March 2005

LM4120
Precision Micropower Low Dropout Voltage Reference

General Description

The LM4120 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 12V consuming 160 µA (Typ.) supply current. In power down mode, device current drops to less than 2 µA.

The LM4120 comes in two grades (A and Standard) and seven 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 LM4120 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 LM4120 is available in a standard 5-pin SOT-23 package.

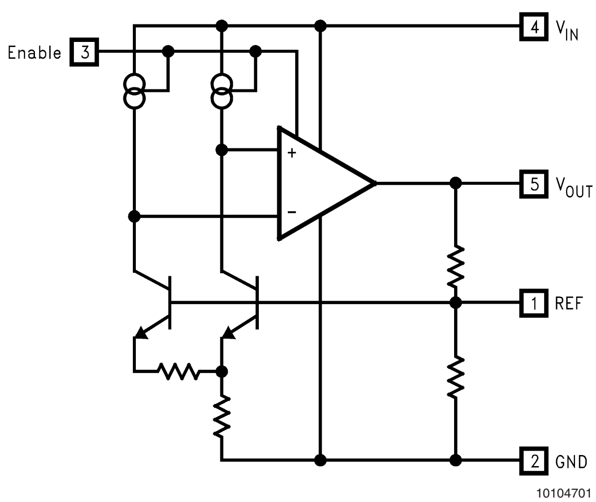
Features

- 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
- Enable pin
- Fixed output voltages: 1.8, 2.048, 2.5, 3.0, 3.3, 4.096 and 5.0V
- Industrial temperature Range: −40˚C to +85˚C
- (For extended temperature range, −40˚C to 125˚C, contact National Semiconductor)

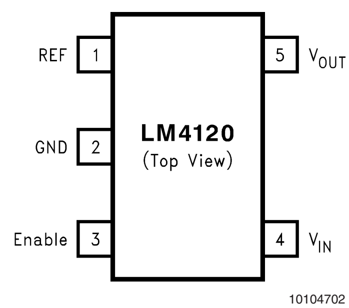
Applications

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

Functional Block Diagram



Connection Diagram



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	LM4120 Supplied as 1000 Units, Tape and Reel	LM4120 Supplied as 3000 Units, Tape and Reel	Top Marking
0.2%, 50 ppm/˚C max (A grade)	LM4120AIM5-1.8	LM4120AIM5X-1.8	R21A
	LM4120AIM5-2.0	LM4120AIM5X-2.0	R14A
	LM4120AIM5-2.5	LM4120AIM5X-2.5	R08A
	LM4120AIM5-3.0	LM4120AIM5X-3.0	R15A
	LM4120AIM5-3.3	LM4120AIM5X-3.3	R16A
	LM4120AIM5-4.1	LM4120AIM5X-4.1	R17A
	LM4120AIM5-5.0	LM4120AIM5X-5.0	R18A
0.5%, 50 ppm/˚C max	LM4120IM5-1.8	LM4120IM5X-1.8	R21B
	LM4120IM5-2.0	LM4120IM5X-2.0	R14B
	LM4120IM5-2.5	LM4120IM5X-2.5	R08B
	LM4120IM5-3.0	LM4120IM5X-3.0	R15B
	LM4120IM5-3.3	LM4120IM5X-3.3	R16B
	LM4120IM5-4.1	LM4120IM5X-4.1	R17B
	LM4120IM5-5.0	LM4120IM5X-5.0	R18B

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:
21 = 1.800V Voltage Option
14 = 2.048V Voltage Option
08 = 2.500V Voltage Option
15 = 3.000V Voltage Option
16 = 3.300V Voltage Option
17 = 4.096V Voltage Option
18 = 5.000V 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 14V
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

