

## 2.5V and 4.096V Voltage References

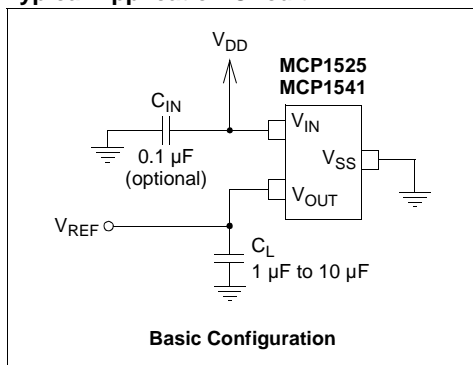
### Features

- Precision Voltage Reference
- Output Voltages: 2.5V and 4.096V
- Initial Accuracy:  $\pm 1\%$  (max.)
- Temperature Drift:  $\pm 50$  ppm/ $^{\circ}\text{C}$  (max.)
- Output Current Drive:  $\pm 2$  mA
- Maximum Input Current: 100  $\mu\text{A}$  @  $+25^{\circ}\text{C}$  (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)

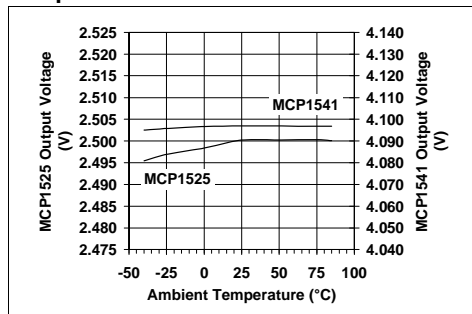
### Typical Application Circuit



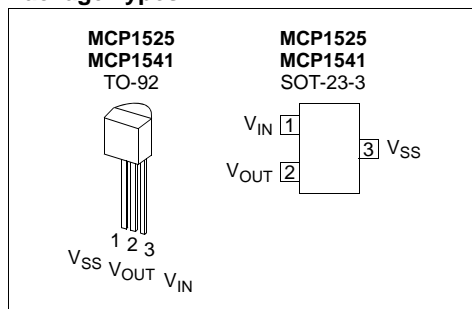
### Description

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  $\pm 50$  ppm/ $^{\circ}\text{C}$  (max.). In addition to a low quiescent current of 100  $\mu\text{A}$  (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°C                                  |
| Maximum Junction Temperature ( $T_J$ ).....                     | +125°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 $C_L = 1\text{ }\mu\text{F}$ . |                                 |       |       |       |                 |                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------|-------|-------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Parameter                                                                                                                                                                                       | Sym                             | Min   | Typ   | Max   | Units           | Conditions                                                                                                                                                                |
| <b>Output</b>                                                                                                                                                                                   |                                 |       |       |       |                 |                                                                                                                                                                           |
| Output Voltage, <b>MCP1525</b>                                                                                                                                                                  | $V_{OUT}$                       | 2.475 | 2.5   | 2.525 | V               | $2.7\text{V} \leq V_{IN} \leq 5.5\text{V}$                                                                                                                                |
| Output Voltage, <b>MCP1541</b>                                                                                                                                                                  | $V_{OUT}$                       | 4.055 | 4.096 | 4.137 | V               | $4.3\text{V} \leq V_{IN} \leq 5.5\text{V}$                                                                                                                                |
| Output Voltage Drift                                                                                                                                                                            | $\text{TCV}_{OUT}$              | —     | 27    | 50    | ppm/°C          | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ ( <b>Note 1</b> )                                                                                                         |
| 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 $-2\text{ mA}$                                                                                                                                 |
|                                                                                                                                                                                                 | $\Delta V_{OUT}/\Delta I_{OUT}$ | —     | 0.6   | 1     | mV/mA           | $I_{OUT} = 0\text{ mA}$ to $2\text{ mA}$                                                                                                                                  |
|                                                                                                                                                                                                 | $\Delta V_{OUT}/\Delta I_{OUT}$ | —     | —     | 1.3   | mV/mA           | $I_{OUT} = 0\text{ mA}$ to $-2\text{ mA}$ , $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                                               |
|                                                                                                                                                                                                 | $\Delta V_{OUT}/\Delta I_{OUT}$ | —     | —     | 1.3   | mV/mA           | $I_{OUT} = 0\text{ mA}$ to $2\text{ mA}$ , $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                                                |
| Output Voltage Hysteresis                                                                                                                                                                       | $V_{HYS}$                       | —     | 115   | —     | ppm             | <b>Note 2</b>                                                                                                                                                             |
| Maximum Load Current                                                                                                                                                                            | $I_{SC}$                        | —     | ±8    | —     | mA              | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ , $V_{IN} = 5.5\text{V}$                                                                                                  |
| <b>Input-to-Output</b>                                                                                                                                                                          |                                 |       |       |       |                 |                                                                                                                                                                           |
| Dropout Voltage                                                                                                                                                                                 | $V_{DROP}$                      | —     | 137   | —     | mV              | $I_{OUT} = 2\text{ mA}$                                                                                                                                                   |
