

MAXIM

Low-Power, Low-Drift, +2.5V/+5V/+10V Precision Voltage References

General Description

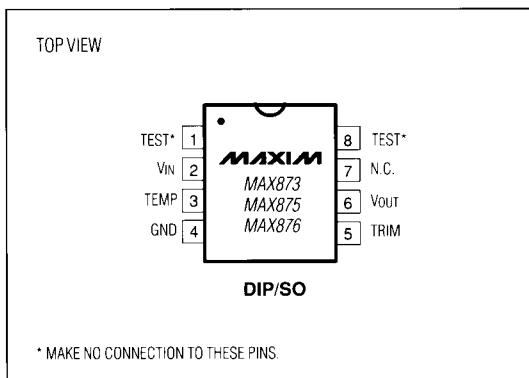
The MAX873/MAX875/MAX876 precision 2.5V, 5V, and 10V references offer excellent accuracy and very low power consumption. Extremely low temperature drift combined with excellent line and load regulation permit stable operation over a wide range of electrical and environmental conditions. Operation for the MAX873 is guaranteed with a +4.5V supply, making the part ideal in systems running from a +5V \pm 10% supply. Low 10Hz to 1kHz noise – typically 15 μ V_{RMS}, 30 μ V_{RMS}, and 60 μ V_{RMS}, respectively, for the MAX873, MAX875, and MAX876 – make the parts suitable for 12-bit data-acquisition systems.

A TRIM pin facilitates adjustment of the reference voltage over a 4% range, using only a 100k Ω potentiometer. A voltage output proportional to temperature provides a source for temperature compensation circuits, temperature warning circuits, and other applications.

Applications

12-Bit A/D and D/A Converters
Digital Multimeters
Portable Data-Acquisition Systems
Low-Power Test Equipment

Pin Configuration



Features

- ◆ MAX873/MAX875/MAX876
+2.5V/+5V/+10V Outputs
 \pm 1.5mV/ \pm 2.0mV/ \pm 3.0mV Max Initial Accuracy
 \pm 2.5mV/ \pm 4mV/ \pm 7mV Max Error Over Temperature
- ◆ 7ppm/ $^{\circ}$ C (Max) Temperature Coefficient
- ◆ 280 μ A (Max) Quiescent Current
- ◆ Sources 10mA, Sinks 2mA
- ◆ 15ppm/mA Load Regulation (Max)
- ◆ 4ppm/V Line Regulation (Max)
- ◆ Wide Supply Voltage Range, +4.5V to +18V (MAX873)
- ◆ TEMP Output Proportional to Temperature

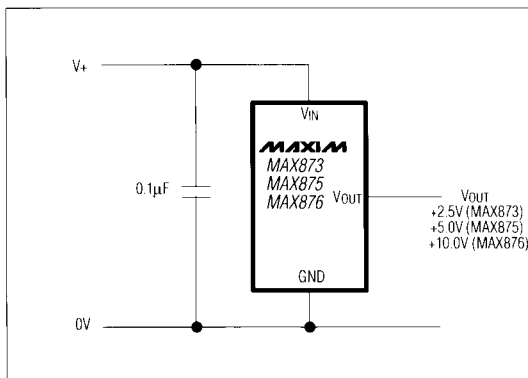
Ordering Information

| PART | PIN-PACKAGE | TEMPCO (ppm/ $^{\circ}$ C max) | V _{OUT} AT +25 $^{\circ}$ C |
|---|---------------|--------------------------------------|--|
| TEMP. RANGE 0$^{\circ}$C to +70$^{\circ}$C | | | |
| MAX873ACPA | 8 Plastic DIP | 7 | 2.5V \pm 1.5mV |
| MAX873BCPA | 8 Plastic DIP | 20 | 2.5V \pm 2.5mV |
| MAX873ACSA | 8 SO | 7 | 2.5V \pm 1.5mV |
| MAX873BCSA | 8 SO | 20 | 2.5V \pm 2.5mV |
| MAX873BC/D | Dice* | 20 | 2.5V \pm 2.5mV |

Ordering Information continued on last page.

* Dice are tested at T_a = +25 $^{\circ}$ C only.

Typical Operating Circuit



MAXIM

Maxim Integrated Products 1

Call toll free 1-800-998-8800 for free samples or literature.