LM4120-1.8V, 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 LM4120A-1.800 LM4120A-2.048 LM4120A-2.500				±0.2	%
	LM4120-1.800 LM4120-2.048 LM4120-2.500				±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} ≤ 12V		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 **80**	mV
		I_{LOAD} = +1 mA		120	150 **180**	
		I_{LOAD} = +5 mA		180	210 **250**	
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	250 **275**	µA
I_{SS}	Power-down Supply Current	Enable = 0.4V −40˚C ≤ T_J ≤ +85˚C Enable = 0.2V			1 **2**	µA
V_H	Logic High Input Voltage		**2.4**	2.4		V

Electrical Characteristics

LM4120-1.8V, 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
V_L	Logic Low Input Voltage			0.4	**0.2**	V
I_H	Logic High Input Current			7	**15**	µA
I_L	Logic Low Input Current			0.1		µA
I_{SC}	Short Circuit Current	V_{IN} = 3.3V, V_{OUT} = 0		15		mA
			6		**30**	
		V_{IN} = 12V, 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

Electrical Characteristics

LM4120-3.0V, 3.3V, 4.096V and 5.0V Unless otherwise specified V_{IN} = V_{OUT} + 1V, 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 LM4120A-3.000 LM4120A-3.300 LM4120A-4.096 LM4120A-5.000				±0.2	%
	LM4120-3.000 LM4120-3.300 LM4120-4.096 LM4120-5.000				±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	(V_{OUT} + 1V) ≤ V_{IN} ≤ 12V		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 **80**	mV
		I_{LOAD} = +1 mA		120	150 **180**	
		I_{LOAD} = +5 mA		180	210 **250**	

Electrical Characteristics

LM4120-3.0V, 3.3V, 4.096V and 5.0V Unless otherwise specified $V_{IN} = V_{OUT} + 1V$, $I_{LOAD} = 0$, $C_{OUT} = 0.01\mu F$, $T_A = T_j = 25^\circ C$. Limits with standard typeface are for $T_j = 25^\circ C$, and limits in **boldface type** apply over the $-40^\circ C \le T_A \le +85^\circ C$ temperature range. (Continued)

Symbol	Parameter	Conditions	Min (Note 5)	Typ (Note 4)	Max (Note 5)	Units
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	250 **275**	μA
I_{SS}	Power-down Supply Current	Enable = 0.4V $-40^\circ C \le T_J \le +85^\circ C$ Enable = 0.2V			1 **2**	μA
V_H	Logic High Input Voltage		**2.4**	2.4		V
V_L	Logic Low Input Voltage			0.4	**0.2**	V
I_H	Logic High Input Current			7	**15**	μA
I_L	Logic Low Input Current			0.1		μA
I_{SC}	Short Circuit Current	$V_{OUT} = 0$		15		mA
			6		**30**	
		$V_{IN} = 12V$, $V_{OUT} = 0$		17		
			6		**30**	
Hyst	Thermal Hysteresis (Note 7)	$-40^\circ C \le T_A \le 125^\circ C$		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 1.8V, 2.0V, 2.5V and V_{OUT} + 1V for others.For 1.8V option, dropout voltage is not guaranteed over temperature. 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.

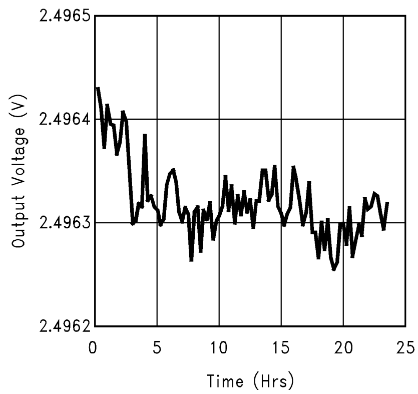
Note 8: Output noise voltage is proportional to V_{OUT}. V_N for other voltage option is calculated using $(V_{N(1.8V)}/1.8) * V_{OUT}$. $V_N (2.5V) = (36\mu V_{PP}/1.8) * 2.5 = 46\mu V_{PP}$.

