristics
LM4125-2.048V and 2.5V

Unless otherwise specified V_{IN} = 3.3V, I_{LOAD} = 0, C_{OUT} = 0.01µF, T_A = T_j = 25˚C. Limits with standard typeface are for T_j = 25˚C, and limits in **boldface type** apply over the −40˚C ≤ T_A ≤ +85˚C temperature range. (Continued)

Symbol	Parameter	Conditions	Min (Note 5)	Typ (Note 4)	Max (Note 5)	Units
ΔV_{OUT}	Long Term Stability (Note 9)	1000 hrs. @ 25˚C		100		ppm

Electrical Characteristics
LM4125-4.096V

Unless otherwise specified V_{IN} = 5V, I_{LOAD} = 0, C_{OUT} = 0.01µF, T_A = T_j = 25˚C. Limits with standard typeface are for T_j = 25˚C, and limits in **boldface type** apply over the −40˚C ≤ T_A ≤ +85˚C temperature range.

Symbol	Parameter	Conditions	**Min** (Note 5)	**Typ** (Note 4)	**Max** (Note 5)	Units
V_{OUT}	Output Voltage Initial Accuracy LM4125A-4.096				±0.2	%
	LM4125-4.096				±0.5	%
TCV_{OUT}/˚C	Temperature Coefficient	−40˚C ≤ T_A ≤ +125˚C		14	50	ppm/˚c
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	5V ≤ V_{IN} ≤ 6V		0.0007	0.008 **0.01**	%/V
$\Delta V_{OUT}/\Delta I_{LOAD}$	Load Regulation	0 mA ≤ I_{LOAD} ≤ 1 mA		0.03	0.08 **0.17**	%/mA
		1 mA ≤ I_{LOAD} ≤ 5 mA		0.01	0.04 **0.1**	
		−1 mA ≤ I_{LOAD} ≤ 0 mA		0.04	0.12	
		−5 mA ≤ I_{LOAD} ≤ −1 mA		0.01		
$V_{IN}–V_{OUT}$	Dropout Voltage (Note 6)	I_{LOAD} = 0 mA		45	65 **100**	mV
		I_{LOAD} = +1 mA		120	150 **200**	
		I_{LOAD} = +5 mA		180	210 **300**	
V_N	Output Noise Voltage (Note 8)	0.1 Hz to 10 Hz		20		$µV_{PP}$
		10 Hz to 10 kHz		36		$µV_{PP}$
I_S	Supply Current			160	257 **290**	µA
I_{SC}	Short Circuit Current	V_{OUT} = 0		15		mA
			6		**30**	
		V_{IN} = 6V, V_{OUT} = 0		17		
			6		**30**	
Hyst	Thermal Hysteresis (Note 7)	−40˚C ≤ T_A ≤ 125˚C		0.5		mV/V
ΔV_{OUT}	Long Term Stability (Note 9)	1000 hrs. @ 25˚C		100		ppm

Note 1: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: Without PCB copper enhancements. The maximum power dissipation must be de-rated at elevated temperatures and is limited by T_{JMAX} (maximum junction temperature), θ_{J-A} (junction to ambient thermal resistance) and T_A (ambient temperature). The maximum power dissipation at any temperature is: $PDiss_{MAX} = (T_{JMAX} - T_A)/\theta_{J-A}$ up to the value listed in the Absolute Maximum Ratings.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

Note 4: Typical numbers are at 25˚C and represent the most likely parametric norm.

Note 5: Limits are 100% production tested at 25˚C. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's Averaging Outgoing Quality Level (AOQL).

Note 6: Dropout voltage is the differential voltage between V_{OUT} and V_{IN} at which V_{OUT} changes ≤ 1% from V_{OUT} at V_{IN} = 3.3V for 2.0V, 2.5V and 5V for 4.1V. A parasitic diode exists between input and output pins; it will conduct if V_{OUT} is pulled to a higher voltage than V_{IN}.

