

2.5V and 4.096V Voltage References

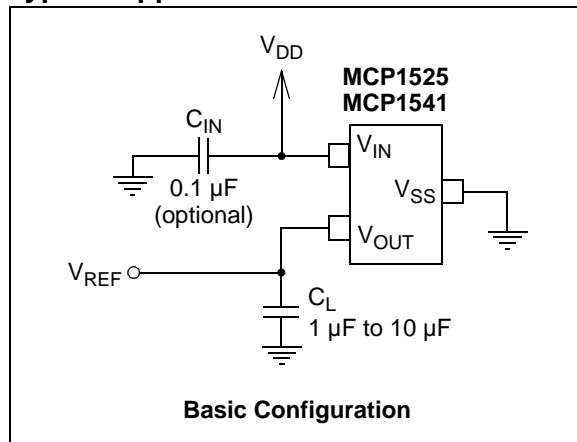
Features

- Precision Voltage Reference
- Output Voltages: 2.5V and 4.096V
- Initial Accuracy: $\pm 1\%$ (max.)
- Temperature Drift: ± 50 ppm/ $^{\circ}\text{C}$ (max.)
- Output Current Drive: ± 2 mA
- Maximum Input Current: 100 μA @ +25 $^{\circ}\text{C}$ (max.)
- Packages: TO-92 and SOT-23-3
- Industrial Temperature Range: -40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$

Applications

- Battery-powered Systems
- Handheld Instruments
- Instrumentation and Process Control
- Test Equipment
- Data Acquisition Systems
- Communications Equipment
- Medical Equipment
- Precision Power supplies
- 8-bit, 10-bit, 12-bit A/D Converters (ADCs)
- D/A Converters (DACs)

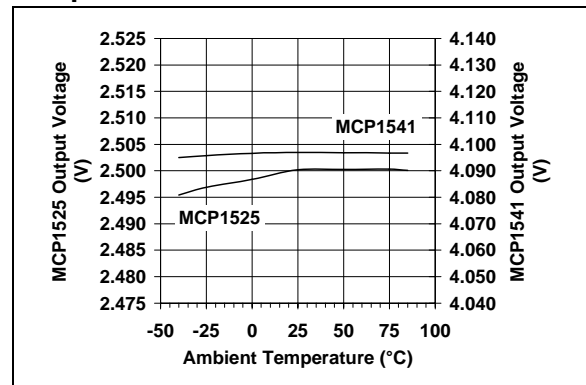
Typical Application Circuit



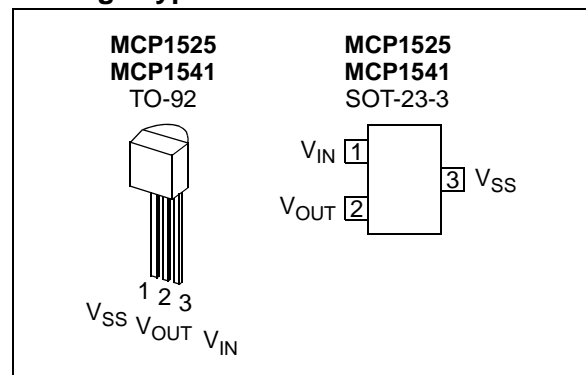
Description

The Microchip Technology Inc. MCP1525/41 devices are 2.5V and 4.096V precision voltage references that use a combination of an advanced CMOS circuit design and EPROM trimming to provide an initial tolerance of $\pm 1\%$ (max.) and temperature stability of ± 50 ppm/ $^{\circ}\text{C}$ (max.). In addition to a low quiescent current of 100 μA (max.) at 25 $^{\circ}\text{C}$, these devices offer a clear advantage over the traditional Zener techniques in terms of stability across time and temperature. The output voltage is 2.5V for the MCP1525 and 4.096V for the MCP1541. These devices are offered in SOT-23-3 and TO-92 packages, and are specified over the industrial temperature range of -40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$.

Temperature Drift



Package Types



MCP1525/41

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

$V_{IN} - V_{SS}$	7.0V
Input Current (V_{IN})	20 mA
Output Current (V_{OUT})	±20 mA
Continuous Power Dissipation ($T_A = 125^\circ\text{C}$).....	140 mW
All Inputs and Outputs	$V_{SS} - 0.6\text{V}$ to $V_{IN} + 1.0\text{V}$
Storage Temperature.....	-65°C to $+150^\circ\text{C}$
Maximum Junction Temperature (T_J).....	$+125^\circ\text{C}$
ESD protection on all pins (HBM)	≥ 4 kV