MAX873/MAX875/MAX876

Low-Power, Low-Drift, +2.5V /+5V/+10V Precision Voltage References

ABSOLUTE MAXIMUM RATINGS

| | |
|---|--|
| V _{CC} to GND | 20V |
| V _{OUT} , TRIM, TEMP, TEST | (GND - 0.3V) to (V _{CC} + 0.3V) |
| Output Short-Circuit Duration (to GND) | Continuous |
| Current into Any Pin | ±50mA |
| Continuous Power Dissipation (T _A = +70°C) | |
| Plastic DIP (derate 9.09mW/°C above +70°C) | 727mW |
| SO (derate 5.88mW/°C above +70°C) | 471mW |
| CERDIP (derate 8.00mW/°C above +70°C) | 640mW |

Operating Temperature Ranges:

| | |
|--------------------------------------|-----------------------|
| MAX87__C_A | 0°C to +70°C |
| MAX87__E_A | -40°C to +85°C |
| MAX87__MJA | -55°C to +125°C |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temperature (soldering, 10 sec) | +300°C |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS – MAX873

(V_{IN} = +5V, I_L = 0mA, C_{LOAD} < 100pF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---------------------------------|---------------------|---|---|--------|--------|--------|-------------------|
| Output Voltage | V _{OUT} | T _A = +25°C | MAX873A | 2.4985 | 2.5000 | 2.5015 | V |
| | | | MAX873B | 2.4975 | 2.5000 | 2.5025 | |
| | | 0°C ≤ T _A ≤ +70°C | MAX873A | 2.4975 | 2.5000 | 2.5025 | |
| | | | MAX873B | 2.4950 | 2.5000 | 2.5050 | |
| | | -40°C ≤ T _A ≤ +85°C | MAX873A | 2.4970 | 2.5000 | 2.5030 | |
| | | | MAX873B | 2.4940 | 2.5000 | 2.5060 | |
| -55°C ≤ T _A ≤ +125°C | MAX873A | 2.4960 | 2.5000 | 2.5040 | | | |
| | MAX873B | 2.4925 | 2.5000 | 2.5075 | | | |
| Output-Voltage Drift | TCV _{OUT} | (Note 1) | MAX873A | | 4 | 7 | ppm/°C |
| | | | MAX873B | | 10 | 20 | |
| Output-Noise Voltage | e _n | T _A = +25°C | 0.1Hz to 10Hz | | 16 | | μV _{p-p} |
| | | | 10Hz to 1kHz | | 15 | | μV _{RMS} |
| Line Regulation | | V _{IN} = 4.5V to 18V | T _A = +25°C | | 1.5 | 4.0 | ppm/V |
| | | MAX873_C/E: V _{IN} = 4.5V to 18V | T _A = T _{MIN} to T _{MAX} | | 3 | 6 | |
| | | MAX873_MJA: V _{IN} = 4.75V to 18V | | | | | |
| Load Regulation | | I _L = 0mA to 10mA (source) | T _A = +25°C | | 6 | 15 | ppm/mA |
| | | | T _A = T _{MIN} to T _{MAX} | | 10 | 20 | |
| | | I _L = 0mA to -2mA (sink) | T _A = +25°C | | 6 | 15 | |
| | | | T _A = T _{MIN} to T _{MAX} | | 10 | 20 | |
| Quiescent Supply Current | I _Q | | T _A = +25°C | | 190 | 280 | μA |
| | | | T _A = T _{MIN} to T _{MAX} | | 190 | 375 | |
| Short-Circuit Output Current | I _{SC} | Output shorted to GND | | | 35 | | mA |
| V _{OUT} Adjust Range | | | | | ±95 | | mV |
| Long-Term Output Drift | | | | | 20 | | ppm/kh |
| TEMP PIN | | | | | | | |
| Voltage Output | V _{TEMP} | | T _A = +25°C | | 608 | | mV |
| Temperature Sensitivity | TCV _{TEMP} | | | | 2 | | mV/°C |