Note 7: Thermal hysteresis is defined as the change in +25˚C output voltage before and after exposing the device to temperature extremes.

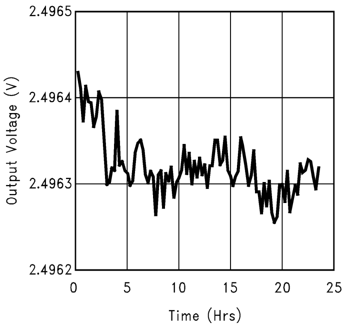
Note 8: Output noise voltage is proportional to V_{OUT}. V_N for other voltage option is calculated using $(V_{N(1.8V)}/1.8) * V_{OUT}$. V_N (2.5V) = $(36µV_{PP}/1.8) * 2.5 = 46µV_{PP}$.

Note 9: Long term stability is change in V_{REF} at 25˚C measured continuously during 1000 hrs.

LM4125 Typical Operating Characteristics

Unless otherwise specified, V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{LOAD} = 0, C_{OUT} = 0.022µF and T_A = 25˚C.

Long Term Drift



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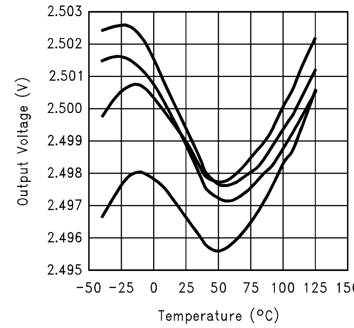
Typical Temperature Drift



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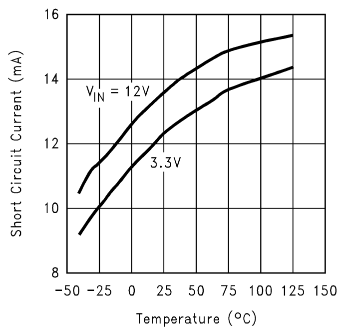
Short Circuit Current vs Temperature



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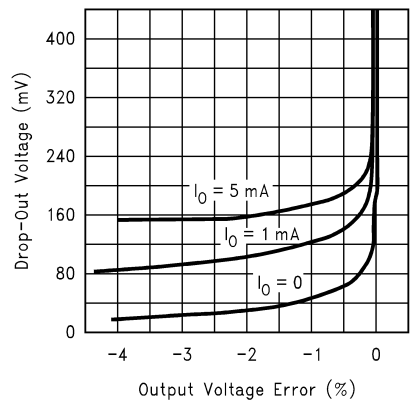
Dropout Voltage vs Output Error



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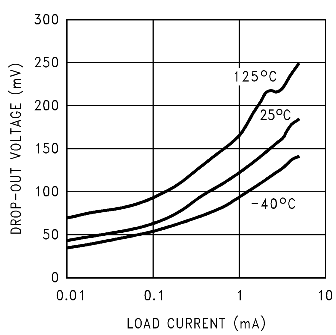
Dropout Voltage vs Load Current



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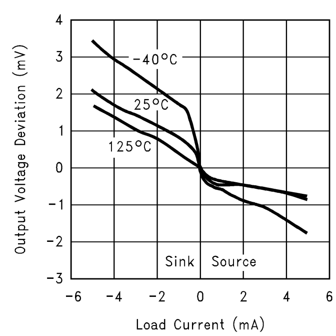
Load Regulation



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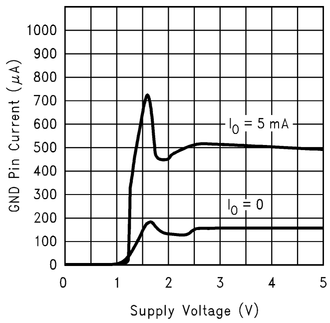
LM4125 Typical Operating Characteristics

Unless otherwise specified, V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{LOAD} = 0, C_{OUT} = 0.022µF and T_A = 25˚C. (Continued)