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

DC ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Unless otherwise indicated, $T_A = +25^\circ\text{C}$, $V_{IN} = 5.0\text{V}$, $V_{SS} = \text{GND}$, $I_{OUT} = 0\text{ mA}$ and $C_L = 1\ \mu\text{F}$.						
Parameter	Sym	Min	Typ	Max	Units	Conditions
Output						
Output Voltage, MCP1525	V_{OUT}	2.475	2.5	2.525	V	$2.7\text{V} \leq V_{IN} \leq 5.5\text{V}$
Output Voltage, MCP1541	V_{OUT}	4.055	4.096	4.137	V	$4.3\text{V} \leq V_{IN} \leq 5.5\text{V}$
Output Voltage Drift	TCV_{OUT}	—	27	50	ppm/ $^\circ\text{C}$	$T_A = -40^\circ\text{C}$ to 85°C (Note 1)
Long-Term Output Stability	V_{OUT}	—	2	—	ppm/hr	Exposed 1008 hrs @ $+125^\circ\text{C}$ (see Figure 1-1), measured @ $+25^\circ\text{C}$
Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	—	0.5	1	mV/mA	$I_{OUT} = 0\text{ mA}$ to -2 mA
	$\Delta V_{OUT}/\Delta I_{OUT}$	—	0.6	1	mV/mA	$I_{OUT} = 0\text{ mA}$ to 2 mA
	$\Delta V_{OUT}/\Delta I_{OUT}$	—	—	1.3	mV/mA	$I_{OUT} = 0\text{ mA}$ to -2 mA , $T_A = -40^\circ\text{C}$ to 85°C
	$\Delta V_{OUT}/\Delta I_{OUT}$	—	—	1.3	mV/mA	$I_{OUT} = 0\text{ mA}$ to 2 mA , $T_A = -40^\circ\text{C}$ to 85°C
Output Voltage Hysteresis	V_{HYS}	—	115	—	ppm	Note 2
Maximum Load Current	I_{SC}	—	±8	—	mA	$T_A = -40^\circ\text{C}$ to 85°C , $V_{IN} = 5.5\text{V}$
Input-to-Output						
Dropout Voltage	V_{DROP}	—	137	—	mV	$I_{OUT} = 2\text{ mA}$
Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	—	107	300	$\mu\text{V}/\text{V}$	$V_{IN} = 2.7\text{V}$ to 5.5V for MCP1525 , $V_{IN} = 4.3\text{V}$ to 5.5V for MCP1541
	$\Delta V_{OUT}/\Delta V_{IN}$	—	—	350	$\mu\text{V}/\text{V}$	$V_{IN} = 2.7\text{V}$ to 5.5V for MCP1525 , $V_{IN} = 4.3\text{V}$ to 5.5V for MCP1541 , $T_A = -40^\circ\text{C}$ to 85°C
Input						
Input Voltage, MCP1525	V_{IN}	2.7	—	5.5	V	$T_A = -40^\circ\text{C}$ to 85°C
Input Voltage, MCP1541	V_{IN}	4.3	—	5.5	V	$T_A = -40^\circ\text{C}$ to 85°C
Input Current	I_{IN}	—	86	100	μA	No load
	I_{IN}	—	95	120	μA	No load, $T_A = -40^\circ\text{C}$ to 85°C

Note 1: Output temperature coefficient is measured using a “box” method, where the $+25^\circ\text{C}$ output voltage is trimmed as close to typical as possible. The 85°C output voltage is then again trimmed to zero out the tempco.

Note 2: Output Voltage Hysteresis is defined as the change in output voltage measured at $+25^\circ\text{C}$ before and after cycling the temperature to $+85^\circ\text{C}$ and -40°C ; refer to **Section 1.1.10 “Output Voltage Hysteresis”**.

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1.1.4 DROPOUT VOLTAGE

The dropout voltage of these devices is measured by reducing V_{IN} to the point where the output drops by 1%. Under these conditions the dropout voltage is equal to:

EQUATION 1-2:

$$V_{DROPOUT} = V_{IN} - V_{OUT}$$

The dropout voltage is affected by ambient temperature and load current.

In Figure 2-18, the dropout voltage is shown over a negative and positive range of output current. For currents above zero milliamps, the dropout voltage is positive. In this case, the voltage reference is primarily powered by V_{IN} . With output currents below zero milliamps, the dropout voltage is negative. As the output current becomes more negative, the input current (I_{IN}) reduces. Under this condition, the output current begins to provide the needed power to the voltage reference.

1.1.5 LINE REGULATION

Line regulation is a measure of the change in output voltage (V_{OUT}) as a function of a change in the input voltage (V_{IN}). This is expressed as $\Delta V_{OUT}/\Delta V_{IN}$ and is measured in either $\mu V/V$ or ppm. For example, a 1 μV change in V_{OUT} caused by a 500 mV change in V_{IN} would net a $\Delta V_{OUT}/\Delta V_{IN}$ of 2 $\mu V/V$, or 2 ppm.

1.1.6 LOAD REGULATION ($\Delta V_{OUT}/\Delta I_{OUT}$)

Load regulation is a measure of the change in the output voltage (V_{OUT}) as a function of the change in output current (I_{OUT}). Load regulation is usually measured in mV/mA.

1.1.7 INPUT CURRENT

The input current (operating current) is the current that sinks from V_{IN} to V_{SS} without a load current on the output pin. This current is affected by temperature and the output current.