Low-Power, Low-Drift, +2.5V/+5V/+10V Precision Voltage References

ELECTRICAL CHARACTERISTICS – MAX875

($V_{IN} = +15V$, $I_L = 0mA$, $C_{LOAD} < 100pF$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--|--------------|---|------------------------------|-----------|-------|--------|-----------------|
| Output Voltage | V_{OUT} | $T_A = +25^\circ C$ | MAX875A | 4.998 | 5.000 | 5.002 | V |
| | | | MAX875B | 4.997 | 5.000 | 5.003 | |
| | | $0^\circ C \leq T_A \leq +70^\circ C$ | MAX875A | 4.996 | 5.000 | 5.004 | |
| | | | MAX875B | 4.992 | 5.000 | 5.008 | |
| | | $-40^\circ C \leq T_A \leq +85^\circ C$ | MAX875A | 4.9945 | 5.000 | 5.0055 | |
| | | | MAX875B | 4.990 | 5.000 | 5.010 | |
| $-55^\circ C \leq T_A \leq +125^\circ C$ | MAX875A | 4.9935 | 5.000 | 5.0065 | | | |
| | MAX875B | 4.988 | 5.000 | 5.012 | | | |
| Output-Voltage Drift | TCV_{OUT} | (Note 1) | MAX875A | 4 | | 7 | ppm/ $^\circ C$ |
| | | | MAX875B | 10 | | 20 | |
| Output-Noise Voltage | e_n | $T_A = +25^\circ C$ | 0.1Hz to 10Hz | 32 | | | μV_{p-p} |
| | | | 10Hz to 1kHz | 30 | | | μV_{RMS} |
| Line Regulation | | $V_{IN} = 7V$ to 18V | $T_A = +25^\circ C$ | 1.5 | | 4.0 | ppm/V |
| | | MAX875_C/E: $V_{IN} = 7V$ to 18V | $T_A = T_{MIN}$ to T_{MAX} | 3 | | 6 | |
| | | MAX875_MJA: $V_{IN} = 7.2V$ to 18V | | | | | |
| Load Regulation | | $I_L = 0mA$ to 10mA (source) | $T_A = +25^\circ C$ | 6 | | 15 | ppm/mA |
| | | | $T_A = T_{MIN}$ to T_{MAX} | 10 | | 20 | |
| | | $I_L = 0mA$ to -2mA (sink) | $T_A = +25^\circ C$ | 6 | | 15 | |
| | | | $T_A = T_{MIN}$ to T_{MAX} | 10 | | 20 | |
| Quiescent Supply Current | I_Q | | $T_A = +25^\circ C$ | 190 | | 280 | μA |
| | | | $T_A = T_{MIN}$ to T_{MAX} | 190 | | 375 | |
| Short-Circuit Output Current | I_{SC} | Output shorted to GND | | 35 | | | mA |
| V_{OUT} Adjust Range | | | | ± 200 | | | mV |
| Long-Term Output Drift | | | | 20 | | | ppm/kh |
| TEMP PIN | | | | | | | |
| Voltage Output | V_{TEMP} | | $T_A = +25^\circ C$ | 608 | | | mV |
| Temperature Sensitivity | TCV_{TEMP} | | | 2 | | | mV/ $^\circ C$ |

