

FEATURES

- 200mV Max Dropout at 10mA Output Current
- 4 μ A Typical Quiescent Current
- 0.15% Max Initial Accuracy
- No Output Capacitor Required
- Output Sources 10mA, Sinks 2mA
- 40ppm/ $^{\circ}$ C Max Drift
- Voltage Options: 2.5V, 3V, 4.1V, 5V and Adjustable

APPLICATIONS

- Battery-Powered Systems
- Handheld Instruments
- Precision Power Supplies
- A/D and D/A Converters


DESCRIPTION

The LTC[®]1798/LTC1798-2.5/LTC1798-3/LTC1798-4.1/LTC1798-5 are micropower bandgap references that combine high accuracy and low drift with very low supply current and small package size. The combination of ultralow quiescent current and low dropout voltage of only 200mV (max) makes them ideal for battery-powered equipment. The output voltage is set by an external resistor divider for the adjustable LTC1798.

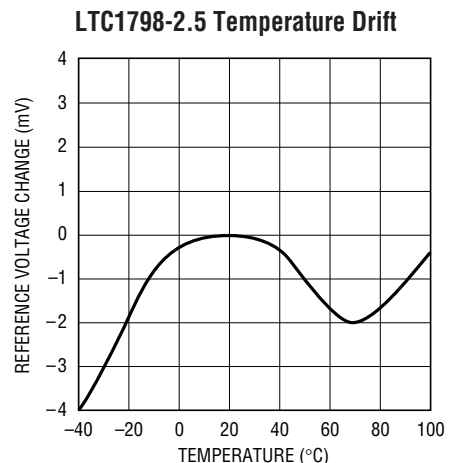
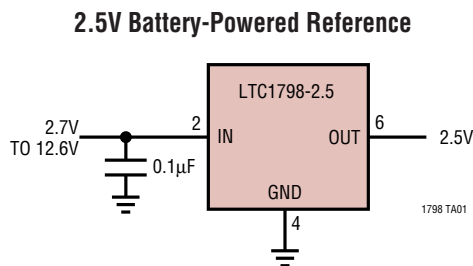
This series of references uses curvature compensation to obtain low temperature coefficient and trimmed thin-film resistors to achieve high output accuracy. These references can source up to 10mA and sink up to 2mA, making them ideal for precision regulator applications. They are stable without an output bypass capacitor, but are also stable with capacitance up to 1 μ F. This feature is important in critical applications where PC board space is a premium and fast settling is demanded.

The LTC1798 series references provided power dissipation advantages over shunt references. In addition to supply current, shunt references must also idle the entire load current to operate.

The LTC1798 series is available in the SO-8 package.

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TYPICAL APPLICATION



1798 TA02

LTC1798 Series

ABSOLUTE MAXIMUM RATINGS

(Note 1)

| | |
|---|----------------|
| Supply Voltage | 13V |
| Input Voltages | -0.3v to 13V |
| Output Voltages | -0.3V to 13V |
| Output Short-Circuit Duration | Indefinite |
| Operating Temperature Range (Note 2) | -40°C to 100°C |
| Specified Temperature Range | 0°C to 70°C |
| Storage Temperature Range (Note 3) ... | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec) | 300°C |

PACKAGE/ORDER INFORMATION

| | |
|--|--|
| <p>S8 PACKAGE 8-LEAD PLASTIC SO</p> <p>$T_{JMAX} = 125^{\circ}\text{C}$, $\theta_{JA} = 190^{\circ}\text{C/W}$</p> <p>* CONNECTED INTERNALLY. DO NOT CONNECT EXTERNAL CIRCUITRY TO THESE PINS</p> <p>** DNC FOR LTC1798-2.5/LTC1798-3/ LTC1798-4.1/LTC1798-5, FB FOR LTC1798</p> | ORDER PART NUMBER |
| | LTC1798CS8 LTC1798CS8-2.5 LTC1798CS8-3 LTC1798CS8-4.1 LTC1798CS8-5 |
| | S8 PART MARKING |
| | 1798 179825 17983 179841 17985 |

Consult factory for parts specified with wider operating temperature range.

