EVALUATION OF LINEAR TECHNOLOGY LT1461 VOLTAGE REFERENCE AT LOW TEMPERATURES

Test Report

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April 25, 2002

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Background

The Linear Technology LT1461 is a low dropout micropower bandgap voltage reference with low drift and very high accuracy. The device draws very small current (35 µA) and is capable of providing an output drive current of 50 mA [1]. The low supply current makes it ideal for low power and portable applications, and its output current capability makes suitable for high power requirements, such as power supplies, analog-to-digital and digital-to-analog converters, and precision regulators. The device has a shutdown feature that can be used to switch full load currents and for system power down. It has excellent thermal regulation and a built-in thermal shutdown protects against overload conditions. The device provides a steady output of 2.5 V from inputs up to 20 V, and is specified for operation from –40 °C to +125 °C [1]. The performance of plastic-packaged devices at low temperatures was investigated in this work.

Test Setup

A circuit board, populated with an LT1461ACS8-2.5 voltage reference and a few passive components, was designed and built for evaluation in the temperature range of +25 °C to –180 °C. The device was characterized at test temperatures of 25, 0, -40, -80, -100, -120, -140, -160 and -180 °C in a liquid nitrogen cooled environmental chamber. At each test temperature, the device was allowed to soak for 15 minutes before measurements were made. Limited thermal cycle testing was also performed on the LT1461 voltage reference. These tests consisted of subjecting the device to a total of ten thermal cycles between +90 °C and –125 °C at a temperature rate of 10 °C/min. Device characterization was also performed at various temperatures after completion of the thermal cycling activity.

The device performance was evaluated in terms of its 2.5 V output voltage regulation at the test temperatures. These characteristics were obtained using input voltages between 3 and 20 volts and at three load levels. Differing resistive loads were selected so that the load current ranged between 0 and 20 mA. The LT1461ACS8-2.5 device is specified to source or sink up to 50 mA with an output voltage between 2.499 and 2.501 volts.

Results and Discussion

Figure 1 shows the deviation in the output voltage of the device with respect to its room temperature value. The data, which is shown as a function of temperature, is depicted for input voltages of 3, 12, and 20 volts at three different load levels. It can be seen that the reference output voltage generally remains within specifications (2.499 to 2.501 V) between temperatures of 25 °C to –40 °C. Beyond –40 °C, however, the output voltage begins to fluctuate as the temperature is decreased. While the output voltage undergoes a slight increase with decrease in temperature for the no load condition, it exhibits a decrease when a load is applied. The intensity of this drop in the output voltage seems to depend on both the levels of the input voltage and the

applied load. For example, the decrease is most dramatic at the highest load level with input voltages of 12 and 20 volts, as seen in Figure 1. In addition, the beginning of this trend occurs at temperatures as low as – 80 °C, as compared to –120 °C for the case of other load/ input voltage combinations. Furthermore, the device exhibits unstable operation at the two extreme low temperatures; namely –160 °C and –180 °C. Instability was also observed at temperature as low as -80 °C only when an input voltage of 3 V is applied under high load condition. It is important to point out that at test temperature of –180 °C, the device completely loses its voltage regulation and it tends to behave almost like a unity-gain amplifier stage.

Table I lists all the data obtained under the various test conditions. The operating points at which the output voltage went out of specification limits and device instability occurred are shown as shaded areas in Table I.