MAX873/MAX875/MAX876

Low-Power, Low-Drift, +2.5V /+5V/+10V Precision Voltage References

ELECTRICAL CHARACTERISTICS – MAX876

($V_{IN} = +15V$, $I_L = 0mA$, $C_{LOAD} < 100pF$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS | |
|--|--------------|--|---|---------------|-----------|--------|-----------------|---|
| Output Voltage | V_{OUT} | | $T_A = +25^\circ C$ | MAX876A | 9.997 | 10.000 | 10.003 | V |
| | | | | MAX876B | 9.995 | 10.000 | 10.005 | |
| | | | $0^\circ C \leq T_A \leq +70^\circ C$ | MAX876A | 9.993 | 10.000 | 10.007 | |
| | | | | MAX876B | 9.985 | 10.000 | 10.015 | |
| | | | $-40^\circ C \leq T_A \leq +85^\circ C$ | MAX876A | 9.990 | 10.000 | 10.010 | |
| | | | | MAX876B | 9.975 | 10.000 | 10.025 | |
| $-55^\circ C \leq T_A \leq +125^\circ C$ | MAX876A | 9.990 | 10.000 | 10.010 | | | | |
| | MAX876B | 9.975 | 10.000 | 10.025 | | | | |
| Output-Voltage Drift | TCV_{OUT} | (Note 1) | | MAX876A | 4 | 7 | ppm/ $^\circ C$ | |
| | | | | MAX876B | 10 | 20 | | |
| Output-Noise Voltage | e_n | | $T_A = +25^\circ C$ | 0.1Hz to 10Hz | 64 | | μV_{p-p} | |
| | | | | 10Hz to 1kHz | 60 | | μV_{RMS} | |
| Line Regulation | | $V_{IN} = 12V$ to 18V | $T_A = +25^\circ C$ | | 1.5 | 4.0 | ppm/V | |
| | | MAX876_C/E: $V_{IN} = 12V$ to 18V | $T_A = T_{MIN}$ to T_{MAX} | | 3 | 6 | | |
| | | MAX876_MJA: $V_{IN} = 12.2V$ to 18V | | | | | | |
| Load Regulation | | $I_L = 0mA$ to 10mA (source) | $T_A = +25^\circ C$ | | 6 | 15 | ppm/mA | |
| | | | $T_A = T_{MIN}$ to T_{MAX} | | 10 | 20 | | |
| | | $I_L = 0mA$ to -2mA (sink) | $T_A = +25^\circ C$ | | 6 | 15 | | |
| | | | $T_A = T_{MIN}$ to T_{MAX} | | 10 | 20 | | |
| Quiescent Supply Current | I_Q | | $T_A = +25^\circ C$ | | 190 | 280 | μA | |
| | | | $T_A = T_{MIN}$ to T_{MAX} | | 190 | 375 | | |
| Short-Circuit Output Current | I_{SC} | Output shorted to GND | | | 35 | | mA | |
| V_{OUT} Adjust Range | | | | | ± 400 | | mV | |
| Long-Term Output Drift | | | | | 20 | | ppm/kh | |
| TEMP PIN | | | | | | | | |
| Voltage Output | V_{TEMP} | $T_A = +25^\circ C$ | | | 608 | | mV | |
| Temperature Sensitivity | TCV_{TEMP} | | | | 2 | | mV/ $^\circ C$ | |