| Line Regulation                                                                                                                                                                                 | $\Delta V_{OUT}/\Delta V_{IN}$  | —     | 107   | 300   | $\mu\text{V/V}$ | $V_{IN} = 2.7\text{V}$ to $5.5\text{V}$ for <b>MCP1525</b> , $V_{IN} = 4.3\text{V}$ to $5.5\text{V}$ for <b>MCP1541</b>                                                   |
|                                                                                                                                                                                                 | $\Delta V_{OUT}/\Delta V_{IN}$  | —     | —     | 350   | $\mu\text{V/V}$ | $V_{IN} = 2.7\text{V}$ to $5.5\text{V}$ for <b>MCP1525</b> , $V_{IN} = 4.3\text{V}$ to $5.5\text{V}$ for <b>MCP1541</b> , $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ |
| <b>Input</b>                                                                                                                                                                                    |                                 |       |       |       |                 |                                                                                                                                                                           |
| Input Voltage, MCP1525                                                                                                                                                                          | $V_{IN}$                        | 2.7   | —     | 5.5   | V               | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                                                                                           |
| Input Voltage, MCP1541                                                                                                                                                                          | $V_{IN}$                        | 4.3   | —     | 5.5   | V               | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                                                                                           |
| Input Current                                                                                                                                                                                   | $I_{IN}$                        | —     | 86    | 100   | $\mu\text{A}$   | No load                                                                                                                                                                   |
|                                                                                                                                                                                                 | $I_{IN}$                        | —     | 95    | 120   | $\mu\text{A}$   | No load, $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$                                                                                                                  |

- 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  $85^\circ\text{C}$  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  $-40^\circ\text{C}$ ; refer to **Section 1.1.10 “Output Voltage Hysteresis”**.

## AC 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 $C_L = 1\text{ }\mu\text{F}$ . |          |     |     |     |                     |                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----|-----|-----|---------------------|-----------------|
| Parameter                                                                                                                                                                                         | Sym      | Min | Typ | Max | Units               | Conditions      |
| <b>AC Response</b>                                                                                                                                                                                |          |     |     |     |                     |                 |
| Bandwidth                                                                                                                                                                                         | BW       | —   | 100 | —   | kHz                 |                 |
| <b>Input and Load Capacitors (see Figure 4-1)</b>                                                                                                                                                 |          |     |     |     |                     |                 |
| Input Capacitor                                                                                                                                                                                   | $C_{IN}$ | —   | 0.1 | —   | $\mu\text{F}$       | <b>Notes 1</b>  |
| Load Capacitor                                                                                                                                                                                    | $C_L$    | 1   | —   | 10  | $\mu\text{F}$       | <b>Notes 2</b>  |
| <b>Noise</b>                                                                                                                                                                                      |          |     |     |     |                     |                 |
| <b>MCP1525</b> Output Noise Voltage                                                                                                                                                               | $E_{no}$ | —   | 90  | —   | $\mu\text{V}_{P-P}$ | 0.1 Hz to 10 Hz |
|                                                                                                                                                                                                   | $E_{no}$ | —   | 500 | —   | $\mu\text{V}_{P-P}$ | 10 Hz to 10 kHz |
| <b>MCP1541</b> Output Noise Voltage                                                                                                                                                               | $E_{no}$ | —   | 145 | —   | $\mu\text{V}_{P-P}$ | 0.1 Hz to 10 Hz |
|                                                                                                                                                                                                   | $E_{no}$ | —   | 700 | —   | $\mu\text{V}_{P-P}$ | 10 Hz to 10 kHz |

**Note 1:** The input capacitor is optional; Microchip recommends using a ceramic capacitor.

**Note 2:** These parts are tested at both 1  $\mu\text{F}$  and 10  $\mu\text{F}$  to ensure proper operation over this range of load capacitors. A wider range of load capacitor values has been characterized successfully, but is not tested in production.