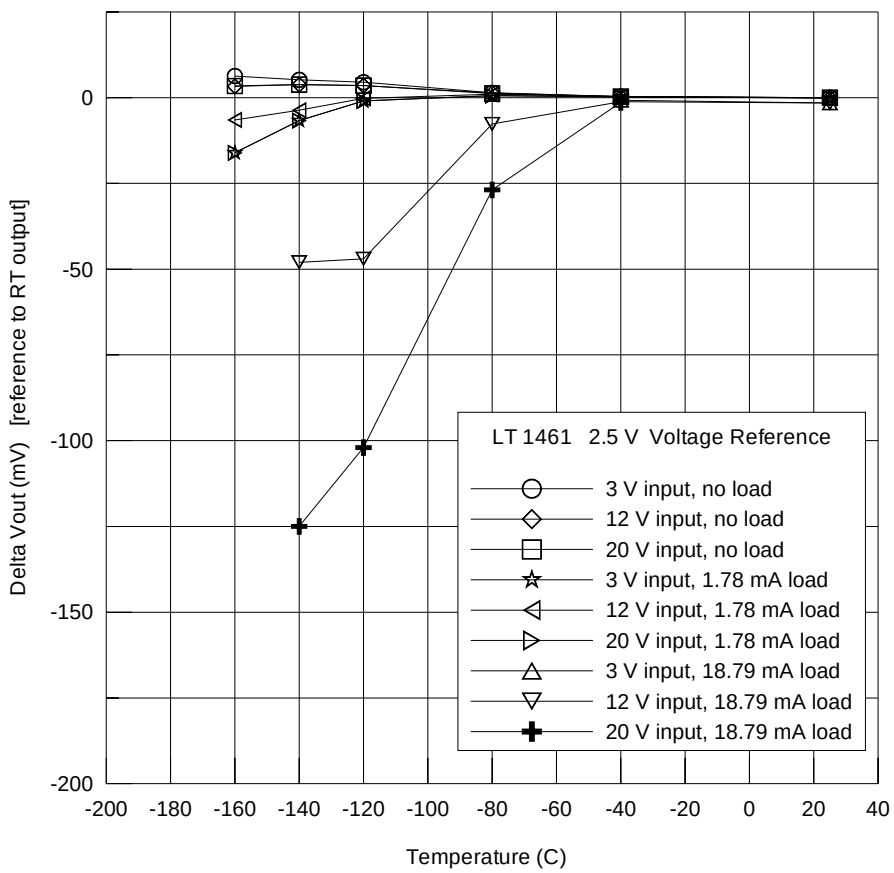

Figure 1. Deviation in the output voltage versus temperature at different test conditions.

Table I. Output voltage of Linear Technology LT1461 voltage reference at various temperatures.

Input Voltage (V)	Output Current (mA)	Temp (°C)	Output Voltage (V)
3	0	25	2.4997
12	0	25	2.4997
20	0	25	2.4997
3	1.78	25	2.4996
12	1.78	25	2.4996
20	1.78	25	2.4996
3	18.79	25	2.4981
12	18.79	25	2.4981
20	18.79	25	2.4981
3	0	0	2.4997
12	0	0	2.4997
20	0	0	2.4997
3	1.78	0	2.4997
12	1.78	0	2.4997
20	1.78	0	2.4996
3	18.79	0	2.4983
12	18.79	0	2.4982
20	18.79	0	2.4982
3	0	-40	2.5000
12	0	-40	2.5000
20	0	-40	2.5000
3	1.78	-40	2.5000
12	1.78	-40	2.5000
20	1.78	-40	2.4999
3	18.79	-40	2.4988
12	18.79	-40	2.4986
20	18.79	-40	2.4983
3	0	-80	2.5011
12	0	-80	2.5010
20	0	-80	2.5009
3	1.78	-80	2.5010
12	1.78	-80	2.5007
20	1.78	-80	2.5003
3	18.79	-80	1.2001
12	18.79	-80	2.4920
20	18.79	-80	2.4728
3	0	-100	2.5024
12	0	-100	2.5019
20	0	-100	2.5019
3	1.78	-100	2.5024
12	1.78	-100	2.5005
20	1.78	-100	2.5000
3	18.79	-100	1.2084
Input Voltage (V)	**Output Current (mA)**	**Temp (°C)**	**Output Voltage (V)**
12	18.79	-100	2.4718
20	18.79	-100	2.4311
3	0	-120	2.5042
12	0	-120	2.5037
20	0	-120	2.5032
3	1.78	-120	2.5042
12	1.78	-120	2.4997
20	1.78	-120	2.4987
3	18.79	-120	
12	18.79	-120	2.4527
20	18.79	-120	2.3973
3	0	-140	2.5049
12	0	-140	2.5041
20	0	-140	2.5035
3	1.78	-140	2.5049
12	1.78	-140	2.4960
20	1.78	-140	2.4930
3	18.79	-140	
12	18.79	-140	2.4382
20	18.79	-140	2.3741
3	0	-160	2.5060
12	0	-160	2.5042
20	0	-160	2.5031
3	1.78	-160	2.2760
12	1.78	-160	2.4932
20	1.78	-160	2.4836
3	18.79	-160	
12	18.79	-160	
20	18.79	-160	
3	0	-180	3.0010
6	0	-180	5.9910
20	0	-180	
3	1.78	-180	
12	1.78	-180	
20	1.78	-180	
3	18.79	-180	
12	18.79	-180	
20	18.79	-180	

