

# 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  $\mu$ A (Typ.) supply current. In power down mode, device current drops to less than 2  $\mu$ A.

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/ $^{\circ}$ C guaranteed from  $-40^{\circ}$ C to  $+125^{\circ}$ 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 ( $-40^{\circ}$ C to  $+85^{\circ}$ C), while certain specs are guaranteed over the extended temperature range ( $-40^{\circ}$ C to  $+125^{\circ}$ C). Please contact National for full specifications over the extended temperature range. The LM4120 is available in a standard 5-pin SOT-23 package.

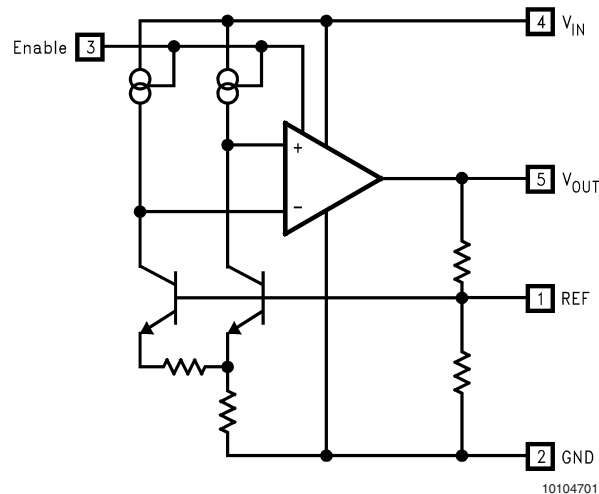
### Features

- Small SOT23-5 package
- Low dropout voltage: 120 mV Typ @ 1 mA
- High output voltage accuracy: 0.2%
- Source and Sink current output:  $\pm$ 5 mA
- Supply current: 160  $\mu$ A Typ.
- Low Temperature Coefficient: 50 ppm/ $^{\circ}$ C
- Enable pin
- Fixed output voltages: 1.8, 2.048, 2.5, 3.0, 3.3, 4.096 and 5.0V
- Industrial temperature Range:  $-40^{\circ}$ C to  $+85^{\circ}$ C
- (For extended temperature range,  $-40^{\circ}$ C to  $125^{\circ}$ C, contact National Semiconductor)

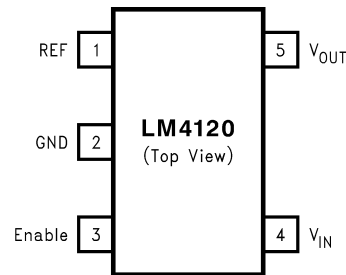
### Applications

- 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 ( $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ )

| Initial Output Voltage Accuracy at 25°C<br>And Temperature Coefficient | LM4120 Supplied as<br>1000 Units, Tape and<br>Reel | LM4120 Supplied as<br>3000 Units, Tape and<br>Reel | Top<br>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  |
|--|
| <p>First Field:<br/>R = Reference</p> <p>Second and third Field:<br/>21 = 1.800V Voltage Option<br/>14 = 2.048V Voltage Option<br/>08 = 2.500V Voltage Option<br/>15 = 3.000V Voltage Option<br/>16 = 3.300V Voltage Option<br/>17 = 4.096V Voltage Option<br/>18 = 5.000V Voltage Option</p> <p>Fourth Field:<br/>A-B = Initial Reference Voltage Tolerance<br/>A = <math>\pm 0.2\%</math><br/>B = <math>\pm 0.5\%</math></p> |

**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 ( $T_A = 25^\circ\text{C}$ ) (Note 2): |              |
| MA05B package – $\theta_{JA}$                            | 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  $V_{IN} = 3.3\text{V}$ ,  $I_{LOAD} = 0$ ,  $C_{OUT} = 0.01\mu\text{F}$ ,  $T_A = T_j = 25^\circ\text{C}$ . Limits with standard typeface are for  $T_j = 25^\circ\text{C}$ , and limits in **boldface type** apply over the  $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$  temperature range.