## TEMPERATURE SPECIFICATIONS

| Electrical Characteristics: Unless otherwise indicated, $T_A = +25^{\circ}\text{C}$ , $V_{IN} = 5.0\text{V}$ and $V_{SS} = \text{GND}$ . |               |     |     |      |                      |               |
|------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----|-----|------|----------------------|---------------|
| Parameter                                                                                                                                | Sym           | Min | Typ | Max  | Units                | Conditions    |
| <b>Temperature Ranges</b>                                                                                                                |               |     |     |      |                      |               |
| Specified Temperature Range                                                                                                              | $T_A$         | -40 | —   | +85  | $^{\circ}\text{C}$   |               |
| Operating Temperature Range                                                                                                              | $T_A$         | -40 | —   | +125 | $^{\circ}\text{C}$   | <b>Note 1</b> |
| Storage Temperature Range                                                                                                                | $T_A$         | -65 | —   | +150 | $^{\circ}\text{C}$   |               |
| <b>Thermal Package Resistances</b>                                                                                                       |               |     |     |      |                      |               |
| Thermal Resistance, TO-92                                                                                                                | $\theta_{JA}$ | —   | 132 | —    | $^{\circ}\text{C/W}$ |               |
| Thermal Resistance, SOT-23-3                                                                                                             | $\theta_{JA}$ | —   | 336 | —    | $^{\circ}\text{C/W}$ |               |

**Note 1:** These voltage references operate over the Operating Temperature Range, but with reduced performance. In any case, the internal Junction Temperature ( $T_J$ ) must not exceed the Absolute Maximum specification of  $+150^{\circ}\text{C}$ .

### 1.1 Specification Descriptions and Test Circuits

#### 1.1.1 OUTPUT VOLTAGE

Output voltage is the reference voltage that is available on the output pin ( $V_{OUT}$ ).

#### 1.1.2 INPUT VOLTAGE

The input (operating) voltage is the range of voltage that can be applied to the  $V_{IN}$  pin and still have the device produce the designated output voltage on the  $V_{OUT}$  pin.

#### 1.1.3 OUTPUT VOLTAGE DRIFT ( $TCV_{OUT}$ )

The output temperature coefficient or voltage drift is a measure of how much the output voltage ( $V_{OUT}$ ) will vary from its initial value with changes in ambient temperature. The value specified in the electrical specifications is measured and equal to:

#### EQUATION 1-1:

$$TCV_{OUT} = \frac{\Delta V_{OUT}/V_{NOM}}{\Delta T_A} \quad (ppm/^{\circ}\text{C})$$

Where:

$$V_{NOM} = 2.5\text{V, MCP1525}$$

$$V_{NOM} = 4.096\text{V, MCP1541}$$

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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:

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

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  $\mu V$  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

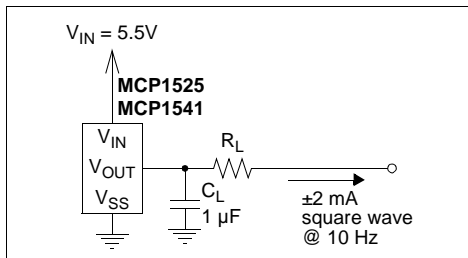
The Input Voltage Rejection Ratio (IVRR) is a measure of the change in output voltage versus the change in input voltage over frequency, as shown in Figure 2-7. The calculation used for this plot is:

### 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.

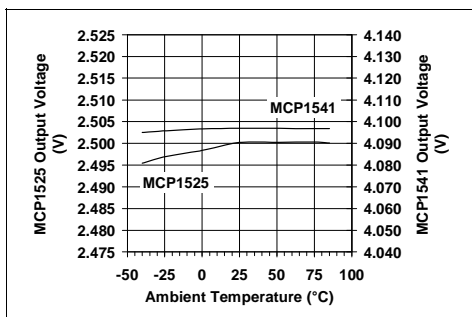
## 1.1.10 OUTPUT VOLTAGE HYSTERESIS

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.