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

LM4120 Typical Operating Characteristics

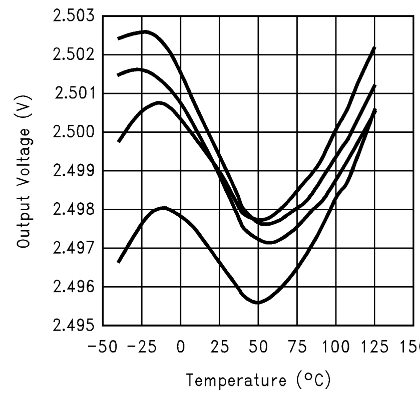
Unless otherwise specified, V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{LOAD} = 0, C_{OUT} = 0.022µF, T_A = 25˚C and V_{EN} = V_{IN}.

Long Term Drift



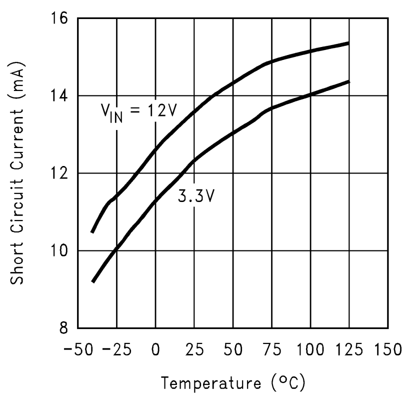
10104712

Typical Temperature Drift



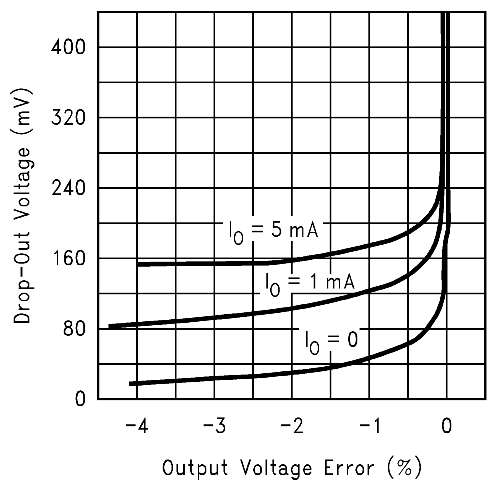
10104713

Short Circuit Current vs Temperature



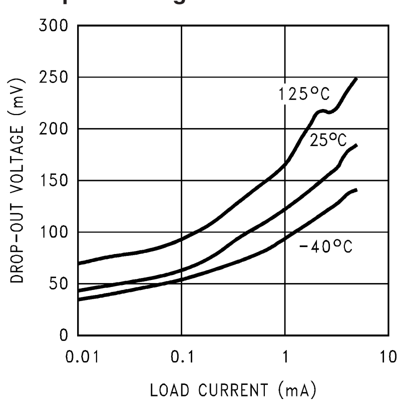
10104714

Dropout Voltage vs Output Error



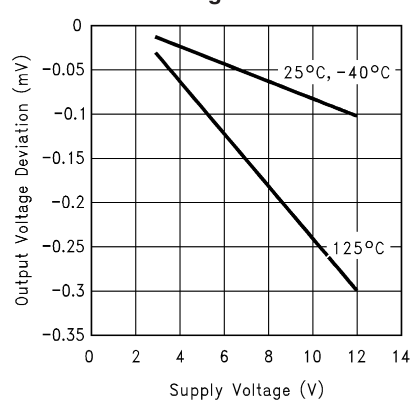
10104715

Dropout Voltage vs Load Current



10104733

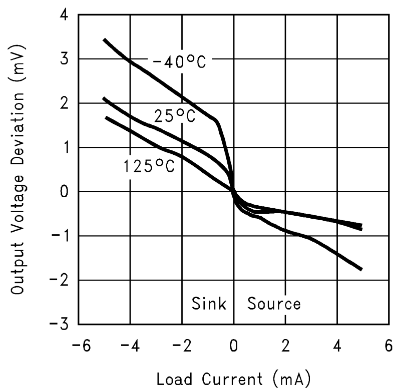
Line Regulation



10104717

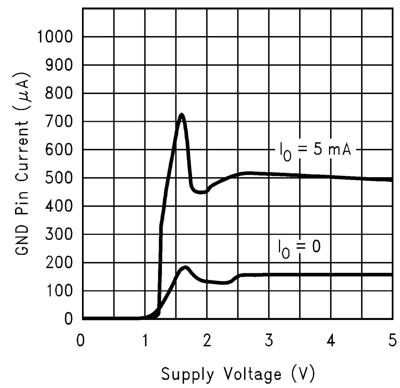
LM4120 Typical Operating Characteristics