1.1.8 INPUT VOLTAGE REJECTION RATIO

The Input Voltage Rejection Ratio (IVRR) is a measure of the change in output voltage versus the change in input voltage over frequency, as shown in Figure 2-7. The calculation used for this plot is:

EQUATION 1-3:

$$IVRR = 20 \log \left| \frac{V_{IN}}{V_{OUT}} \right| \text{ (dB)}$$

1.1.9 LONG-TERM OUTPUT STABILITY

The long-term output stability is measured by exposing the devices to an ambient temperature of 125°C (Figure 2-9) while configured in the circuit shown in Figure 1-1. In this test, all electrical specifications of the devices are measured periodically at +25°C.

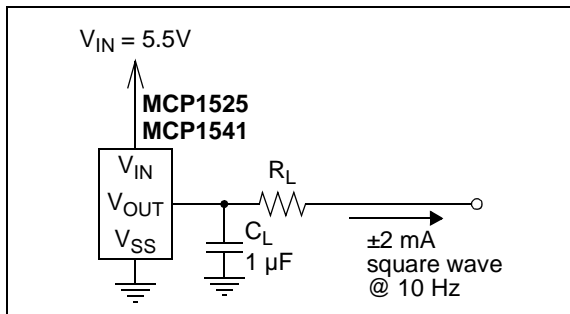


FIGURE 1-1: Dynamic Life Test Configuration.

1.1.10 OUTPUT VOLTAGE HYSTERESIS

The output voltage hysteresis is a measure of the output voltage error once the powered devices are cycled over the entire operating temperature range. The amount of hysteresis can be quantified by measuring the change in the +25°C output voltage after temperature excursions from +25°C to +85°C to +25°C and also from +25°C to -40°C to +25°C.

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise indicated, $T_A = +25^\circ\text{C}$, $V_{IN} = 5.0\text{V}$, $V_{SS} = \text{GND}$, $I_{OUT} = 0\text{ mA}$ and $C_L = 1\ \mu\text{F}$.

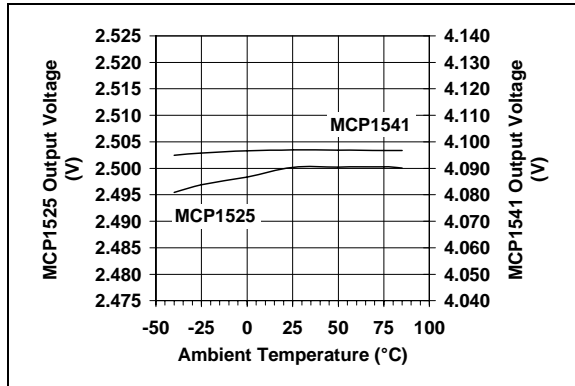


FIGURE 2-1: Output Voltage vs. Ambient Temperature.

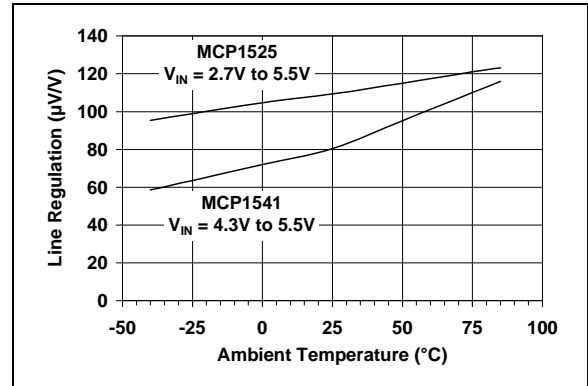


FIGURE 2-4: Line Regulation vs. Ambient Temperature.

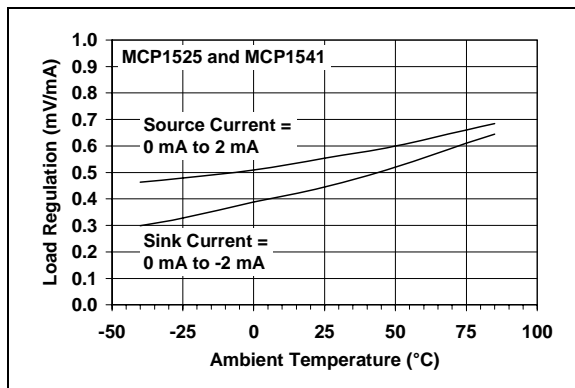


FIGURE 2-2: Load Regulation vs. Ambient Temperature.

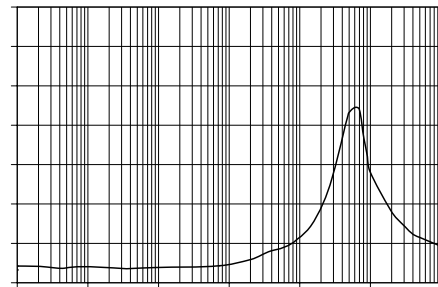


FIGURE 2-5: Output Impedance vs. Frequency.