| Symbol                           | Parameter  | Conditions   | Min (Note 5) | Typ (Note 4) | Max (Note 5)         | Units              |
|----------------------------------|--|--|--------------|--------------|----------------------|--------------------|
| $V_{OUT}$                        | Output Voltage Initial Accuracy<br>LM4120A-1.800<br>LM4120A-2.048<br>LM4120A-2.500 |  |              |              | ±0.2                 | %                  |
|                                  | LM4120-1.800<br>LM4120-2.048<br>LM4120-2.500                                       |  |              |              | ±0.5                 | %                  |
| $TCV_{OUT}/^\circ\text{C}$       | Temperature Coefficient  | $-40^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$                 |              | 14           | 50                   | ppm/°c             |
| $\Delta V_{OUT}/\Delta V_{IN}$   | Line Regulation  | $3.3\text{V} \leq V_{IN} \leq 12\text{V}$                            |              | 0.0007       | 0.008<br><b>0.01</b> | %/V                |
| $\Delta V_{OUT}/\Delta I_{LOAD}$ | Load Regulation  | $0\text{ mA} \leq I_{LOAD} \leq 1\text{ mA}$                         |              | 0.03         | 0.08<br><b>0.17</b>  | %mA                |
|                                  |  | $1\text{ mA} \leq I_{LOAD} \leq 5\text{ mA}$                         |              | 0.01         | 0.04<br><b>0.1</b>   |                    |
|                                  |  | $-1\text{ mA} \leq I_{LOAD} \leq 0\text{ mA}$                        |              | 0.04         | 0.12                 |                    |
|                                  |  | $-5\text{ mA} \leq I_{LOAD} \leq -1\text{ mA}$                       |              | 0.01         |                      |                    |
| $V_{IN}-V_{OUT}$                 | Dropout Voltage (Note 6)   | $I_{LOAD} = 0\text{ mA}$   |              | 45           | 65<br><b>80</b>      | mV                 |
|                                  |  | $I_{LOAD} = +1\text{ mA}$  |              | 120          | 150<br><b>180</b>    |                    |
|                                  |  | $I_{LOAD} = +5\text{ mA}$  |              | 180          | 210<br><b>250</b>    |                    |
| $V_N$                            | Output Noise Voltage (Note 8)  | 0.1 Hz to 10 Hz  |              | 20           |                      | $\mu\text{V}_{PP}$ |
|                                  |  | 10 Hz to 10 kHz  |              | 36           |                      | $\mu\text{V}_{PP}$ |
| $I_S$                            | Supply Current   |  |              | 160          | 250<br><b>275</b>    | $\mu\text{A}$      |
| $I_{SS}$                         | Power-down Supply Current  | Enable = 0.4V  |              |              | 1                    | $\mu\text{A}$      |
|                                  |  | $-40^\circ\text{C} \leq T_j \leq +85^\circ\text{C}$<br>Enable = 0.2V |              |              | <b>2</b>             |                    |
| $V_H$                            | Logic High Input Voltage   |  | <b>2.4</b>   | 2.4          |                      | V                  |

## Electrical Characteristics

**LM4120-1.8V, 2.048V and 2.5V** Unless otherwise specified  $V_{IN} = 3.3V$ ,  $I_{LOAD} = 0$ ,  $C_{OUT} = 0.01\mu F$ ,  $T_A = T_j = 25^\circ C$ . Limits with standard typeface are for  $T_j = 25^\circ C$ , and limits in **boldface type** apply over the  $-40^\circ C \leq T_A \leq +85^\circ C$  temperature range. (Continued)

| Symbol           | Parameter                    | Conditions                              | Min (Note 5) | Typ (Note 4) | Max (Note 5) | Units   |
|------------------|------------------------------|---|--------------|--------------|--------------|---------|
| $V_L$            | Logic Low Input Voltage      |   |              | 0.4          | <b>0.2</b>   | V       |
| $I_H$            | Logic High Input Current     |   |              | 7            | <b>15</b>    | $\mu A$ |
| $I_L$            | Logic Low Input Current      |   |              | 0.1          |              | $\mu A$ |
| $I_{SC}$         | Short Circuit Current        | $V_{IN} = 3.3V$ , $V_{OUT} = 0$         |              | 15           |              | mA      |
|                  |                              |   | <b>6</b>     |              | <b>30</b>    |         |
|                  |                              | $V_{IN} = 12V$ , $V_{OUT} = 0$          |              | 17           |              | mA      |
|                  |                              |   | <b>6</b>     |              | <b>30</b>    |         |
| Hyst             | Thermal Hysteresis (Note 7)  | $-40^\circ C \leq T_A \leq 125^\circ C$ |              | 0.5          |              | mV/V    |
| $\Delta V_{OUT}$ | Long Term Stability (Note 9) | 1000 hrs. @ $25^\circ C$                |              | 100          |              | ppm     |