Unless otherwise specified, V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{LOAD} = 0, C_{OUT} = 0.022µF, T_A = 25˚C and V_{EN} = V_{IN}. (Continued)

Load Regulation



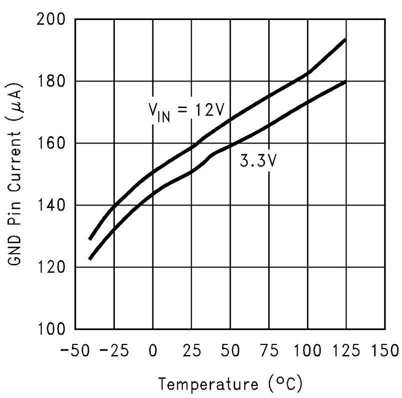
10104718

GND Pin Current



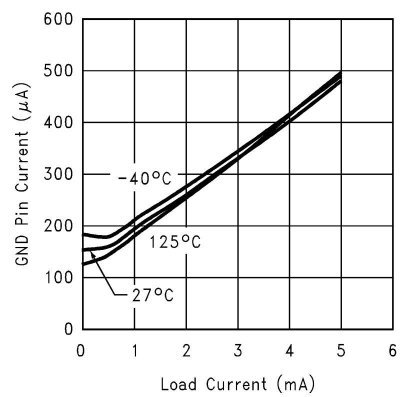
10104719

GND Pin Current at No Load vs Temperature



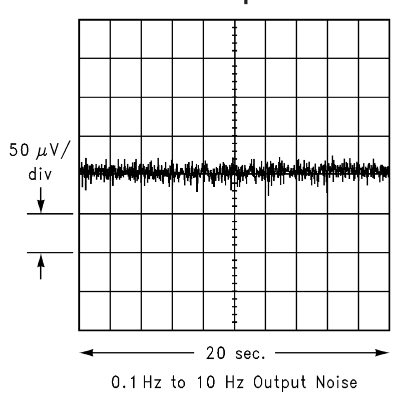
10104721

GND Pin Current vs Load



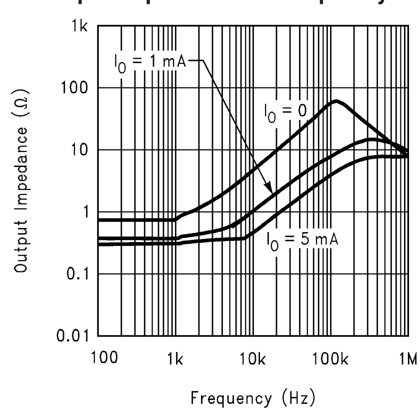
10104722

0.1Hz to 10Hz output Noise



10104723

Output Impedance vs Frequency

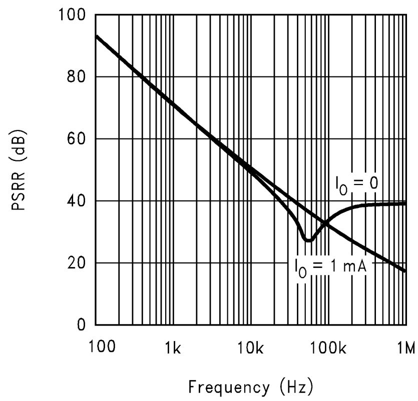


10104724

LM4120 Typical Operating Characteristics

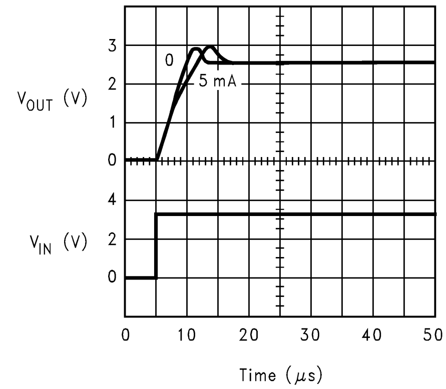
Unless otherwise specified, V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{LOAD} = 0, C_{OUT} = 0.022µF, T_A = 25˚C and V_{EN} = V_{IN}. (Continued)