GND Pin Current



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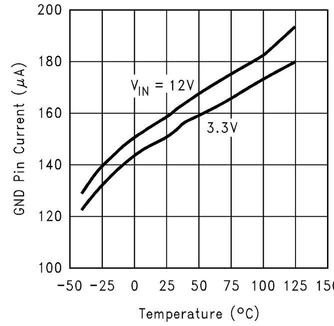
GND Pin Current at No Load vs Temperature



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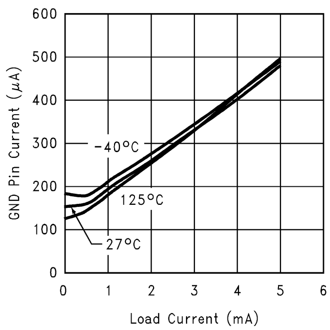
GND Pin Current vs Load



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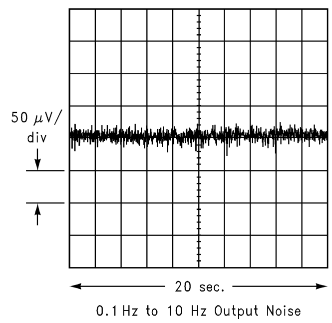
0.1Hz to 10Hz output Noise



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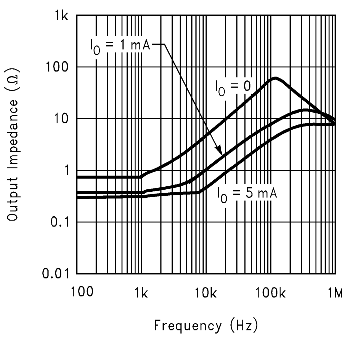
Output Impedance vs Frequency



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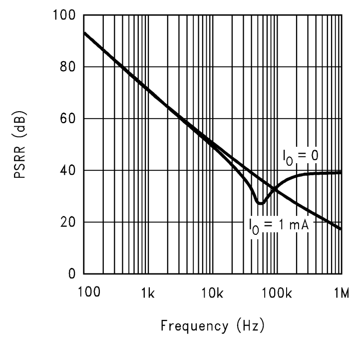
PSRR vs Frequency



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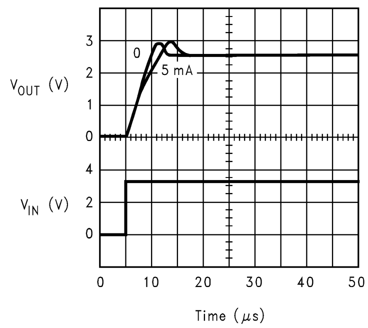
LM4125 Typical Operating Characteristics Unless otherwise specified, V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{LOAD} = 0, C_{OUT} = 0.022µF and T_A = 25˚C. (Continued)

Start-Up Response



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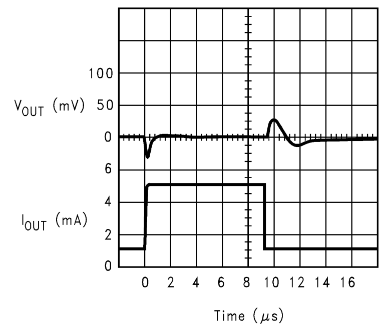
Load Step Response



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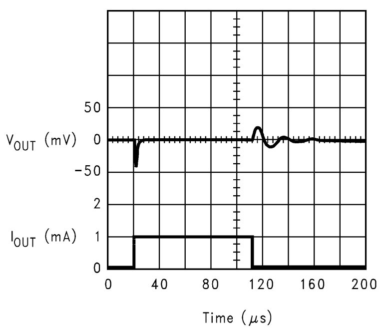
Load Step Response



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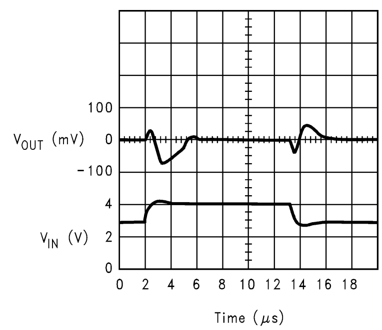
Line Step Response



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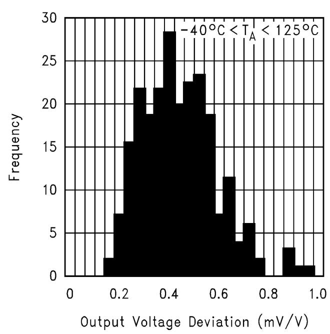
Thermal Hysteresis



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Pin Functions

Output (Pin 5): Reference Output.