## Electrical Characteristics

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

| Symbol                           | Parameter   | Conditions   | Min (Note 5) | Typ (Note 4) | Max (Note 5)         | Units           |
|----------------------------------|---|--|--------------|--------------|----------------------|-----------------|
| $V_{OUT}$                        | Output Voltage Initial Accuracy<br>LM4120A-3.000<br>LM4120A-3.300<br>LM4120A-4.096<br>LM4120A-5.000 |  |              |              | $\pm 0.2$            | %               |
|                                  |   | LM4120-3.000<br>LM4120-3.300<br>LM4120-4.096<br>LM4120-5.000 |              |              | $\pm 0.5$            | %               |
| $TCV_{OUT}/^\circ C$             | Temperature Coefficient   | $-40^\circ C \leq T_A \leq +125^\circ C$                     |              | 14           | 50                   | ppm/ $^\circ C$ |
| $\Delta V_{OUT}/\Delta V_{IN}$   | Line Regulation   | $(V_{OUT} + 1V) \leq V_{IN} \leq 12V$                        |              | 0.0007       | 0.008<br><b>0.01</b> | %/V             |
| $\Delta V_{OUT}/\Delta I_{LOAD}$ | Load Regulation   | $0 mA \leq I_{LOAD} \leq 1 mA$                               |              | 0.03         | 0.08<br><b>0.17</b>  | %/mA            |
|                                  |   | $1 mA \leq I_{LOAD} \leq 5 mA$                               |              | 0.01         | 0.04<br><b>0.1</b>   |                 |
|                                  |   | $-1 mA \leq I_{LOAD} \leq 0 mA$                              |              | 0.04         | 0.12                 |                 |
|                                  |   | $-5 mA \leq I_{LOAD} \leq -1 mA$                             |              | 0.01         |                      |                 |
| $V_{IN}-V_{OUT}$                 | Dropout Voltage (Note 6)  | $I_{LOAD} = 0 mA$  |              | 45           | 65<br><b>80</b>      | mV              |
|                                  |   | $I_{LOAD} = +1 mA$   |              | 120          | 150<br><b>180</b>    |                 |
|                                  |   | $I_{LOAD} = +5 mA$   |              | 180          | 210<br><b>250</b>    |                 |

## 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  $-40^\circ C \leq T_A \leq +85^\circ C$  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           |                   | $\mu V_{PP}$ |
|                  |                               | 10 Hz to 10 kHz   |              | 36           |                   | $\mu V_{PP}$ |
| $I_S$            | Supply Current                |   |              | 160          | 250<br><b>275</b> | $\mu A$      |
| $I_{SS}$         | Power-down Supply Current     | Enable = 0.4V<br>$-40^\circ C \leq T_j \leq +85^\circ C$<br>Enable = 0.2V |              |              | 1<br><b>2</b>     | $\mu A$      |
| $V_H$            | Logic High Input Voltage      |   | <b>2.4</b>   | 2.4          |                   | V            |
| $V_L$            | Logic Low Input Voltage       |   |              | 0.4          | <b>0.2</b>        | V            |
| $I_H$            | Logic High Input Current      |   |              | 7            | <b>15</b>         | $\mu A$      |
| $I_L$            | Logic Low Input Current       |   |              | 0.1          |                   | $\mu A$      |
| $I_{SC}$         | Short Circuit Current         | $V_{OUT} = 0$   |              | 15           |                   | mA           |
|                  |                               | $V_{IN} = 12V, V_{OUT} = 0$   | <b>6</b>     |              | <b>30</b>         |              |
|                  |                               |   | <b>6</b>     |              | <b>30</b>         |              |
| Hyst             | Thermal Hysteresis (Note 7)   | $-40^\circ C \leq T_A \leq 125^\circ C$                                   |              | 0.5          |                   | mV/V         |
| $\Delta V_{OUT}$ | Long Term Stability (Note 9)  | 1000 hrs. @ $25^\circ C$  |              | 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),  $\theta_{JA}$  (junction to ambient thermal resistance) and  $T_A$  (ambient temperature). The maximum power dissipation at any temperature is:  $PD_{ISSMAX} = (T_{JMAX} - T_A)/\theta_{JA}$  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 k $\Omega$  resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

**Note 4:** Typical numbers are at  $25^\circ C$  and represent the most likely parametric norm.

**Note 5:** Limits are 100% production tested at  $25^\circ C$ . 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  $\leq 1\%$  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  $V_{IN}$ .