PSRR vs Frequency



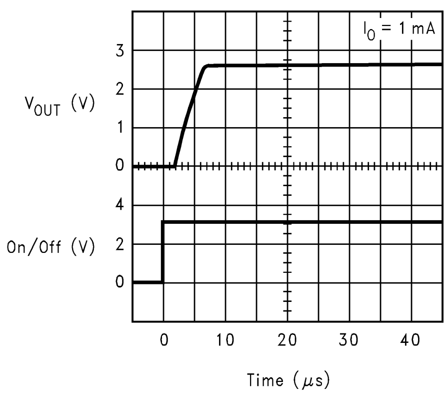
10104725

Start-Up Response



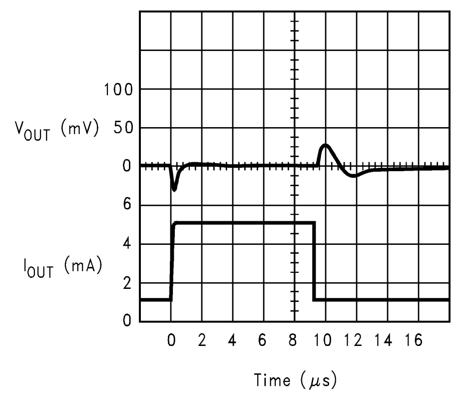
10104726

Enable Response



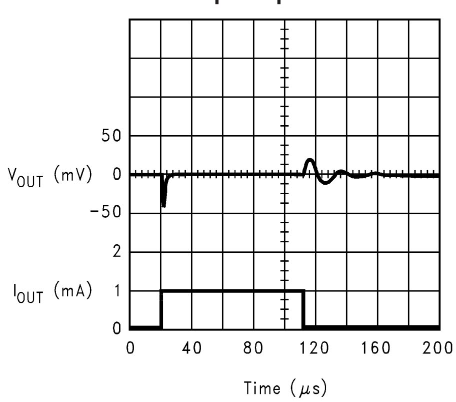
10104727

Load Step Response



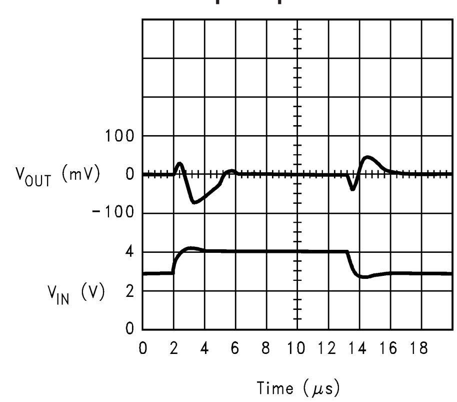
10104728

Load Step Response



10104729

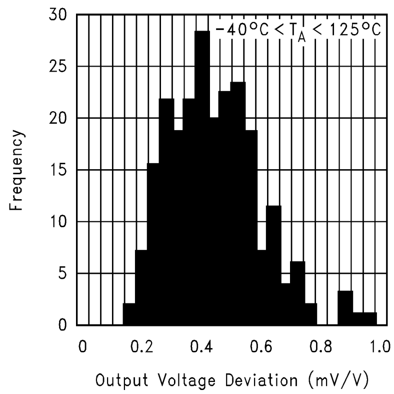
Line Step Response



10104730

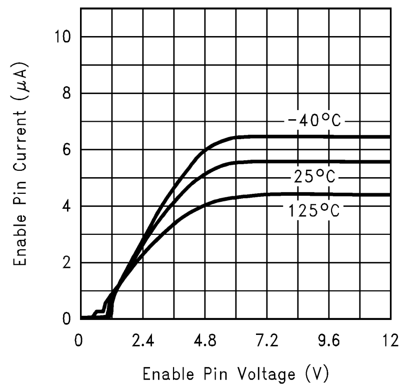
LM4120 Typical Operating Characteristics Unless otherwise specified, V_{IN} = 3.3V, V_{OUT} = 2.5V, I_{LOAD} = 0, C_{OUT} = 0.022µF, T_A = 25˚C and V_{EN} = V_{IN}. (Continued)

Thermal Hysteresis



10104731

Enable Pin Current



10104716

Pin Functions

Output (Pin 5): Reference Output.

Input (Pin 4): Positive Supply.

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

Enable (Pin 3): Pulled to input for normal operation. Forcing this pin to ground will turn-off the output.

REF (Pin 1):REF Pin. This pin should be left unconnected.

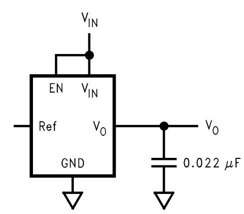
Application Hints

The standard application circuit for the LM4120 is shown in *Figure 1*. It is designed to be stable with ceramic output capacitors in the range of 0.022µF to 0.047µF. 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 LM4120. Larger input capacitors should be tantalum or aluminium.

The reference pin is sensitive to noise, and capacitive loading. Therefore, the PCB layout should isolate this pin as much as possible.

The enable pin is an analog input with very little hysteresis. About 6µA into this pin is required to turn the part on, and it must be taken close to GND to turn the part off (see spec. table for thresholds). There is a *minimum* slew rate on this pin of about 0.003V/µS to prevent glitches on the output. All of these conditions can easily be met with ordinary CMOS or TTL logic. If the shutdown feature is not required, then this pin can safely be connected directly to the input supply. Floating this pin is not recommended.



10104732

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.

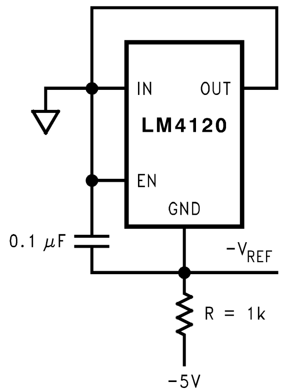
PRINTED CIRCUIT BOARD LAYOUT CONSIDERATION

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.