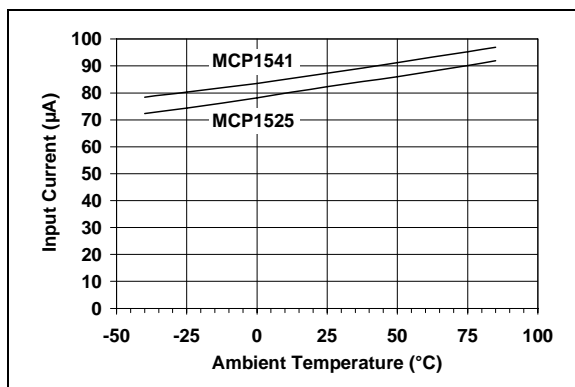


FIGURE 2-3: Input Current vs. Ambient Temperature.

FIGURE 2-6: Output Noise Voltage Density vs. Frequency.

MCP1525/41

Note: Unless otherwise indicated, $T_A = +25^\circ\text{C}$, $V_{IN} = 5.0\text{V}$, $V_{SS} = \text{GND}$, $I_{OUT} = 0\text{ mA}$ and $C_L = 1\text{ }\mu\text{F}$.

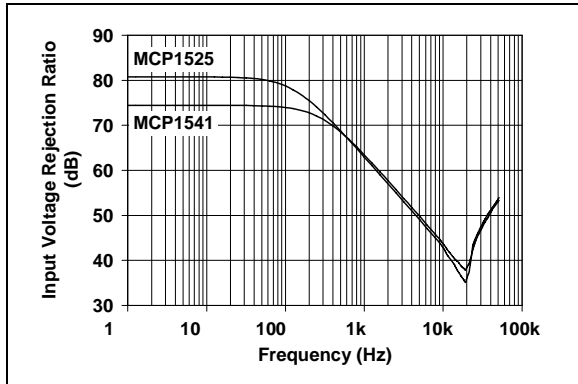


FIGURE 2-7: Input Voltage Rejection Ratio vs. Frequency.

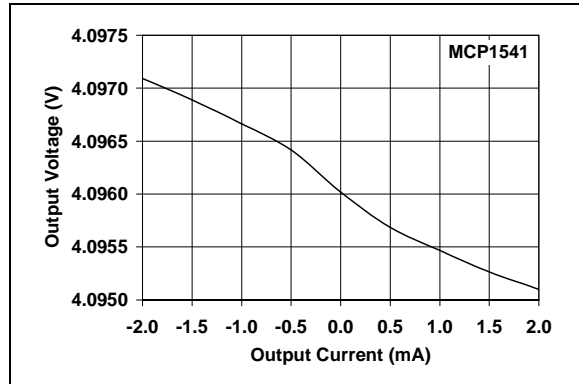


FIGURE 2-10: MCP1541 Output Voltage vs. Output Current.

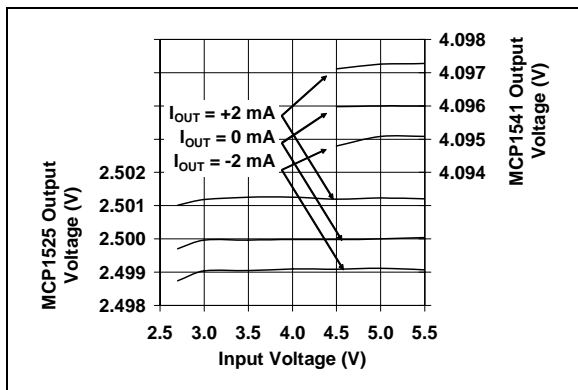


FIGURE 2-8: Output Voltage vs. Input Voltage.

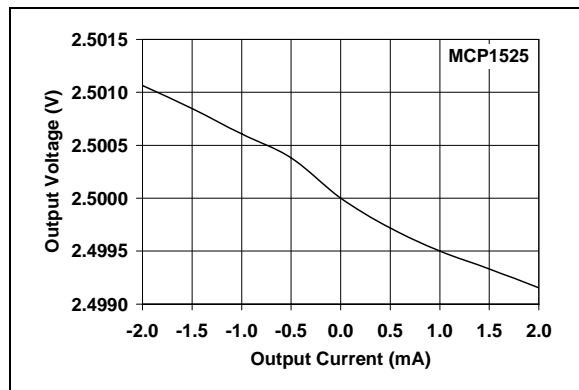


FIGURE 2-11: MCP1525 Output Voltage vs. Output Current.

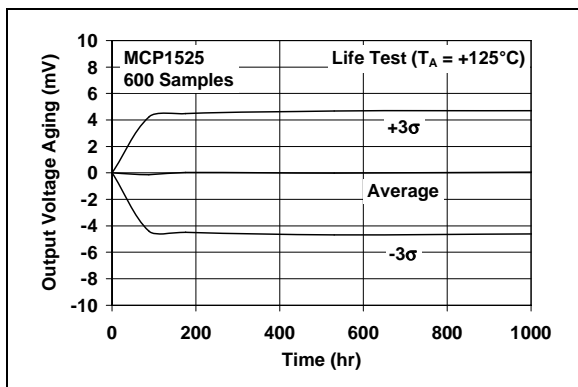


FIGURE 2-9: Output Voltage Aging vs. Time (MCP1525 Device Life Test data).