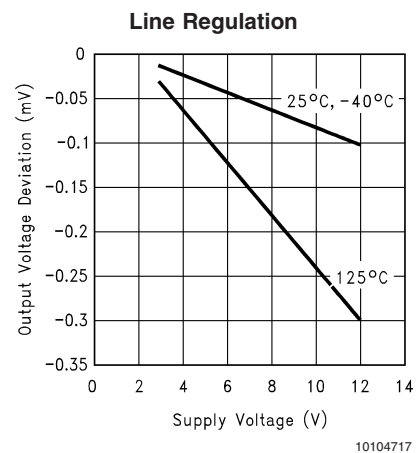
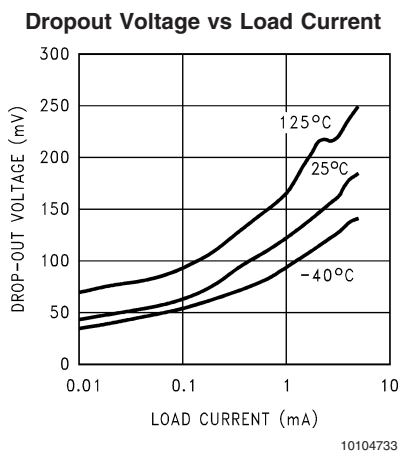
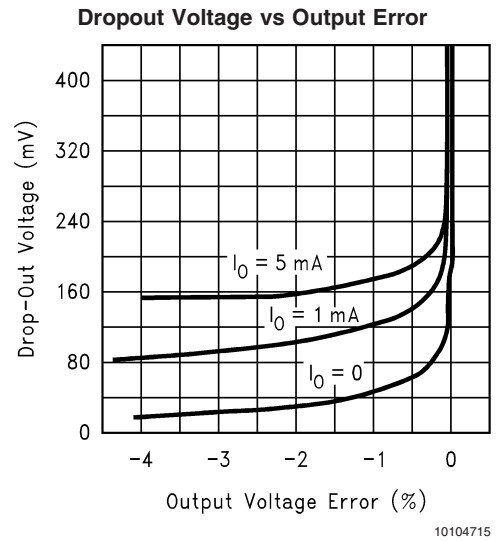
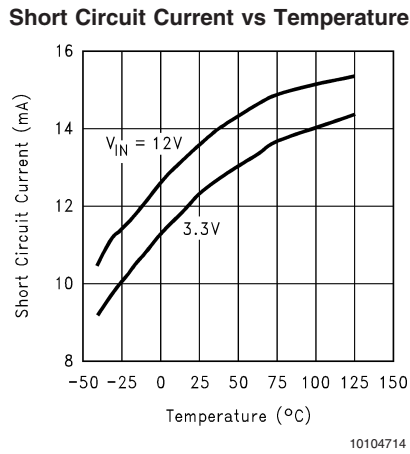
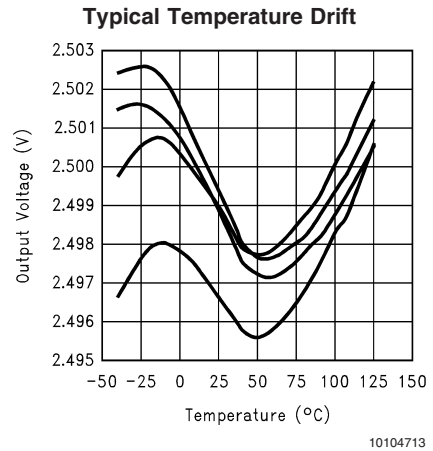
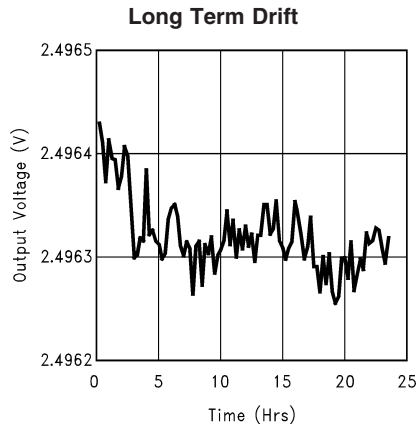
**Note 7:** Thermal hysteresis is defined as the change in  $+25^\circ C$  output voltage before and after exposing the device to temperature extremes.

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

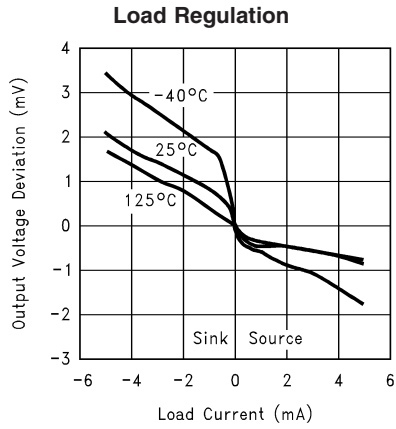
**Note 9:** Long term stability is change in  $V_{REF}$  at  $25^\circ C$  measured continuously during 1000 hrs.

# LM4120 Typical Operating Characteristics

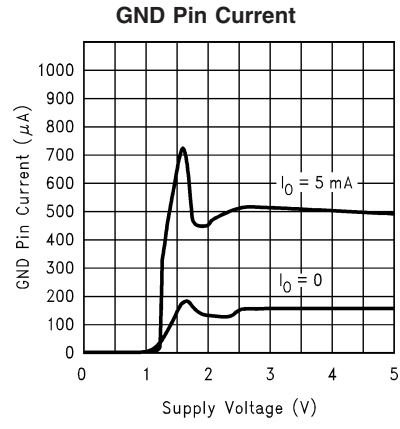
Unless otherwise specified,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 2.5V$ ,  $I_{LOAD} = 0$ ,  $C_{OUT} = 0.022\mu F$ ,  $T_A = 25^\circ C$  and  $V_{EN} = V_{IN}$ .