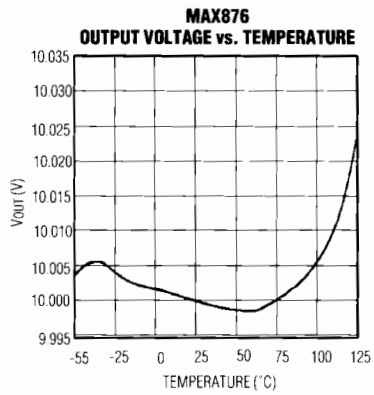
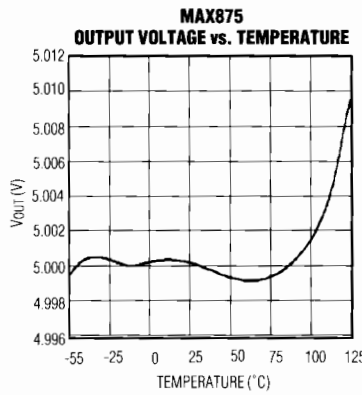
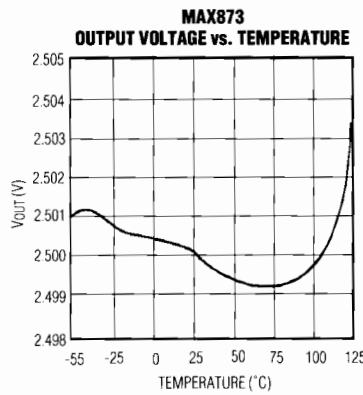
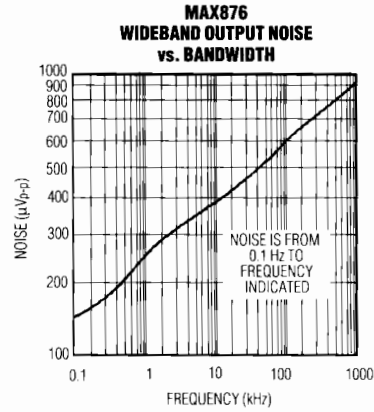
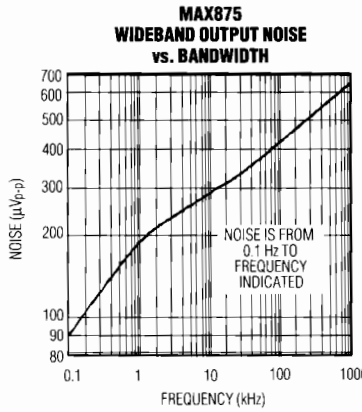
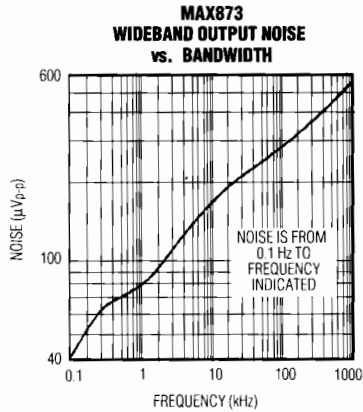
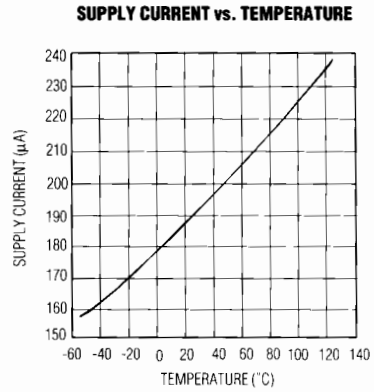
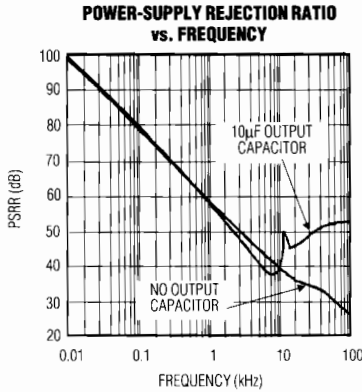
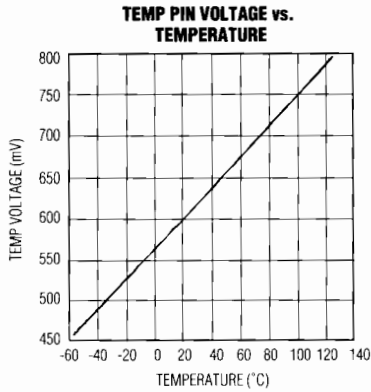
Note 1: Temperature coefficient is determined by the "box" method in which the maximum ΔV_{OUT} over the temperature range is divided by ΔT .

Low-Power, Low-Drift, +2.5V/+5V/+10V Precision Voltage References

Typical Operating Characteristics

T_A = +25°C, V_{IN} = +5V (MAX873), V_{IN} = +15V (MAX875/MAX876), I_L = 0mA, C_{LOAD} < 100pF, unless otherwise noted.)

MAX873/MAX875/MAX876



Low-Power, Low-Drift, +2.5V /+5V/+10V Precision Voltage References

Pin Description

| PIN | NAME | FUNCTION |
|-----|------------------|--|
| 1,8 | TEST | For factory test use only. Make no connections to these pins. |
| 2 | V _{IN} | Supply Voltage |
| 3 | TEMP | Temperature Proportional Output Voltage. Generates a voltage proportional to the temperature of the die. |
| 4 | GND | Ground |
| 5 | TRIM | Output Voltage Trim. Connect to the center of a voltage divider for trimming; otherwise, make no connection. |
| 6 | V _{OUT} | Output Voltage |
| 7 | N.C. | No Connect - not internally connected. |

Detailed Description

The bipolar MAX873, MAX875, and MAX876 are bandgap references, amplified to give an output voltage of 2.500V, 5.000V, and 10.000V, respectively. Laser trimming is used to adjust the output voltage and minimize thermal drift. Post-package trimming allows control of the output to within ±1.5mV, ±2.0mV, and ±3.0mV, respectively.

The MAX873, MAX875, and MAX876 are essentially three-terminal references with a power-supply input, ground, and reference output. Additionally, a TRIM pin facilitates adjustment of the reference voltage over a 4% range using only a 100kΩ potentiometer. A voltage output proportional to temperature provides a source for temperature compensation circuits, temperature warning circuits, and other applications.