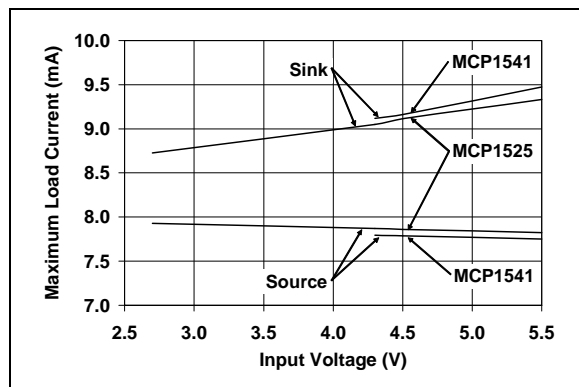


FIGURE 2-12: Maximum Load Current vs. Input Voltage.

Note: Unless otherwise indicated, $T_A = +25^\circ\text{C}$, $V_{IN} = 5.0\text{V}$, $V_{SS} = \text{GND}$, $I_{OUT} = 0\text{ mA}$ and $C_L = 1\ \mu\text{F}$.

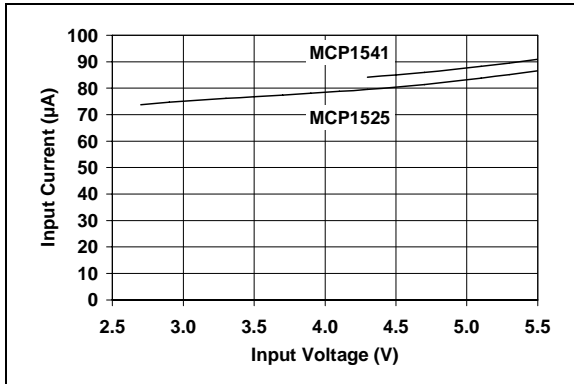


FIGURE 2-13: Input Current vs. Input Voltage.

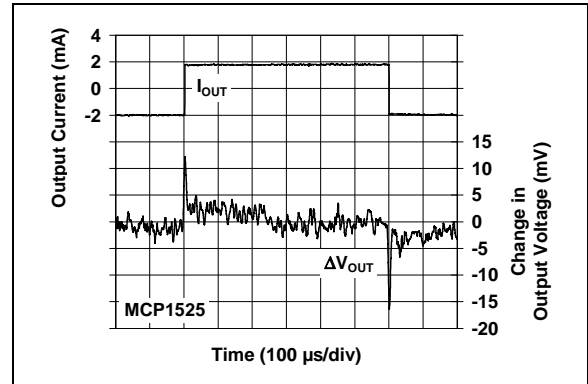


FIGURE 2-16: MCP1525 Load Transient Response.

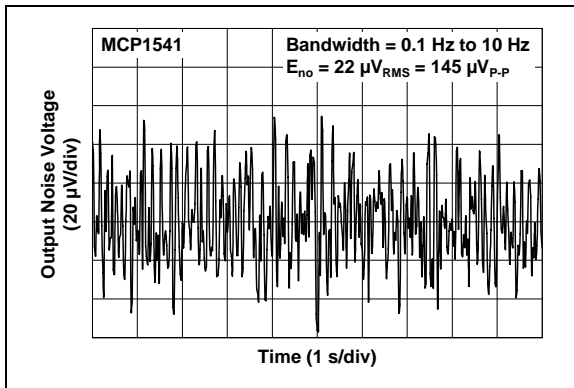


FIGURE 2-14: MCP1541 0.1 Hz to 10 Hz Output Noise.

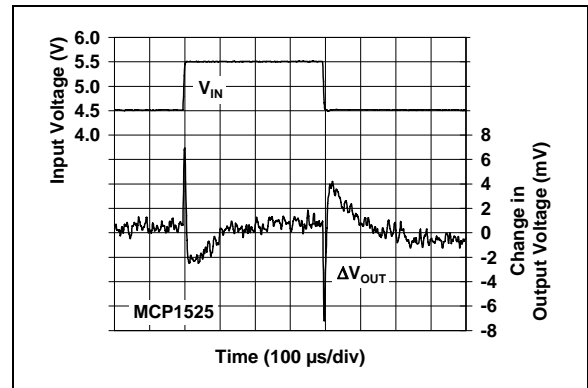


FIGURE 2-17: MCP1525 Line Transient Response.

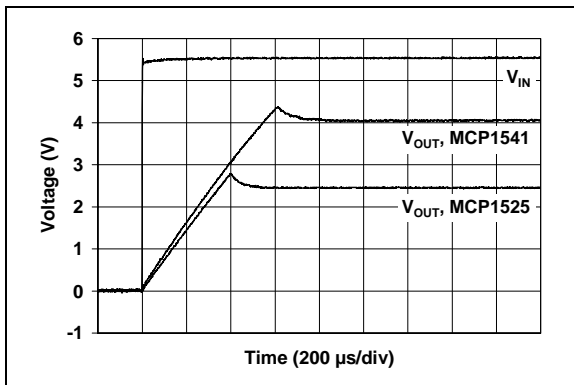


FIGURE 2-15: Turn-on Transient Time.