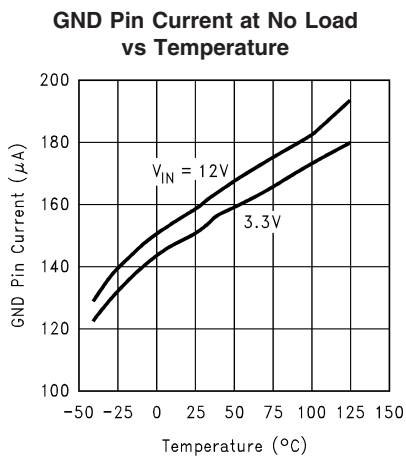
**LM4120 Typical Operating Characteristics** Unless otherwise specified,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 2.5V$ ,  $I_{LOAD} = 0$ ,  $C_{OUT} = 0.022\mu F$ ,  $T_A = 25^\circ C$  and  $V_{EN} = V_{IN}$ . (Continued)



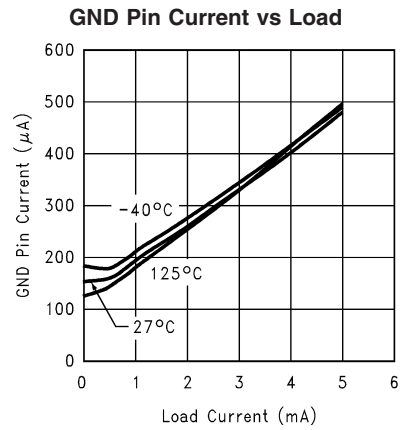
10104718



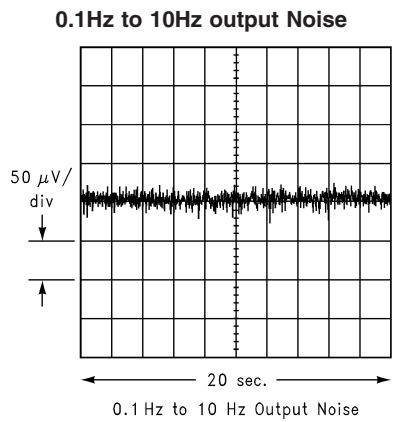
10104719



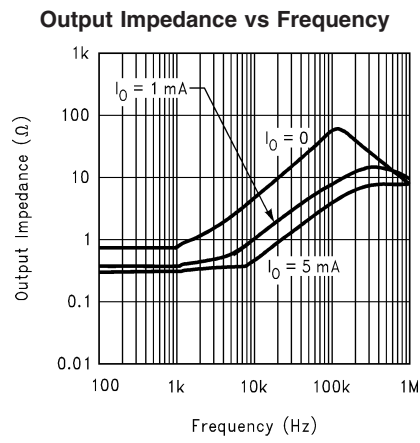
10104721



10104722

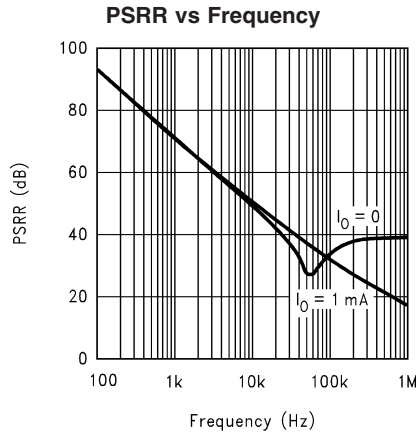


10104723

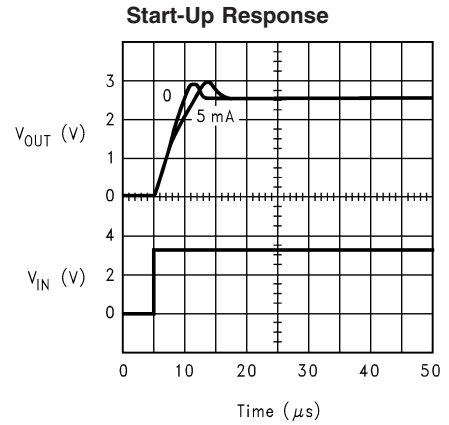


10104724

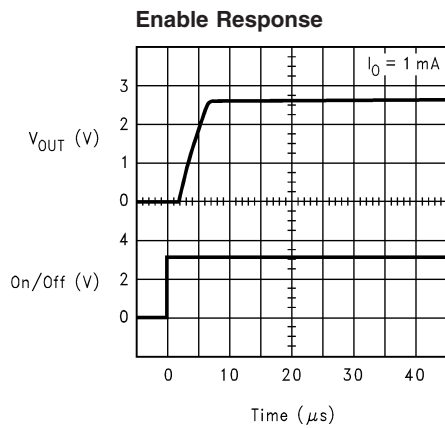
**LM4120 Typical Operating Characteristics** Unless otherwise specified,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 2.5V$ ,  $I_{LOAD} = 0$ ,  $C_{OUT} = 0.022\mu F$ ,  $T_A = 25^\circ C$  and  $V_{EN} = V_{IN}$ . (Continued)