AVAILABLE OPTIONS

| OUTPUT VOLTAGE (V) | TEMPERATURE RANGE (°C) | ACCURACY (%) | TEMPERATURE COEFFICIENT (ppm/°C) | PACKAGE TYPE | |
|--------------------|------------------------|--------------|----------------------------------|----------------|--------------|
| | | | | SO-8 (S8) | |
| | | | | ORDER NUMBER | PART MARKING |
| 2.5 | 0 to 70 | 0.15 | 40 | LTC1798CS8-2.5 | 179825 |
| 3 | 0 to 70 | 0.15 | 40 | LTC1798CS8-3 | 17983 |
| 4.096 | 0 to 70 | 0.15 | 40 | LTC1798CS8-4.1 | 179841 |
| 5 | 0 to 70 | 0.15 | 40 | LTC1798CS8-5 | 17985 |
| Adjustable | 0 to 70 | 0.4 | 40 | LTC1798CS8 | 1798 |

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full specified temperature range, otherwise specifications are at $T_A = 25^{\circ}\text{C}$. $V_{IN} = V_{OUT(NOMINAL)} + 0.2\text{V}$, $I_{OUT} = 0\text{mA}$ unless otherwise noted. FB = OUT for the LTC1798.

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|-----------|-------------------------|---------------------------|--------|-------|--------|---------------|
| V_{IN} | Input Voltage Range | | | | 12.6 | V |
| I_{IN} | Input Current | FB = OUT for LTC1798 | | 4.0 | 6.5 | μA |
| | | | | | 8.5 | μA |
| V_{OUT} | Output Voltage (Note 4) | LTC1798, FB = OUT | 2.3755 | 2.385 | 2.3945 | V |
| | | LTC1798 ADJ | -0.4 | | 0.4 | % |
| | | LTC1798-2.5 | 2.4963 | 2.5 | 2.5037 | V |
| | | LTC1798-3 | 2.9955 | 3 | 3.0045 | V |
| | | LTC1798-4.1 | 4.090 | 4.096 | 4.102 | V |
| | | LTC1798-5 | 4.9925 | 5 | 5.0075 | V |
| | | LTC1798 All Fixed Options | -0.15 | | 0.15 | % |

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full specified temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $V_{IN} = V_{OUT(NOMINAL)} + 0.2\text{V}$, $I_{OUT} = 0\text{mA}$ unless otherwise noted. FB = OUT for the LTC1798.

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|-------------------|--|---|-----|------|-----|-----------------------|
| e_n | Output Voltage Noise (Note 5) | $0.1\text{Hz} \leq f \leq 10\text{Hz}$ | | 8 | | ppm _{p-p} |
| TC | Output Voltage Temp Coefficient (Note 6) | $T_{MIN} \leq T_J \leq T_{MAX}$ | ● | 15 | 40 | ppm/ $^\circ\text{C}$ |
| V_{OUT}/V_{IN} | Line Regulation | $V_{IN} = (V_{OUT(NOMINAL)} + 0.2\text{V})$ to 12.6V | ● | 30 | 120 | ppm/V |
| V_{OUT}/I_{OUT} | Load Regulation (Note 7) | Sourcing 0mA to 10mA | ● | 0.1 | 0.3 | mV/mA |
| | | Sinking 0mA to 2mA | ● | 1.75 | 4.0 | mV/mA |
| I_{SC} | Short-Circuit Output Current | V_{OUT} Shorted to GND | | 20 | 40 | mA |
| | | V_{OUT} Shorted to V_{IN} | | 2 | 4 | mA |
| ΔV_{DO} | Dropout Voltage (Note 8) | $I_{OUT} = 0$, $\Delta V_{OUT} \leq 0.1\%$ | ● | | 100 | mV |
| | | $I_{OUT} = 10\text{mA}$, $\Delta V_{OUT} \leq 0.1\%$ | ● | | 200 | mV |
| V_{HYST} | Output Hysteresis (Note 9) | $\Delta T = -40^\circ\text{C}$ to 85°C | | 200 | | ppm |
| | | $\Delta T = 0^\circ\text{C}$ to 70°C | | 50 | | ppm |
| I_{FB} | FB Pin Input Current | LTC1798, OUT = FB | | 10 | | nA |

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

Note 2: The LTC1798 is guaranteed functional over the operating temperature range of -40°C to 100°C .

Note 3: If the part is stored outside of the specified operating temperature range, the output may shift due to hysteresis.