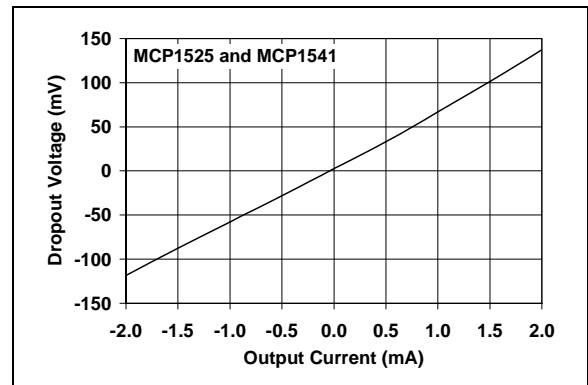


FIGURE 2-18: Dropout Voltage vs. Output Current.

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3.0 PIN DESCRIPTIONS

Descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE.

MCP1525, MCP1541 (TO-92-3)	MCP1525, MCP1541 (SOT-23-3)	Symbol	Description
3	1	V_{IN}	Input Voltage (or Positive Power Supply)
2	2	V_{OUT}	Output Voltage (or Reference Voltage)
1	3	V_{SS}	Ground (or Negative Power Supply)

3.1 Input Voltage (V_{IN})

V_{IN} functions as the positive power supply input (or operating input). An optional 0.1 μF ceramic capacitor can be placed at this pin if the input voltage is too noisy; it needs to be within 5 mm of this pin. The input voltage needs to be at least 0.2V higher than the output voltage for normal operation.

3.2 Output Voltage (V_{OUT})

V_{OUT} is an accurate reference voltage output. It can source and sink small currents, and has a low output impedance. A load capacitor between 1 μF and 10 μF needs to be located within 5 mm of this pin.

3.3 Ground (V_{SS})

Normally connected directly to ground. It can be placed at another voltage as long as all of the voltages shift with it, and proper bypassing is observed.

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4.2 Typical Application Circuits

4.2.1 NEGATIVE VOLTAGE REFERENCE

A negative precision voltage reference can be generated by using the MCP1525 or MCP1541 in the configuration shown in Figure 4-3.

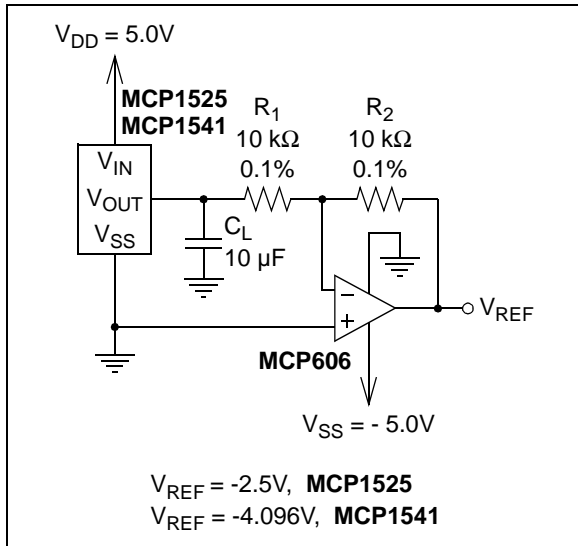


FIGURE 4-3: Negative Voltage Reference.

In this circuit, the voltage inversion is implemented using the MCP606 and two equal resistors. The voltage at the output of the MCP1525 or MCP1541 voltage reference drives R_1 , which is connected to the inverting input of the MCP606 amplifier. Since the non-inverting input of the amplifier is biased to ground, the inverting input will also be close to ground potential. The second 10 kΩ resistor is placed around the feedback loop of the amplifier. Since the inverting input of the amplifier is high-impedance, the current generated through R_1 will also flow through R_2 . As a consequence, the output voltage of the amplifier is equal to -2.5V for the MCP1525 and -4.1V for the MCP1541.

4.2.2 A/D CONVERTER REFERENCE

The MCP1525 and MCP1541 were carefully designed to provide a voltage reference for Microchip's 10-bit and 12-bit families of ADCs. The circuit shown in Figure 4-4 shows a MCP1541 configured to provide the reference to the MCP3201, a 12-bit ADC.

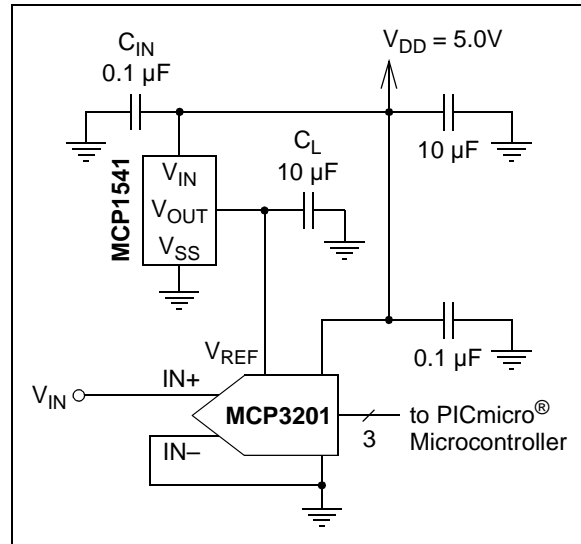
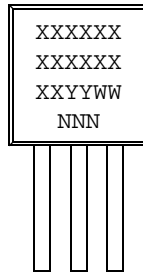


FIGURE 4-4: ADC Reference Circuit.