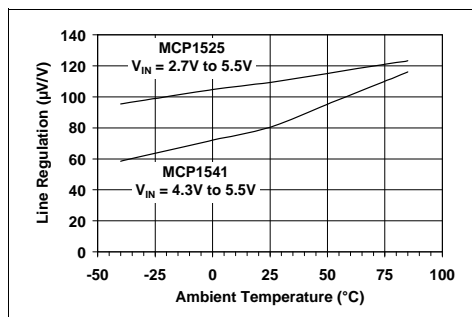
## 2.0 TYPICAL PERFORMANCE CURVES

**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.

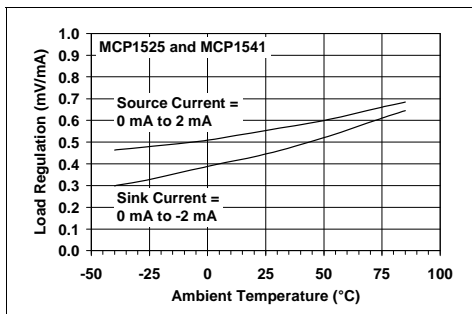
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{IN} = 5.0\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $I_{OUT} = 0\text{ mA}$  and  $C_L = 1\text{ }\mu\text{F}$ .



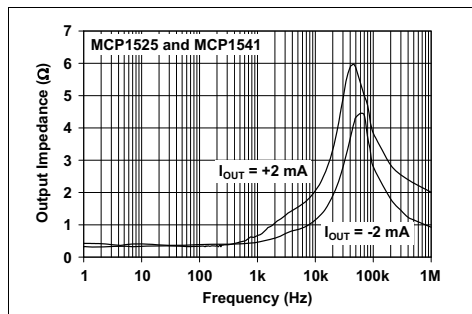
**FIGURE 2-1:** Output Voltage vs. Ambient Temperature.



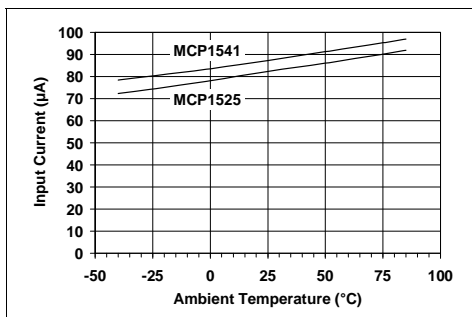
**FIGURE 2-4:** Line Regulation vs. Ambient Temperature.



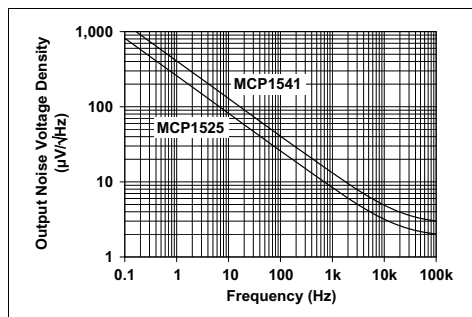
**FIGURE 2-2:** Load Regulation vs. Ambient Temperature.



**FIGURE 2-5:** Output Impedance vs. Frequency.



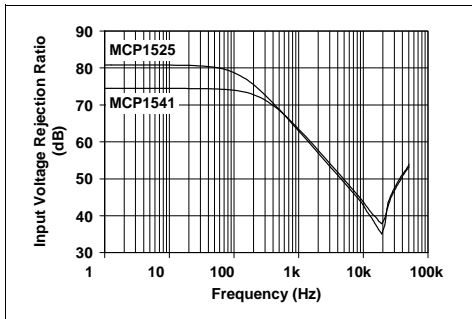
**FIGURE 2-3:** Input Current vs. Ambient Temperature.



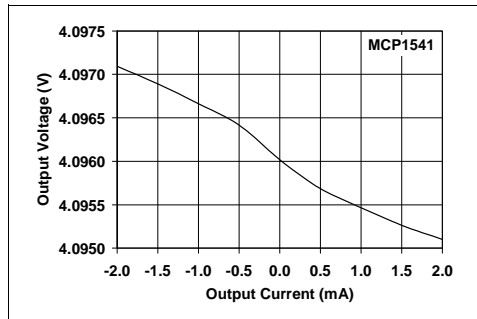
**FIGURE 2-6:** Output Noise Voltage Density vs. Frequency.