Note 4: ESD (Electrostatic Discharge) sensitive device. Extensive use of ESD protection devices are used internal to the LTC1798, however, high electrostatic discharge can damage or degrade the device. Use proper ESD handling precautions.

Note 5: Peak-to-peak noise is measured with a single pole highpass filter at 0.1Hz and 2-pole lowpass filter at 10Hz.

Note 6: Temperature coefficient is the change in output voltage divided by the nominal output voltage divided by the specified temperature range.

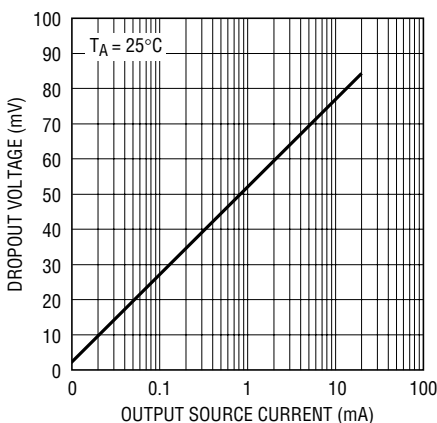
Note 7: Load regulation is measured on a pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.

Note 8: Dropout voltage is $(V_{IN} - V_{OUT})$ when V_{OUT} falls to 0.1% below its nominal value at $V_{IN} = V_{OUT} + 0.5\text{V}$.

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 hot or cold before successive measurements. Hysteresis is not normally a problem for operational temperature excursions where the instrument might be stored at high or low temperature.

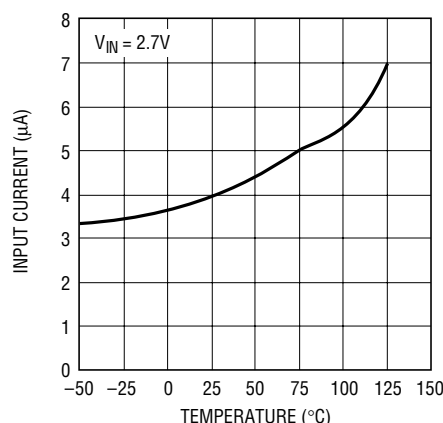
TYPICAL PERFORMANCE CHARACTERISTICS

LTC1798-2.5* Dropout Voltage vs Output Source Current



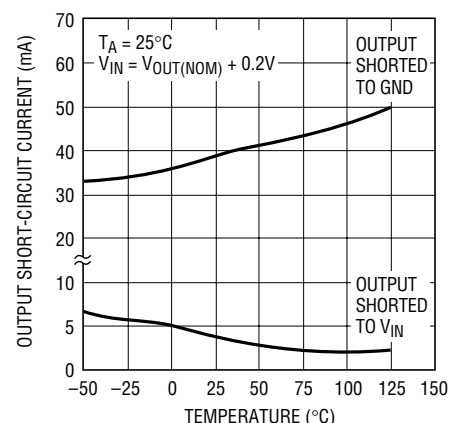
1798 G01

LTC1798-2.5* Input Current vs Temperature



1798 G02

LTC1798 Series Output Short-Circuit Current vs Temperature

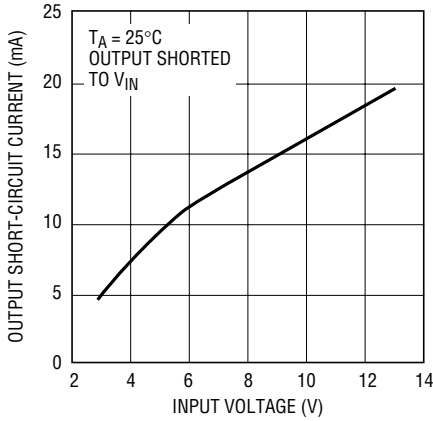


1798 G03

*Similar performance characteristics can be expected for all voltage options.