Applications Information

Input Bypassing

For best transient performance, decouple the input with a 10μF electrolytic capacitor in parallel with a 0.01μF to 0.1μF ceramic capacitor as shown in Figure 1. Where transient performance is less important, a single 0.1μF capacitor is sufficient.

Output Bypassing

These devices perform well with no output decoupling capacitance. However, if the capacitive load on the output exceeds 100pF, bypass the output with at least 1μF to ensure stability. A 10μF electrolytic capacitor in parallel with a 0.01μF to 0.1μF ceramic capacitor provides excellent load-transient performance and guarantees stability as shown in Figure 1.

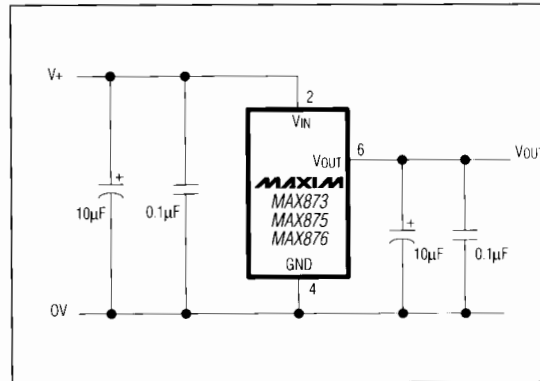


Figure 1. Recommended Bypassing for Good High-Frequency Response

Standard Application

The standard application for the references is shown in the *Typical Operating Circuit*. Additional bypassing, shown in Figure 1, provides superior performance over a range of conditions.

Output-Voltage Trimming

Use a 100kΩ potentiometer as shown in Figure 2 to trim the output voltage to the desired level. A trim range of ±95mV (MAX873), ±200mV (MAX875), or ±400mV (MAX876) is available using this technique. Large adjustments of the output voltage may degrade its temperature coefficient by as much as 5ppm/°C.

Low-Power, Low-Drift, +2.5V/+5V/+10V Precision Voltage References

MAX873/MAX875/MAX876

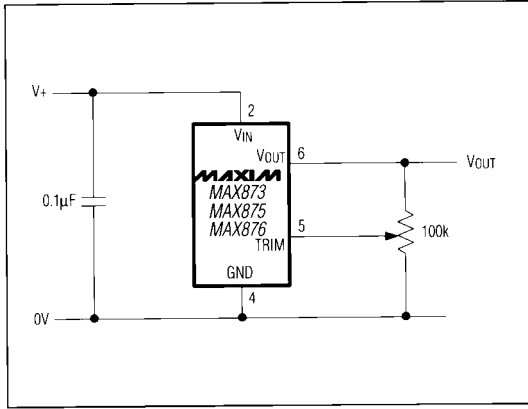


Figure 2. Output-Voltage Trim Circuit

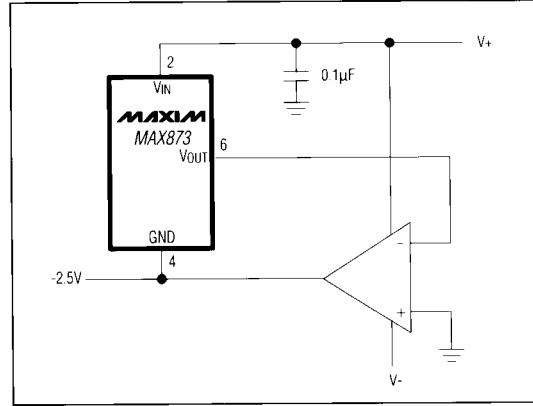


Figure 4. Low-Dropout -2.5V Reference

Inverting Applications

+2.5V and -2.5V reference voltages can be generated using the MAX873 with an op amp in the traditional gain of -1 configuration shown in Figure 3. The accuracy of this circuit depends on the matching of the two resistors R and R' . A similar configuration using the MAX875 and MAX876 can provide $\pm 5V$ and $\pm 10V$ references, respectively.