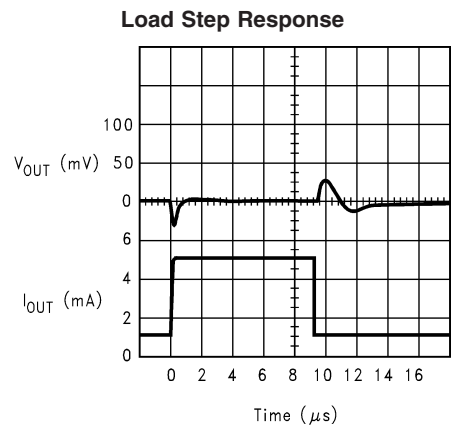
10104725



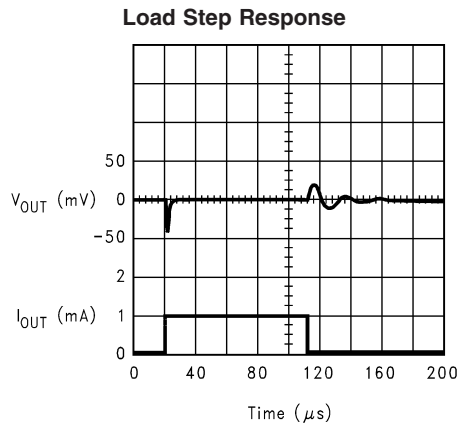
10104726



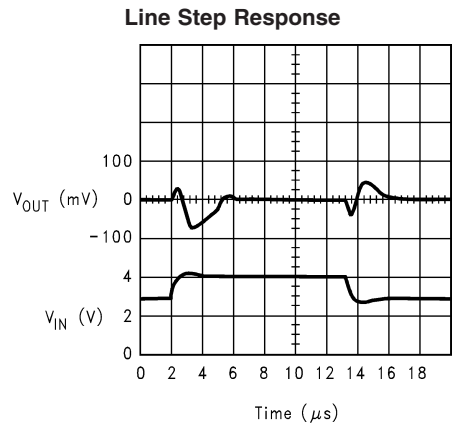
10104727



10104728



10104729

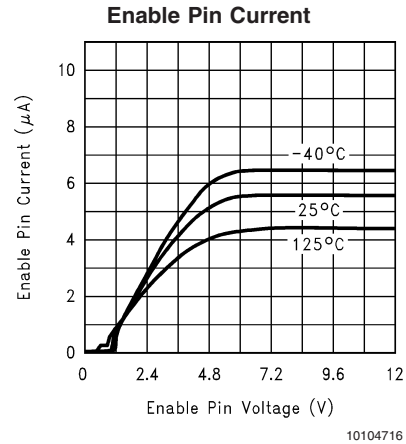
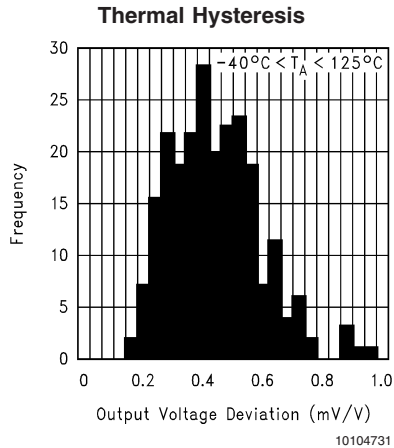


10104730



## LM4120 Typical Operating Characteristics

Unless otherwise specified,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 2.5V$ ,  $I_{LOAD} = 0$ ,  $C_{OUT} = 0.022\mu F$ ,  $T_A = 25^\circ C$  and  $V_{EN} = V_{IN}$ . (Continued)



## 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  $0.022\mu F$  to  $0.047\mu F$ . Note that  $0.022\mu F$  is the minimum required output capacitor. These capacitors typically have an ESR of about 0.1 to  $0.5\Omega$ . Smaller ESR can be tolerated, however larger ESR can not. The output capacitor can be increased to improve load transient response, up to about  $1\mu F$ . However, values above  $0.047\mu F$  must be tantalum. With tantalum capacitors, in the  $1\mu F$  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  $1\mu F$  or larger. These application must be thoroughly tested over temperature, line and load.

An input capacitor is typically not required. However, a  $0.1\mu F$  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  $6\mu A$  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  $0.003V/\mu S$  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.

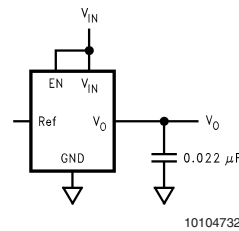


FIGURE 1.

### 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.

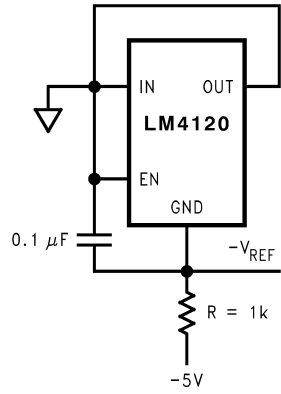
### PRINTED CIRCUIT BOARD LAYOUT CONSIDERATION

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.