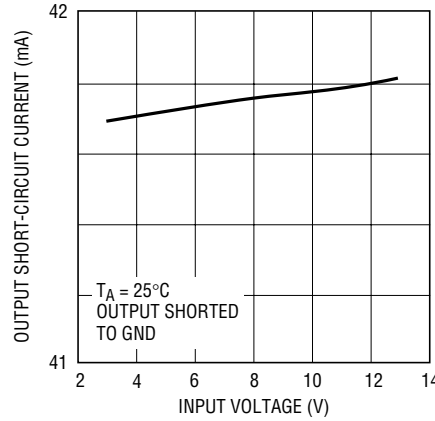
TYPICAL PERFORMANCE CHARACTERISTICS

LTC1798-2.5* Output Short-Circuit Current vs Input Voltage



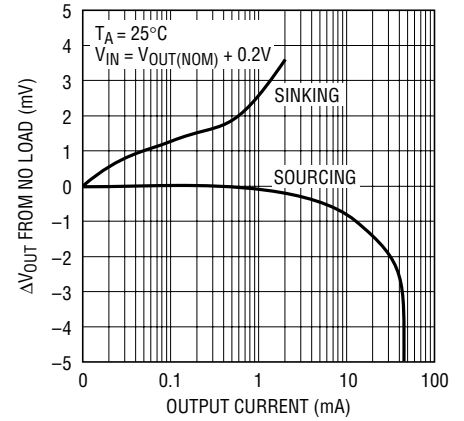
1258-G04

LTC1798-2.5* Output Short-Circuit Current vs Input Voltage



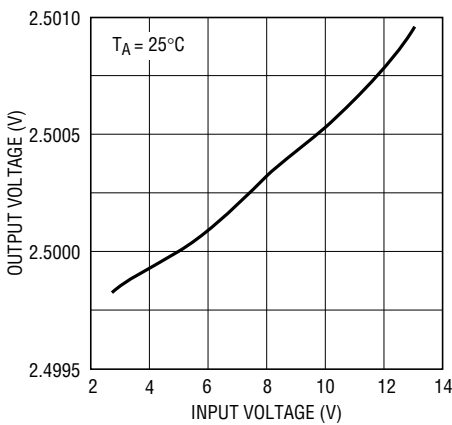
1798 G05

LTC1798 Series Load Regulation



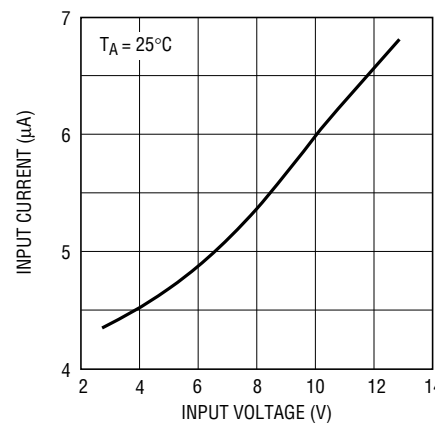
1798 G06

LTC1798-2.5* Output Voltage vs Input Voltage



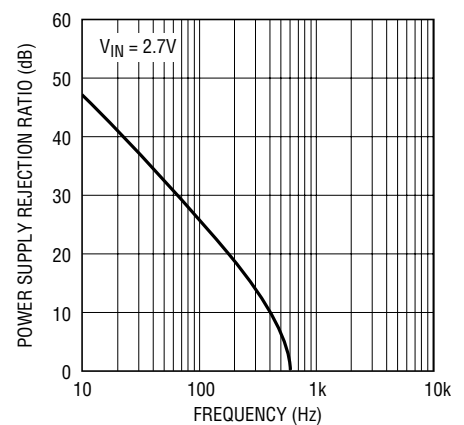
1798 G07

LTC1798-2.5* Input Current vs Input Voltage



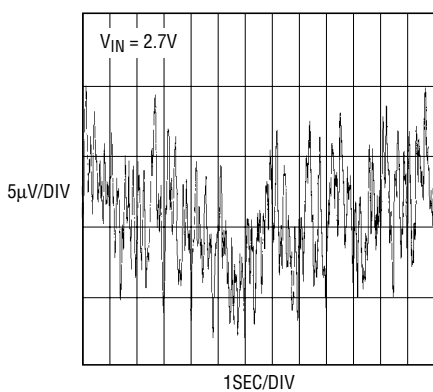
1798 G08

LTC1798-2.5 PSRR vs Frequency



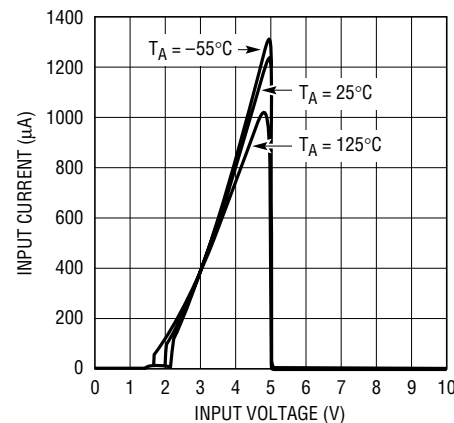
1798 G09

LTC1798-2.5 0.1Hz to 10Hz Noise



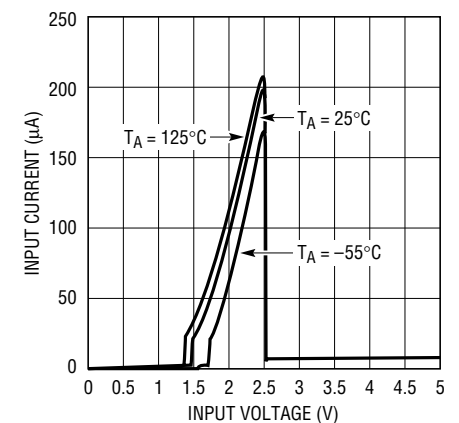
1798 G10

LTC1798-5 Input Current vs Input Voltage in Dropout



1798 G11

LTC1798-2.5 Input Current vs Input Voltage in Dropout



1798 G12

PIN FUNCTIONS

DNC (Pins 1, 5, 7, 8): Do Not Connect. Connected internally for post package trim. These pins must be left unconnected.

IN (Pin 2): Positive Supply. Bypassing with a 0.1 μ F capacitor is recommended if the output loading changes. $(V_{OUT} + 0.2V) \leq V_{IN} \leq 12.6V$.

DNC (Pin 3): (LTC1798-2.5/LTC1798-3/LTC1798-4.1/LTC1798-5) Do Not Connect. Connected internally for post package trim. This pin must be left unconnected.

FB (Pin 3): (LTC1798) Resistor Divider Feedback Pin. Connect a resistor divider from OUT to GND and the center tap to FB. This pin sets the output potential.

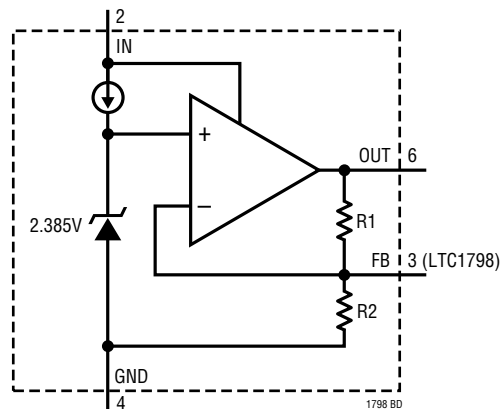