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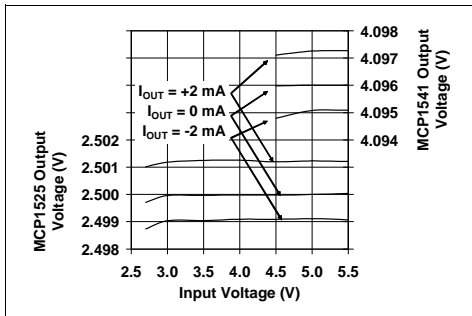
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{IN} = 5.0\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $I_{OUT} = 0\text{ mA}$  and  $C_L = 1\text{ }\mu\text{F}$ .



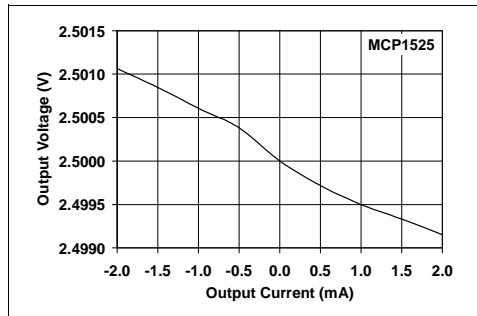
**FIGURE 2-7:** Input Voltage Rejection Ratio vs. Frequency.



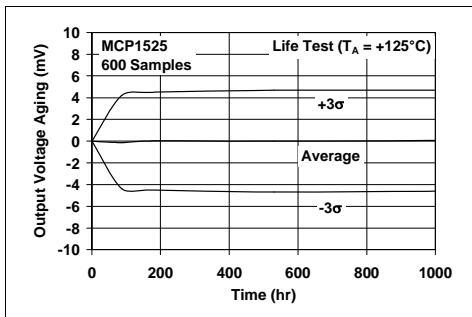
**FIGURE 2-10:** MCP1541 Output Voltage vs. Output Current.



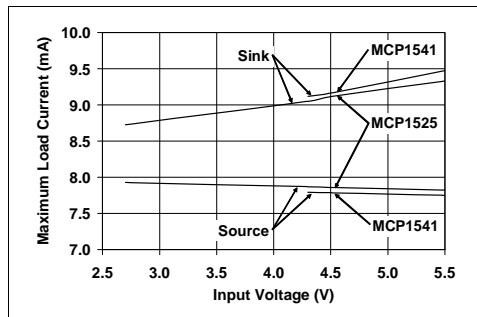
**FIGURE 2-8:** Output Voltage vs. Input Voltage.



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

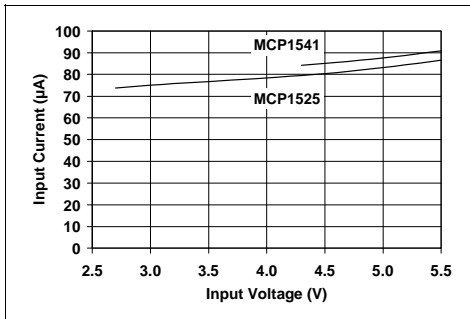


**FIGURE 2-9:** Output Voltage Aging vs. Time (MCP1525 Device Life Test data).

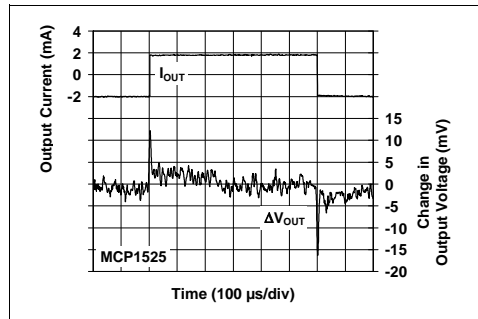


**FIGURE 2-12:** Maximum Load Current vs. Input Voltage.

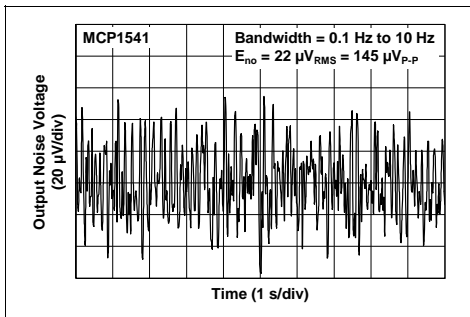
**Note:** Unless otherwise indicated,  $T_A = +25^\circ\text{C}$ ,  $V_{IN} = 5.0\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $I_{OUT} = 0\text{ mA}$  and  $C_L = 1\text{ }\mu\text{F}$ .