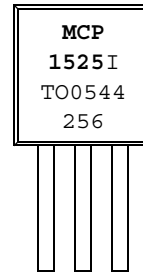
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

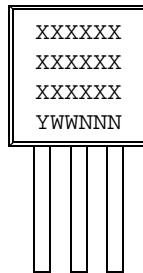
3-Lead TO-92 (Leaded)



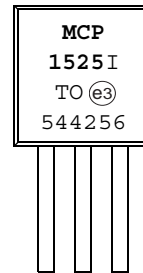
Example:



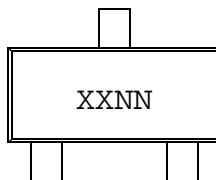
3-Lead TO-92 (Lead Free)



Example:

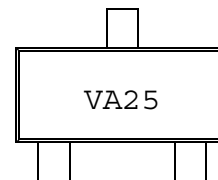


3-Lead SOT-23-3



Device	I-Temp Code
MCP1525	VANN
MCP1541	VBNN

Example:



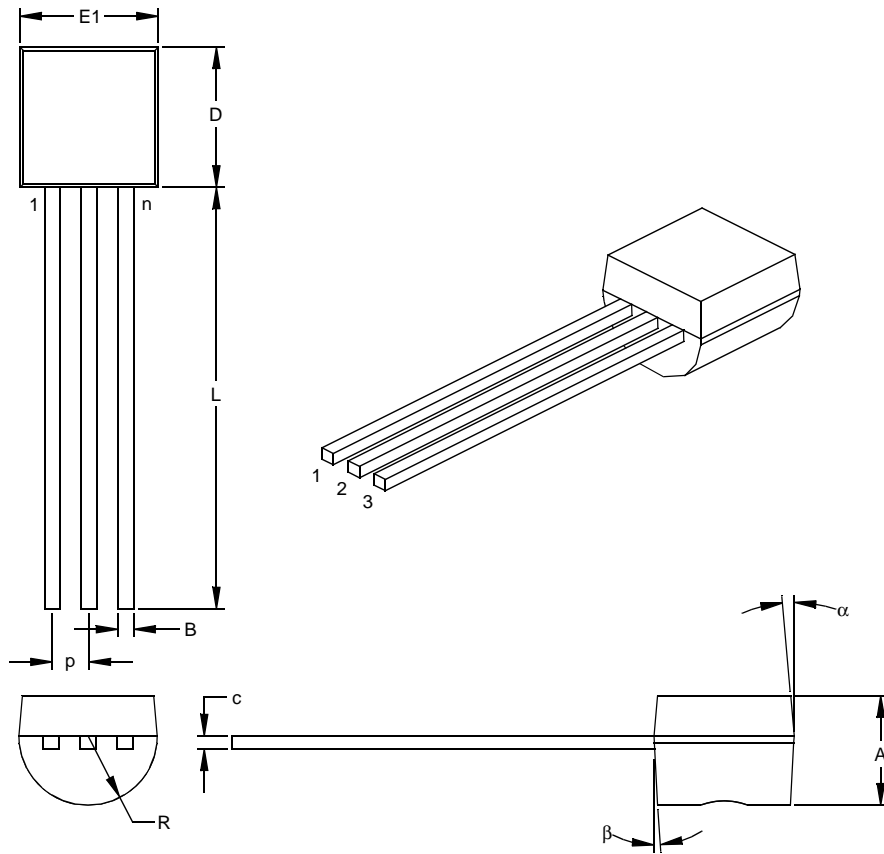
Note: Applies to 3-Lead SOT-23.

Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

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3-Lead Plastic Transistor Outline (TO) (TO-92)



Dimension Limits	Units	INCHES*			MILLIMETERS		
		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		3			3	
Pitch	p		.050			1.27	
Bottom to Package Flat	A	.130	.143	.155	3.30	3.62	3.94
Overall Width	E1	.175	.186	.195	4.45	4.71	4.95
Overall Length	D	.170	.183	.195	4.32	4.64	4.95
Molded Package Radius	R	.085	.090	.095	2.16	2.29	2.41
Tip to Seating Plane	L	.500	.555	.610	12.70	14.10	15.49
Lead Thickness	c	.014	.017	.020	0.36	0.43	0.51
Lead Width	B	.016	.019	.022	0.41	0.48	0.56
Mold Draft Angle Top	α	4	5	6	4	5	6
Mold Draft Angle Bottom	β	2	3	4	2	3	4

*Controlling Parameter

Notes:

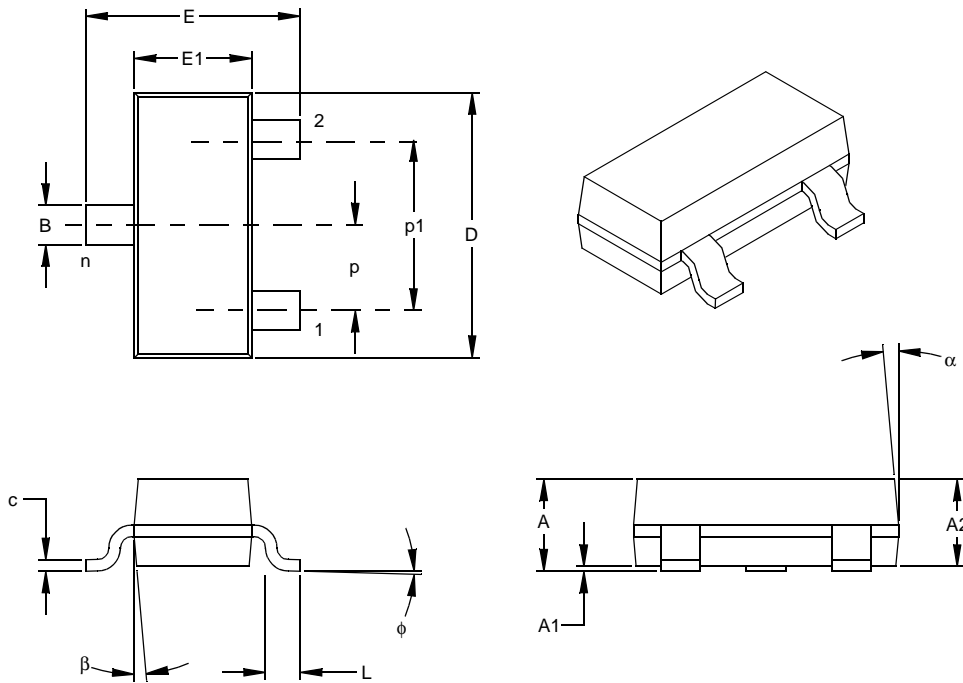
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed

.010" (0.254mm) per side.

JEDEC Equivalent: TO-92

Drawing No. C04-101

3-Lead Plastic Small Outline Transistor (TT) (SOT23)



Units		INCHES*			MILLIMETERS		
Dimension	Limits	MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		3			3	
Pitch	p		.038			0.96	
Outside lead pitch (basic)	p1		.076			1.92	
Overall Height	A	.035	.040	.044	0.89	1.01	1.12
Molded Package Thickness	A2	.035	.037	.040	0.88	0.95	1.02
Standoff §	A1	.000	.002	.004	0.01	0.06	0.10
Overall Width	E	.083	.093	.104	2.10	2.37	2.64
Molded Package Width	E1	.047	.051	.055	1.20	1.30	1.40
Overall Length	D	.110	.115	.120	2.80	2.92	3.04
Foot Length	L	.014	.018	.022	0.35	0.45	0.55
Foot Angle	φ	0	5	10	0	5	10
Lead Thickness	c	.004	.006	.007	0.09	0.14	0.18
Lead Width	B	.015	.017	.020	0.37	0.44	0.51
Mold Draft Angle Top	α	0	5	10	0	5	10
Mold Draft Angle Bottom	β	0	5	10	0	5	10

* Controlling Parameter
 § Significant Characteristic

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

JEDEC Equivalent: TO-236

Drawing No. C04-104

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NOTES:

APPENDIX A: REVISION HISTORY

Revision B (February 2005)

The following is the list of modifications:

1. Added bandwidth and capacitor specifications (**Section 1.0 “Electrical Characteristics”**).
2. Moved **Section 1.1 “Specification Descriptions and Test Circuits”** to the specifications section (**Section 1.0 “Electrical Characteristics”**).
3. Corrected plots in **Section 2.0 “Typical Performance Curves”**.
4. Added **Section 3.0 “Pin Descriptions”**.
5. Corrected package markings in **Section 5.0 “Packaging Information”**.
6. Added **Appendix A: “Revision History”**.

Revision A (July 2001)

- Original Release of this Document.

MCP1525/41

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	X	XX
Device	Temperature Range	Package
Device	MCP1525: = 2.5V Voltage Reference MCP1541: = 4.096 Voltage Reference	
Temperature Range	I = -40°C to +85°C	
Package	TO = TO-92, Plastic Transistor Outline, 3-Lead TT = SOT23, Plastic Small Outline Transistor, 3-Lead	

Examples:

- a) MCP1525T-I/TT: Tape and Reel, Industrial Temperature, SOT23 package.
- b) MCP1525-I/TO: Industrial Temperature, TO-92 package.
- c) MCP1541T-I/TT: Tape and Reel, Industrial Temperature, SOT23 package.
- d) MCP1541-I/TO: Industrial Temperature, TO-92 package.

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NOTES:

Note the following details of the code protection feature on Microchip devices:

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