Input (Pin 4): Positive Supply.

Ground (Pin 2): Negative Supply or Ground Connection.

Application Hints

The standard application circuit for the LM4125 is shown in *Figure 1*. It is designed to be stable with ceramic output capacitors in the range of 0.022µF to 0.1µF. Note that 0.022µF is the minimum required output capacitor. These capacitors typically have an ESR of about 0.1 to 0.5Ω. Smaller ESR can be tolerated, however larger ESR can not. The output capacitor can be increased to improve load transient response, up to about 1µF. However, values above 0.047µF must be tantalum. With tantalum capacitors, in the 1µF range, a small capacitor between the output and the reference pin is required. This capacitor will typically be in the 50pF range. Care must be taken when using output capacitors of 1µF or larger. These application must be thoroughly tested over temperature, line and load.

An input capacitor is typically not required. However, a 0.1µF ceramic can be used to help prevent line transients from entering the LM4125. Larger input capacitors should be tantalum or aluminium.

The typical thermal hysteresis specification is defined as the change in +25˚C voltage measured after thermal cycling. The device is thermal cycled to temperature -40˚C and then measured at 25˚C. Next the device is thermal cycled to temperature +125˚C and again measured at 25˚C. The resulting V_{OUT} delta shift between the 25˚C measurements is thermal hysteresis. Thermal hysteresis is common in precision references and is induced by thermal-mechanical package stress. Changes in environmental storage temperature, operating temperature and board mounting temperature are all factors that can contribute to thermal hysteresis.

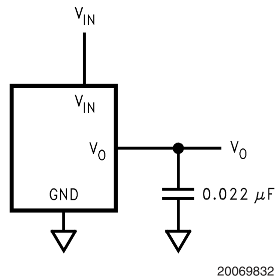


FIGURE 1.

INPUT CAPACITOR

Noise on the power-supply input can effect the output noise, but can be reduced by using an optional bypass capacitor between the input pin and the ground.

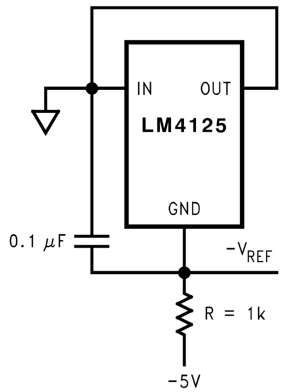
PRINTED CIRCUIT BOARD LAYOUT CONSIDERATION

The mechanical stress due to PC board mounting can cause the output voltage to shift from its initial value. References in SOT packages are generally less prone to assembly stress than devices in Small Outline (SOIC) package.

To reduce the stress-related output voltage shifts, mount the reference on the low flex areas of the PC board such as near to the edge or the corner of the PC board.

Typical Application Circuits

Voltage Reference with Negative Output



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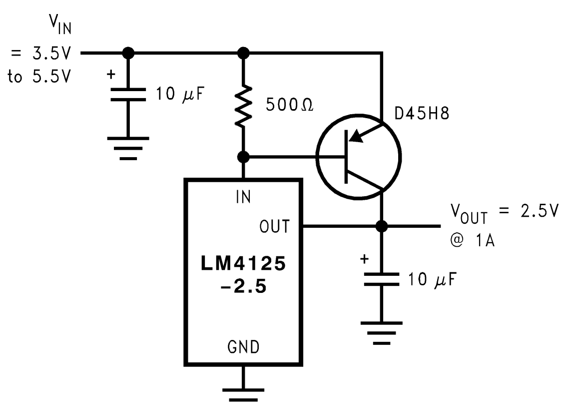
Precision High Current Low Dropout Regulator