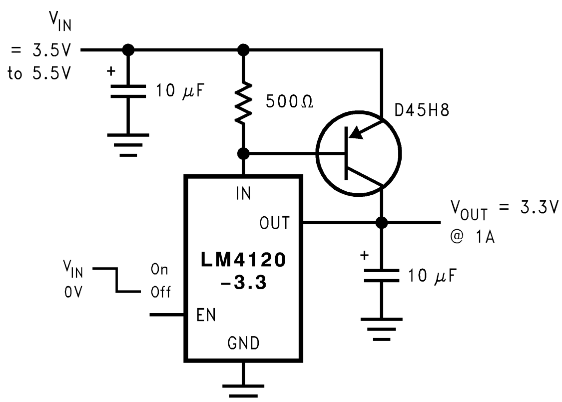
Typical Application Circuits

Voltage Reference with Negative Output



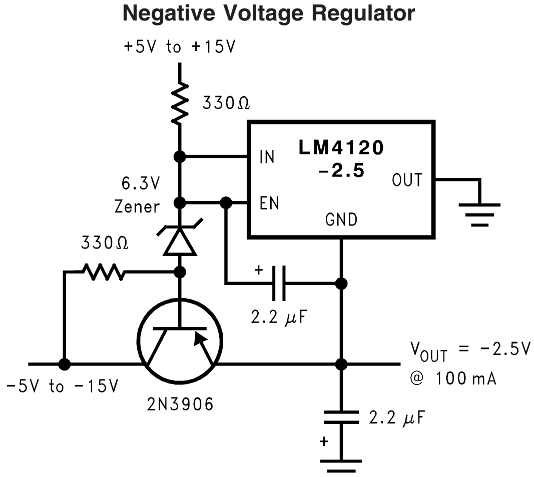
10104703

Precision High Current Low Dropout Regulator



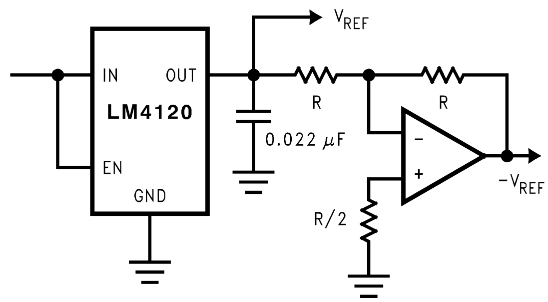
10104704

Precision High Current Negative Voltage Regulator



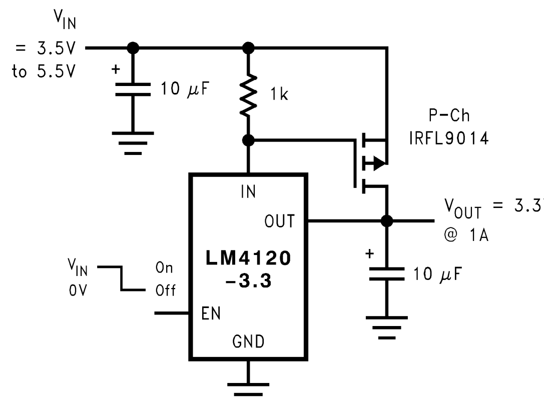
10104705

Voltage Reference with Complimentary Output



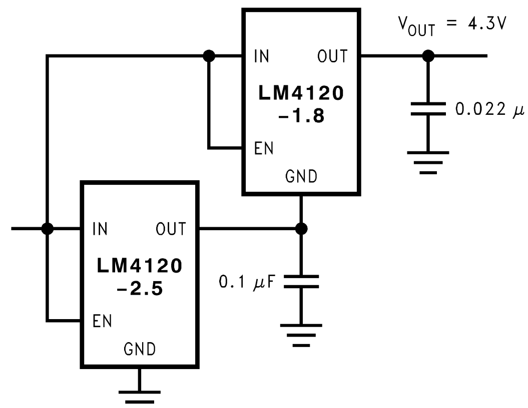
10104706

Precision High Current Low Droput Regulator



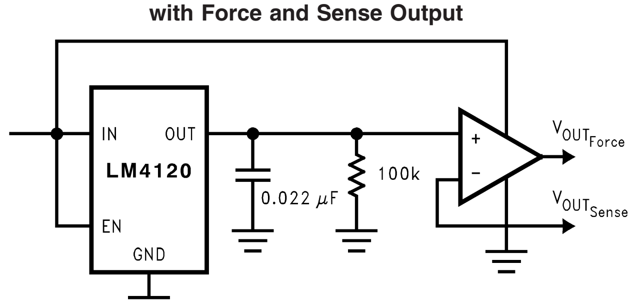
10104707

Stacking Voltage References



10104708

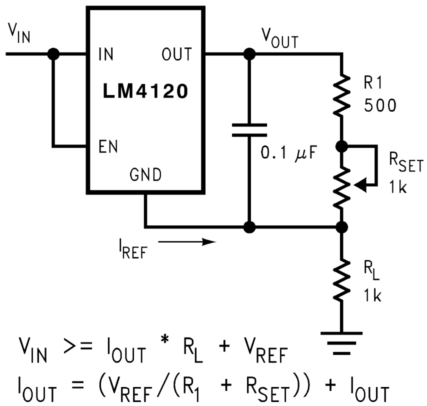
Precision Voltage Reference with Force and Sense Output