	Voltage out of specifications
	No readout/Unstable operation

After this basic characterization with temperature, the device was subjected, as mentioned earlier, to ten thermal cycles between +90 °C and – 125 °C. Measurements of the device parameters were then followed at various temperatures. The post-thermal cycling data is listed in Table II. The results obtained were in good agreement to those obtained prior to the thermal cycling. Hence, it can be concluded that this limited thermal cycling had no effect on the operational characteristics of the LT1461 voltage reference or its plastic-packaged assembly.

Table II. Post-thermal cycling results of Linear Technology LT1461 voltage reference.

Input Voltage (V)	Output Current (mA)	Temp (°C)	Output Voltage (V)
3	0	25	2.5004
12	0	25	2.5004
20	0	25	2.5003
3	1.78	25	2.5003
12	1.78	25	2.5002
20	1.78	25	2.5002
3	18.79	25	2.4988
12	18.79	25	2.4987
20	18.79	25	2.4986
3	0	-40	2.5002
12	0	-40	2.5002
20	0	-40	2.5002
3	1.78	-40	2.5000
12	1.78	-40	2.5000
20	1.78	-40	2.5000
3	18.79	-40	2.4989
12	18.79	-40	2.4985
20	18.79	-40	2.4983
3	0	-120	2.5042
12	0	-120	2.5030
20	0	-120	2.5030
3	1.78	-120	2.5041
12	1.78	-120	2.4997
20	1.78	-120	2.4988
3	18.79	-120	1.2680
12	18.79	-120	2.4528
20	18.79	-120	2.4042

Input Voltage (V)	Output Current (mA)	Temp (°C)	Output Voltage (V)
3	0	-140	2.5051
12	0	-140	2.5036
20	0	-140	2.5037
3	1.78	-140	2.5050
12	1.78	-140	2.4962
20	1.78	-140	2.4941
3	18.79	-140	0.8251
12	18.79	-140	2.4381
20	18.79	-140	2.3755
3	0	-160	2.5058
12	0	-160	2.5031
20	0	-160	2.5031
3	1.78	-160	2.2791
12	1.78	-160	2.4930
20	1.78	-160	2.4835
3	18.79	-160	
12	18.79	-160	2.4105
20	18.79	-160	2.3485
3	0	-180	2.9910
12	0	-180	11.9732
20	0	-180	19.9514
3	1.78	-180	2.2325
12	1.78	-180	7.3833
20	1.78	-180	13.5450
3	18.79	-180	0.6219
12	18.79	-180	2.4632
20	18.79	-180	2.2876

	Voltage out of specifications
	No readout/Unstable operation

Conclusion

The Linear Technology LT1461, which is a low dropout with very high accuracy reference voltage device rated for –40 °C to +125 °C operation, has been evaluated for potential use in low temperature applications. The plastic-packaged device was characterized in terms of its output voltage regulation in the temperature range of +20 °C to -180 °C. While the device performed well with respect to output voltage regulation with temperature down to –40 °C, the manufacturer's specified low temperature rating, it does have potential use down to about –80 °C with little degradation in voltage regulation under heavy load conditions. At temperatures beyond –80 °C, the device begins to show appreciable loss in regulation at heavy loads and, in particular, when an input voltage of 3 volts is used. At –180 °C, a complete loss of voltage regulation takes place as the voltage reference integrated circuit chip behaves as a unity gain amplifier. Subjecting the device to limited thermal cycling between +90 °C and -125°C was found to produce no effect on neither its operational characteristics nor its plastic-encapsulated packaging.

References

1. Linear Technology LT1461-2.5 Micropower Precision Low Dropout Series Voltage Reference Data Sheet.

Acknowledgments

This work was performed under the NASA Glenn Research Center GESS Contract # NAS3-00145. Support was also provided from the NASA Electronic Parts and Packaging (NEPP) Program, EPAC Task "Effects of Wide Temperature Exposure on Characteristics of Plastic Encapsulated COTS Components for Space Applications" and EPAR Task "Electronics for Extreme Environments".