$$V_{OUT} = 2.385V \left(\frac{R1 + R2}{R2} \right); R1 \text{ is connected from OUT}$$

to FB and R2 from FB to GND. Selecting $R2 \geq 10k$ will make $I_{OUT} < 250\mu A$.

GND (Pin 4): Negative Supply or Ground Connection.

OUT (Pin 6): Reference Output. The output can source up to 10mA and sink up to 2mA. It is stable with output bypass capacitor ranging from 0 μ F to 1 μ F.

BLOCK DIAGRAM



NOTE: R1 AND R2 ARE NOT CONNECTED FOR LTC1798

APPLICATIONS INFORMATION

Longer Battery Life

Series references have an advantage over shunt style references. To operate, shunt references require a resistor between the power supply and the output. This resistor must be chosen to supply the maximum current that is 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 power dissipation and short battery life.

The LTC1798 series low dropout references do not require a current setting resistor and can operate with any supply voltage from ($V_{OUT(NOMINAL)} + 0.2V$) to 12.6V. When the circuitry being regulated does not demand current, the LTC1798 series reduces its dissipation and battery life is extended. If the reference is not delivering load current it dissipates only $10.8\mu W$ when operating on a 2.7V supply for LTC1798-2.5, yet the same connection can deliver 10mA of load current when demanded.

Output Bypass Capacitor

The LTC1798 series is designed to be stable with or without capacitive loads. With no capacitive load, the reference is ideal for fast settling applications, or where PC board space is at a premium.