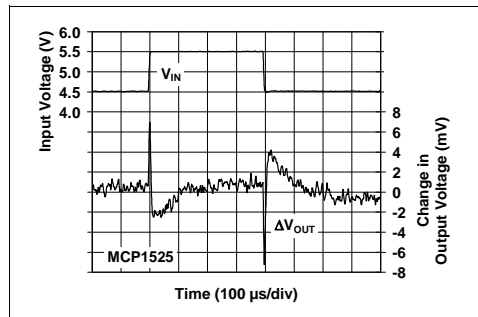
**FIGURE 2-13:** Input Current vs. Input Voltage.



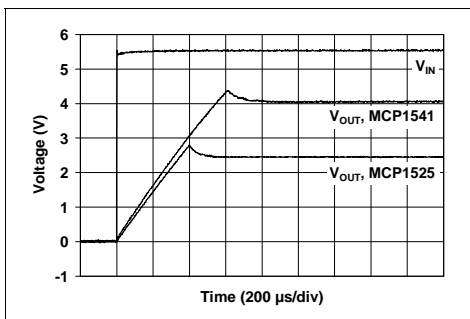
**FIGURE 2-16:** MCP1525 Load Transient Response.



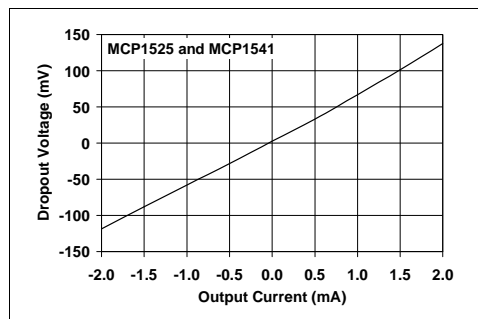
**FIGURE 2-14:** MCP1541 0.1 Hz to 10 Hz Output Noise.



**FIGURE 2-17:** MCP1525 Line Transient Response.



**FIGURE 2-15:** Turn-on Transient Time.



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

# MCP1525/41

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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<br>(TO-92-3) | MCP1525, MCP1541<br>(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  $\mu\text{F}$  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  $\mu\text{F}$  and 10  $\mu\text{F}$  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.

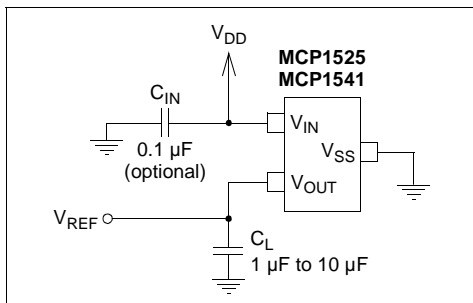


## 4.0 APPLICATIONS INFORMATION

### 4.1 Application Tips

#### 4.1.1 BASIC CIRCUIT CONFIGURATION

The MCP1525 and MCP1541 voltage reference devices should be applied as shown in Figure 4-1 in all applications.



**FIGURE 4-1:** Basic Circuit Configuration.

As shown in Figure 4-1, the input voltage is connected to the device at the  $V_{IN}$  input, with an optional 0.1  $\mu\text{F}$  ceramic capacitor. This capacitor would be required if the input voltage has excess noise. A 0.1  $\mu\text{F}$  capacitor would reject input voltage noise at approximately 1 to 2 MHz. Noise below this frequency will be amply rejected by the input voltage rejection of the voltage reference. Noise at frequencies above 2 MHz will be beyond the bandwidth of the voltage reference and, consequently, not transmitted from the input pin through the device to the output.

The load capacitance ( $C_L$ ) is required in order to stabilize the voltage reference; see **Section 4.1.3 “Load Capacitor”**.

#### 4.1.2 INPUT (BYPASS) CAPACITOR

The MCP1525 and MCP1541 voltage references do not require an input capacitor across  $V_{IN}$  to  $V_{SS}$ . However, for added stability and input voltage transient noise reduction, a 0.1  $\mu\text{F}$  ceramic capacitor is recommended, as shown in Figure 4-1. This capacitor should be close to the device (within 5 mm of the pin).