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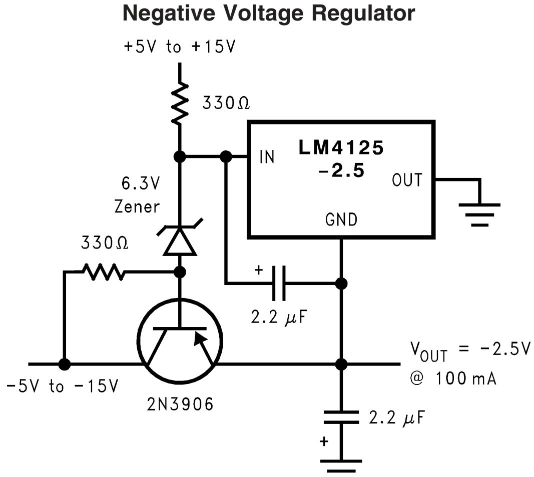
Precision High Current Negative Voltage Regulator



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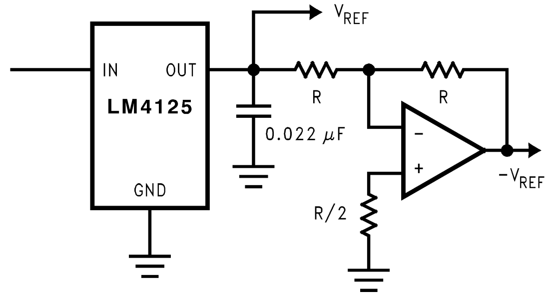
Voltage Reference with Complimentary Output



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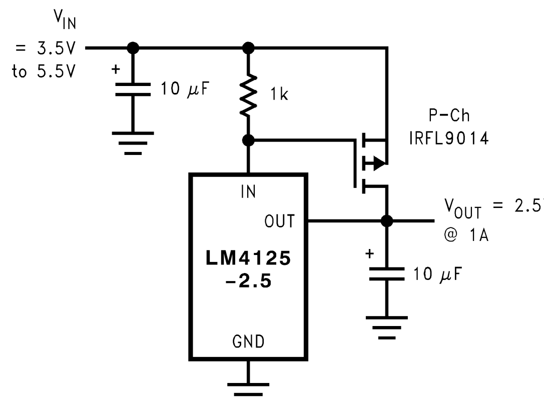
Precision High Current Low Droput Regulator



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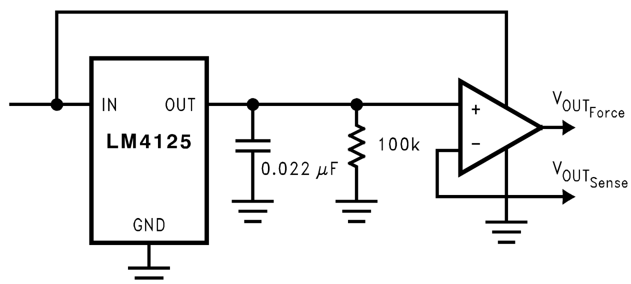
Precision Voltage Reference with Force and Sense Output



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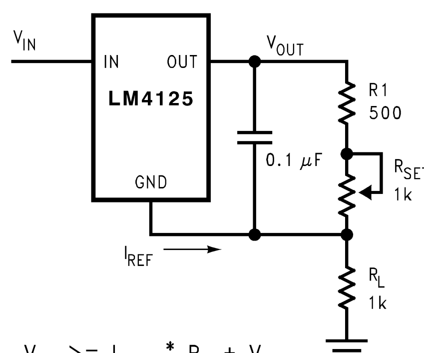
Programmable Current Source