10104709

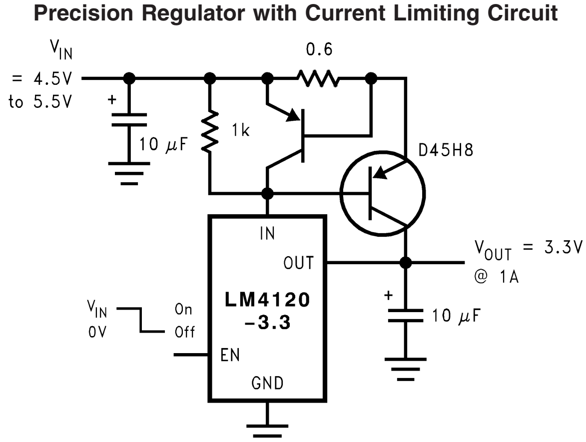
Typical Application Circuits
(Continued)

Programmable Current Source



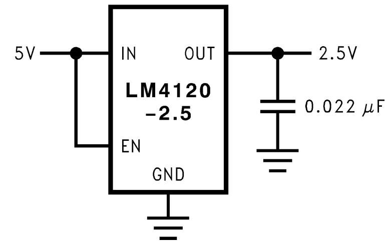
10104710

Precision Regulator with Current Limiting Circuit



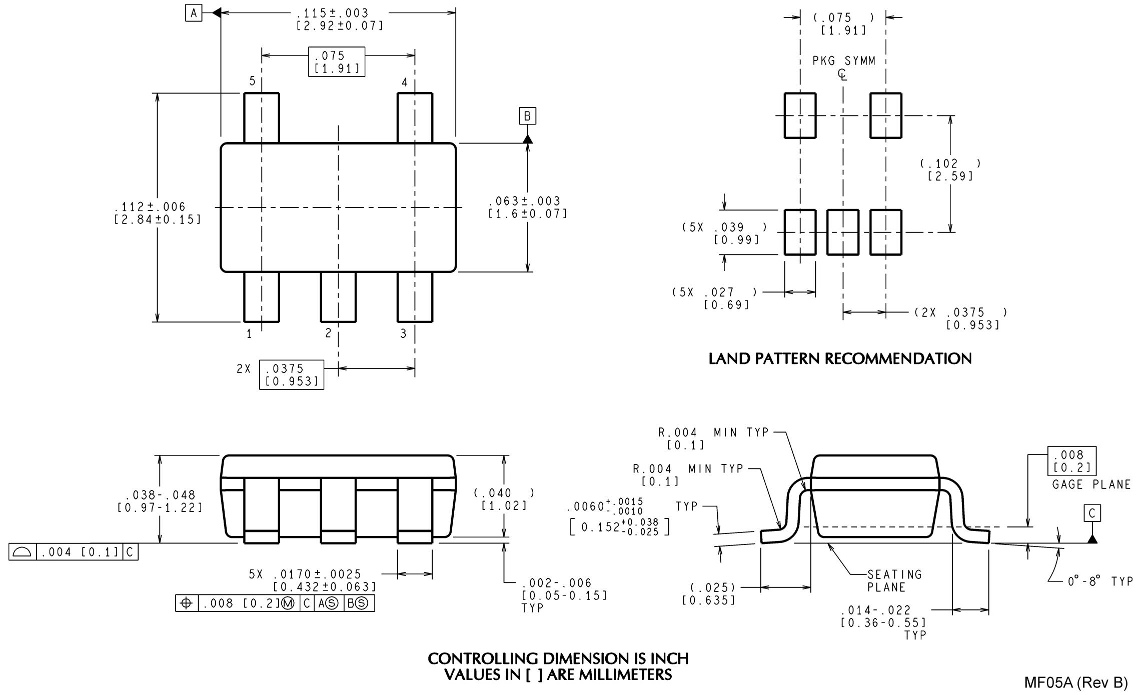
10104711

Power Supply Splitter



10104720

Physical Dimensions inches (millimeters) unless otherwise noted



LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
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.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor manufactures products and uses packing materials that meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.

National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560