In applications with significant output loading changes, an output bypass capacitor of up to $1\mu F$ can be used to improve the output transient response. Figure 1 shows the response of the reference to a 1mA to 0 μA load step with a $1\mu F$ output capacitor. If more than $1\mu F$ of output

capacitance is required, a resistor in series with the capacitor is recommended to reduce the output ringing. Figure 2 illustrates the use of a damping resistor for capacitive loads greater than $1\mu F$. Figure 3 shows the resistor and capacitor values required to achieve critical damping.

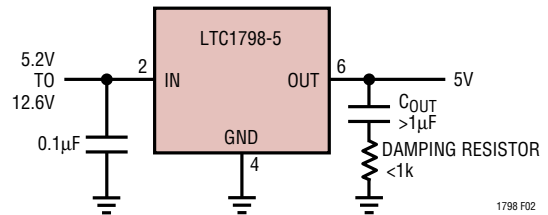


Figure 2. Adding a Damping Resistor with Output Capacitors Greater Than $1\mu F$

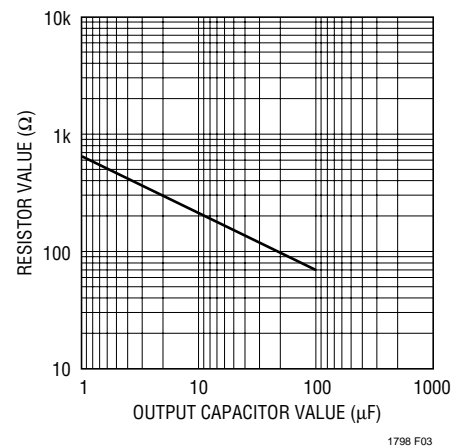
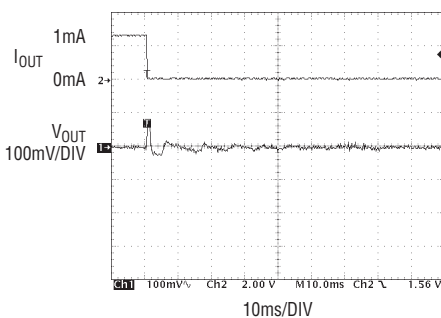
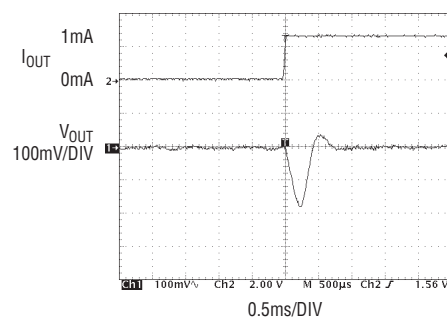


Figure 3. Damping Resistance vs Output Capacitor Value



1798 F01a



1798 F01b

Figure 1. Reference Output Load Transient Response, $1\mu F$ Output Capacitor

APPLICATIONS INFORMATION

Internal P-Channel Pass Transistor

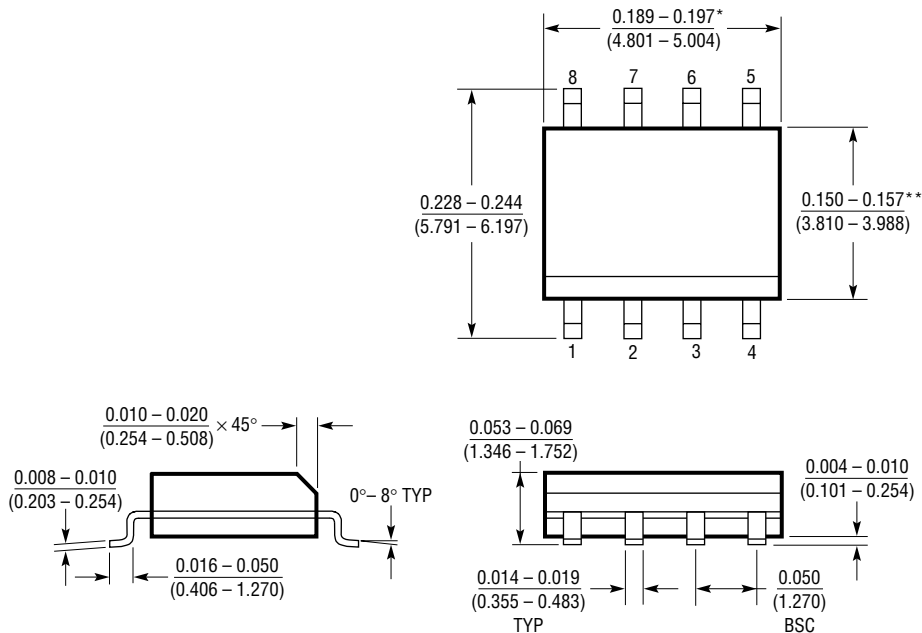
The LTC1798 series features an internal P-channel MOSFET pass transistor. This provides several advantages over similar designs using a PNP bipolar pass transistor.