$V_{IN} >= I_{OUT} * R_L + V_{REF}$

$I_{OUT} = (V_{REF}/(R_1 + R_{SET})) + I_{OUT}$

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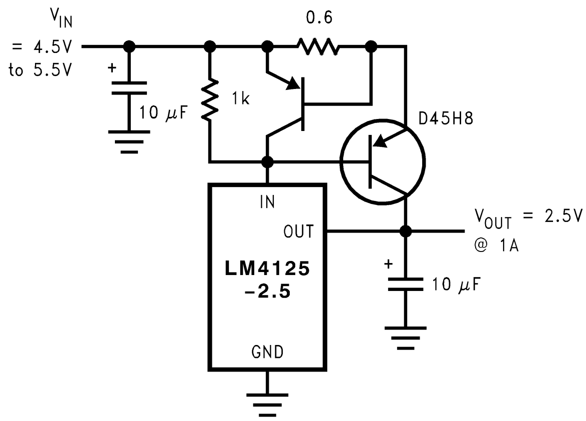
Typical Application Circuits
(Continued)

Precision Regulator with Current Limiting Circuit



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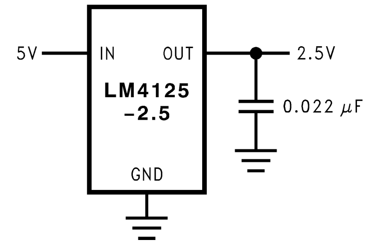
Power Supply Splitter



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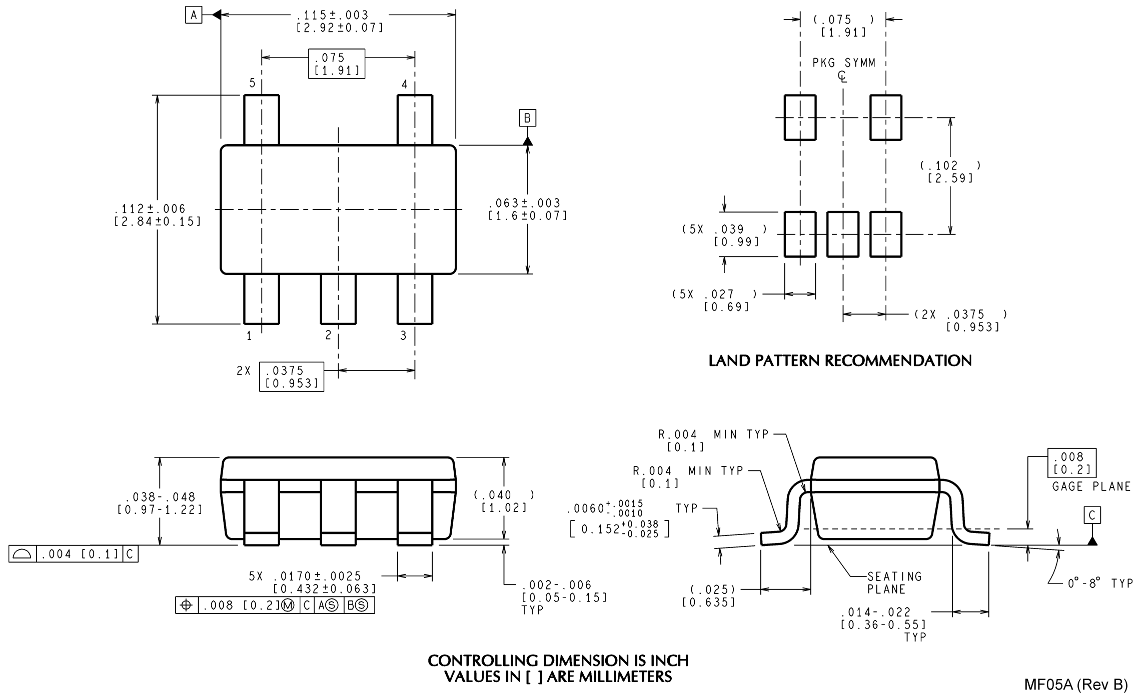
Physical Dimensions inches (millimeters) unless otherwise noted



MF05A (Rev B)

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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