#### 4.1.3 LOAD CAPACITOR

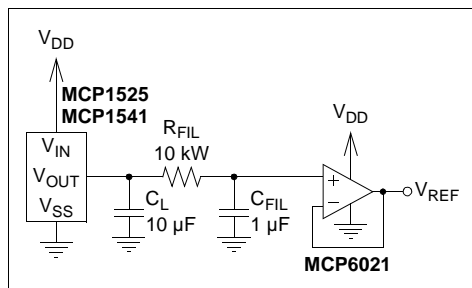
The output capacitor from  $V_{OUT}$  to  $V_{SS}$  acts as a frequency compensation for the references and cannot be omitted. Use load capacitors between 1  $\mu\text{F}$  and 10  $\mu\text{F}$  to compensate these devices. A 10  $\mu\text{F}$  output capacitor has slightly better noise, and provides additional charge for fast load transients, when compared to a 1  $\mu\text{F}$  output capacitor. This capacitor should be close to the device (within 5 mm of the pin).

#### 4.1.4 PRINTED CIRCUIT BOARD LAYOUT CONSIDERATIONS

Mechanical stress due to Printed Circuit Board (PCB) mounting can cause the output voltage to shift from its initial value. Devices in the SOT-23-3 package are generally more prone to assembly stress than devices in the TO-92 package. To reduce stress-related output voltage shifts, mount the reference on low-stress areas of the PCB (i.e., away from PCB edges, screw holes and large components).

#### 4.1.5 OUTPUT FILTERING

If the noise at the output of these voltage references is too high for the particular application, it can be easily filtered with an external RC filter and op amp buffer. The op amp's input and output voltage ranges need to include the reference output voltage.



**FIGURE 4-2:** Output Noise-Reducing Filter.

The RC filter values are selected for a desired cutoff frequency:

#### EQUATION 4-1:

$$f_C = \frac{1}{2\pi R_{FIL} C_{FIL}}$$

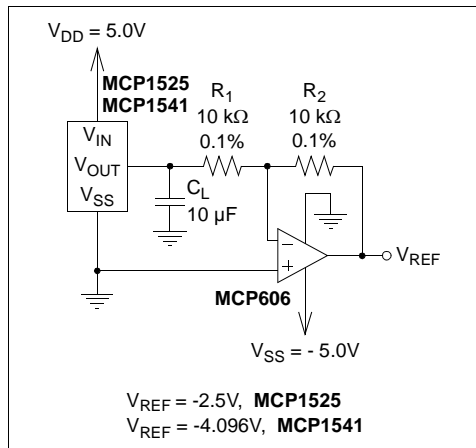
The values that are shown in Figure 4-2 (10 k $\Omega$  and 1  $\mu\text{F}$ ) will create a first-order, low-pass filter at the output of the amplifier. The cutoff frequency of this filter is 15.9 Hz, and the attenuation slope is 20 dB/decade. The MCP6021 amplifier isolates the loading of this low-pass filter from the remainder of the application circuit. This amplifier also provides additional drive, with a faster response time than the voltage reference.

# MCP1525/41

## 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.

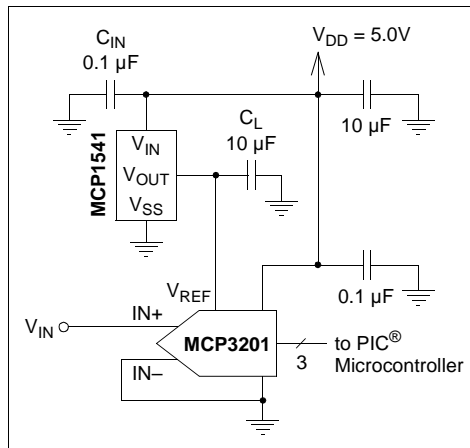


**FIGURE 4-3:** Negative Voltage Reference.

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 k $\Omega$  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.

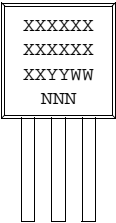


**FIGURE 4-4:** ADC Reference Circuit.

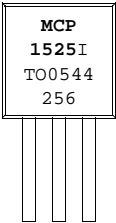
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

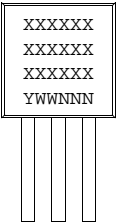
3-Lead TO-92 (Leaded)



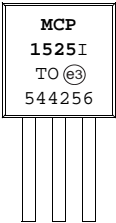
Example:



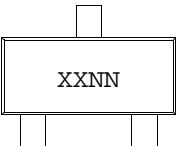
3-Lead TO-92 (Lead Free)



Example:



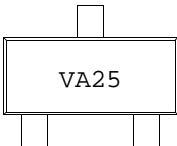
3-Lead SOT-23-3



| Device  | I-Temp Code |
|---------|-------------|
| MCP1525 | VANN        |
| MCP1541 | VBNN        |

Note: Applies to 3-Lead SOT-23.