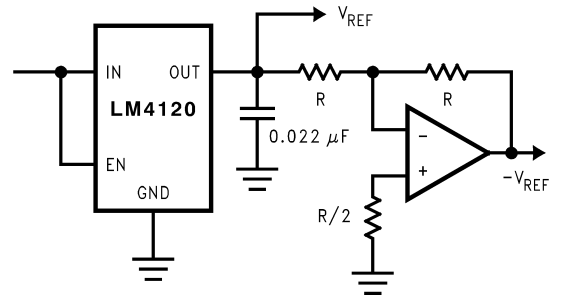
# Typical Application Circuits

Voltage Reference with Negative Output



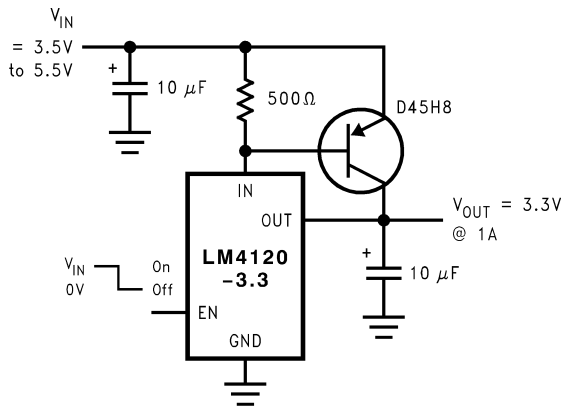
10104703

Voltage Reference with Complimentary Output



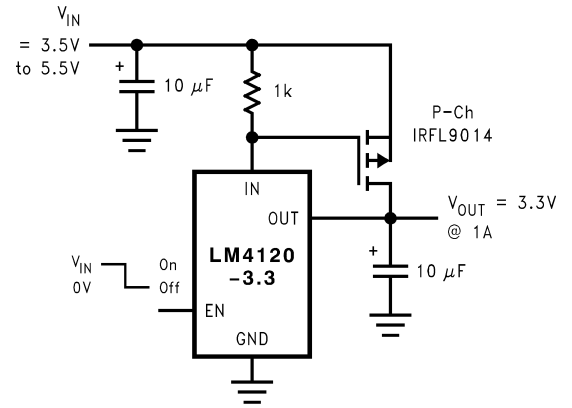
10104706

Precision High Current Low Dropout Regulator



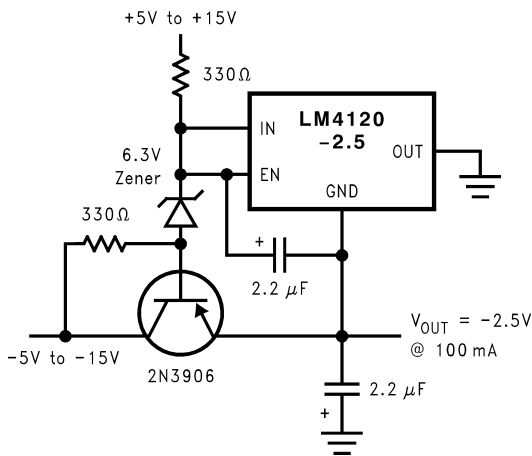
10104704

Precision High Current Low Dropout Regulator



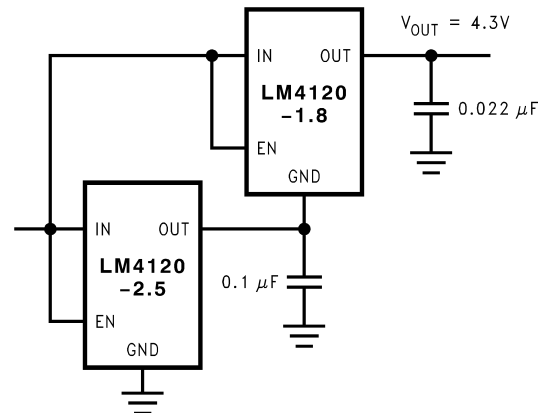
10104707

Precision High Current Negative Voltage Regulator



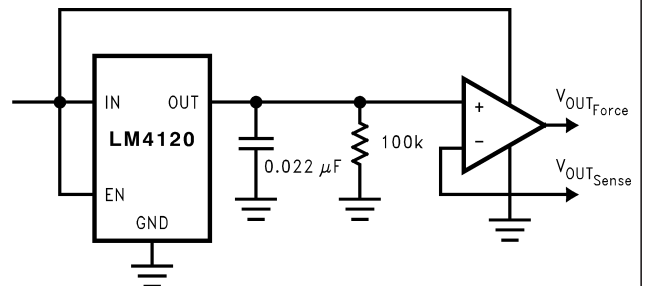
10104705

Stacking Voltage References



10104708

Precision Voltage Reference with Force and Sense Output

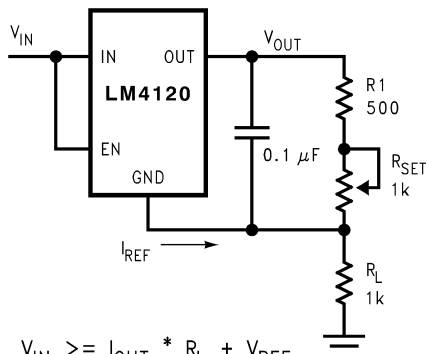


10104709

# Typical Application Circuits

(Continued)