These references consume only 4 μ A of quiescent current under light and heavy loads as well as in dropout; whereas, PNP-based references waste considerable amounts of current when the pass transistor is saturated. In addition, the LTC1798 series provides a lower dropout voltage (200mV max) than PNP-based references.

PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

S8 Package
8-Lead Plastic Small Outline (Narrow 0.150)
 (LTC DWG # 05-08-1610)



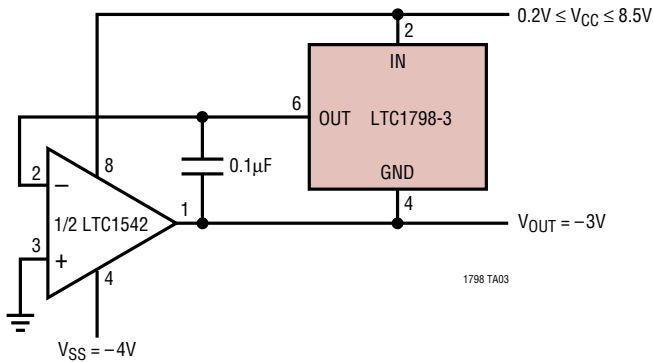
* DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

** DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

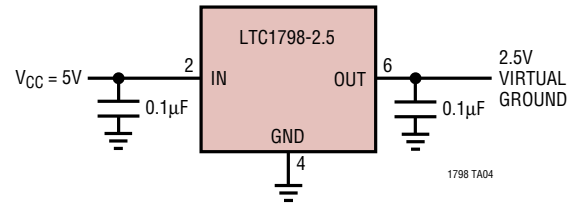
S08 1298

TYPICAL APPLICATIONS

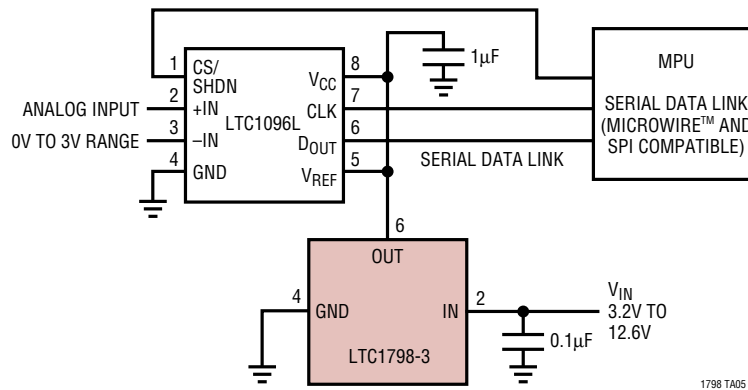
Micropower Low Dropout Negative Reference



Supply Splitter



Low Power, Low Voltage Supply Reference for LTC1096L



MICROWIRE is a trademark of National Semiconductor Corporation.

RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|----------------------|---|---|
| LT [®] 1389 | Nanopower Precision Shunt Voltage Reference | 800nA Quiescent Current, 0.05% Max, 10ppm/°C Max Drift 1.25V and 2.5V Versions, SO-8 Package |
| LT1634 | Micropower Precision Shunt Voltage Reference | 0.05% Max, 25ppm/°C Max Drift, 1.25V, 2.5V, 4.096V and 5V Outputs |
| LT1460 | Micropower Series Reference | 0.075% Max, 10ppm/°C Max Drift, 2.5V, 5V and 10V Outputs |
| LT1461 | Micropower Precision Series Voltage Reference | 0.04% Max, 3ppm/°C Max Drift, 35µA Quiescent Current |
| LT1790 | SOT-23, LDO Precision Micropower Reference | 0.05% Max, 10ppm/°C Max, 2.5V, 60µA Supply |