Example:



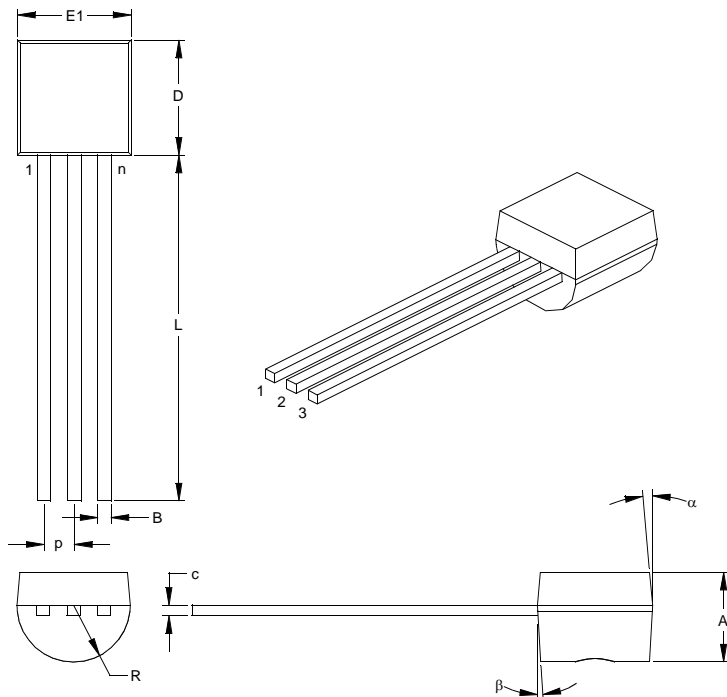
|                |        |                                                                                                                  |
|----------------|--------|------------------------------------------------------------------------------------------------------------------|
| <b>Legend:</b> | 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.

# MCP1525/41

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

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Units                   |        | INCHES* |      |      | MILLIMETERS |       |       |
|-------------------------|--------|---------|------|------|-------------|-------|-------|
| Dimension               | Limits | 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:

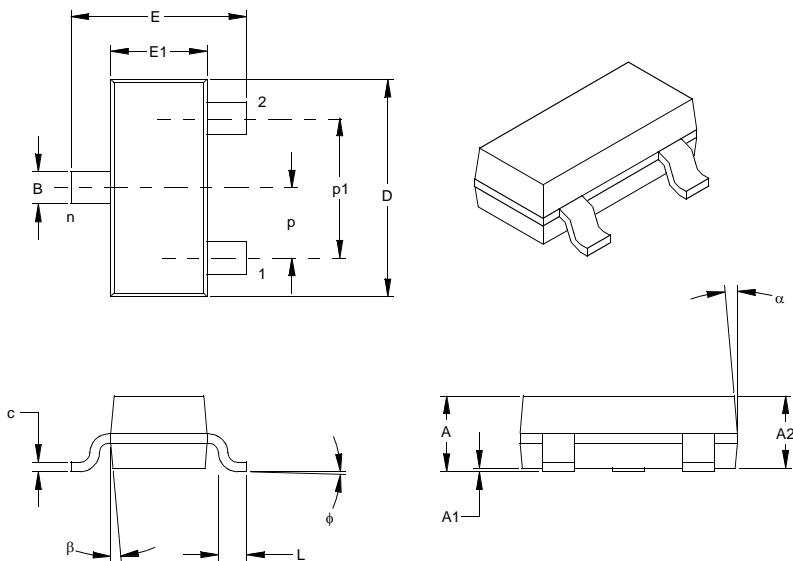
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

JEDEC Equivalent: TO-92

Drawing No. C04-101

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

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| 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

# MCP1525/41

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NOTES:

## APPENDIX A: REVISION HISTORY

### Revision C (December 2012)

Added a note to each package outline drawing.

### 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

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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>   | <u>X</u>                                                                                               | <u>/XX</u> |
|-------------------|--------------------------------------------------------------------------------------------------------|------------|
| Device            | Temperature Range                                                                                      | Package    |
| Device            | MCP1525: = 2.5V Voltage Reference<br>MCP1541: = 4.096 Voltage Reference                                |            |
| Temperature Range | I = -40°C to +85°C                                                                                     |            |
| Package           | TO = TO-92, Plastic Transistor Outline, 3-Lead<br>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.

# MCP1525/41

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NOTES:

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