## Programmable Current Source

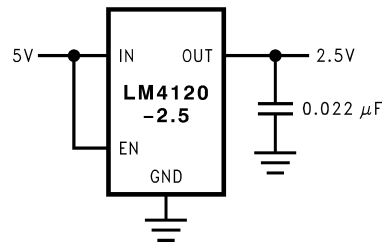


$$V_{IN} \geq I_{OUT} * R_L + V_{REF}$$

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

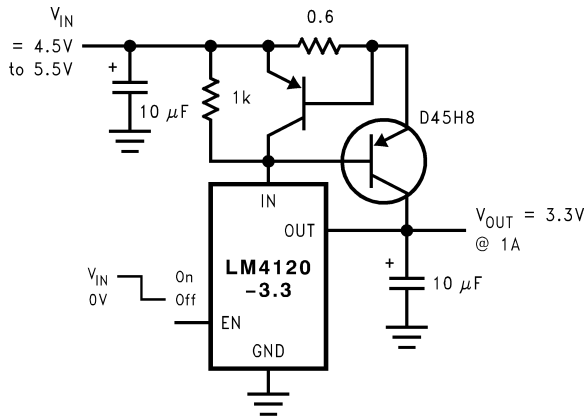
10104710

## Power Supply Splitter



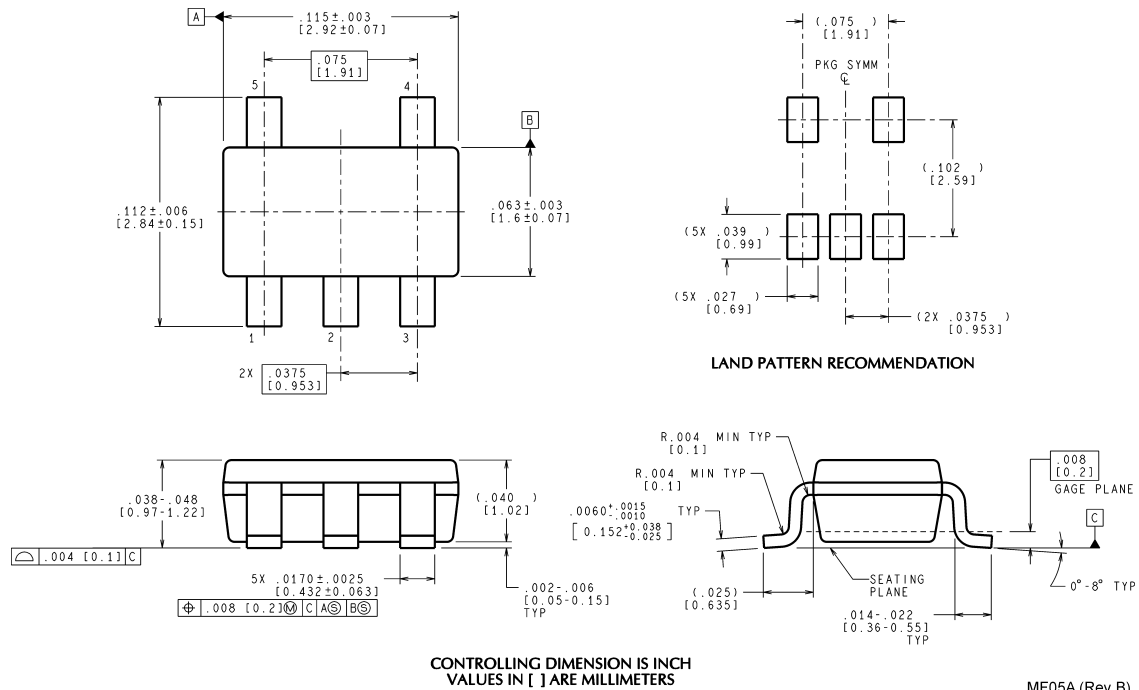
10104720

## Precision Regulator with Current Limiting Circuit



10104711

**Physical Dimensions** inches (millimeters) unless otherwise noted



National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at [www.national.com](http://www.national.com).

**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](mailto:new.feedback@nsc.com)  
Tel: 1-800-272-9959

**National Semiconductor**  
Europe Customer Support Center  
Fax: +49 (0) 180-530 85 86  
Email: [europe.support@nsc.com](mailto: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](mailto:ap.support@nsc.com)

**National Semiconductor**  
Japan Customer Support Center  
Fax: 81-3-5639-7507  
Email: [jpn.feedback@nsc.com](mailto:jpn.feedback@nsc.com)  
Tel: 81-3-5639-7560

[www.national.com](http://www.national.com)