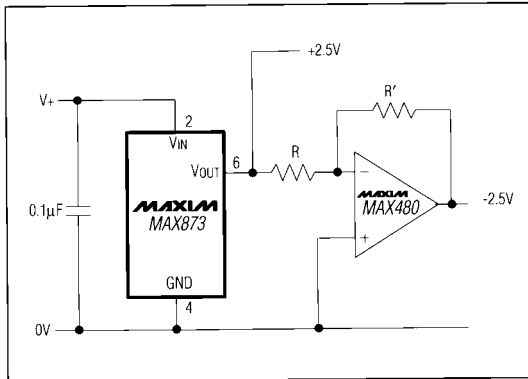


Figure 3. +2.5V and -2.5V Outputs

The circuit in Figure 4 requires no resistors and suffers only from offset and temperature coefficient errors of the op amp itself. The op amp also buffers the reference, so the output capability of this circuit depends on the performance of the op amp selected. In addition, the dropout performance of this circuit is very good: the positive rail can go down to about 1.5V because the MAX873 is unloaded, and the negative rail can decline typically to -3.2V using a MAX480, or to -2.6V using an ICL7611 ($I_Q = 100\mu A$ mode). A similar configuration using the MAX875 or MAX876 can generate -5.0V or -10.0V references, respectively.

Temperature Measurement

The TEMP output delivers a voltage proportional to the absolute temperature of the die. In packaged parts, this closely approximates the ambient temperature of the device because the power dissipation of the reference itself is very small. The temperature coefficient of this output is typically $2mV/^\circ C$, and the nominal voltage at $+25^\circ C$ is 608mV (*Typical Operating Characteristics*).

Low-Power, Low-Drift, +2.5V /+5V/+10V Precision Voltage References

Ordering Information (continued)

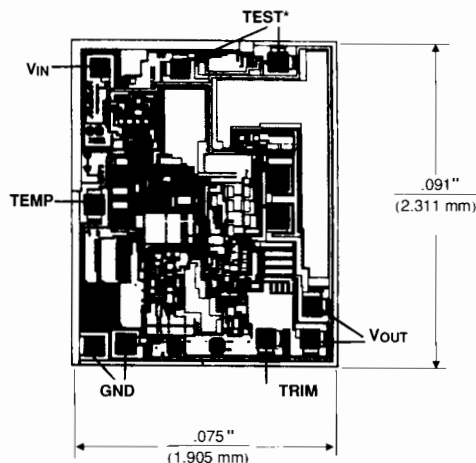
| PART | PIN-PACKAGE | TEMPCO (ppm/°C max) | V _{OUT} AT +25°C |
|------------------------------------|---------------|---------------------------|---------------------------------|
| TEMP. RANGE -40°C TO +85°C | | | |
| MAX873AEPA | 8 Plastic DIP | 7 | 2.5V ±1.5mV |
| MAX873BEPA | 8 Plastic DIP | 20 | 2.5V ±2.5mV |
| MAX873AESA | 8 SO | 7 | 2.5V ±1.5mV |
| MAX873BESA | 8 SO | 20 | 2.5V ±2.5mV |
| TEMP. RANGE -55°C TO +125°C | | | |
| MAX873AMJA | 8 CERDIP** | 7 | 2.5V ±1.5mV |
| MAX873BMJA | 8 CERDIP** | 20 | 2.5V ±2.5mV |
| TEMP. RANGE 0°C to +70°C | | | |
| MAX875 ACPA | 8 Plastic DIP | 7 | 5V ±2.0mV |
| MAX875BCPA | 8 Plastic DIP | 20 | 5V ±3.0mV |
| MAX875ACSA | 8 SO | 7 | 5V ±2.0mV |
| MAX875BCSA | 8 SO | 20 | 5V ±3.0mV |
| MAX875BC/D | Dice* | 20 | 5V ±3.0mV |
| TEMP. RANGE -40°C TO +85°C | | | |
| MAX875AEPA | 8 Plastic DIP | 7 | 5V ±2.0mV |
| MAX875BEPA | 8 Plastic DIP | 20 | 5V ±3.0mV |
| MAX875AESA | 8 SO | 7 | 5V ±2.0mV |
| MAX875BESA | 8 SO | 20 | 5V ±3.0mV |
| TEMP. RANGE -55°C TO +125°C | | | |
| MAX875AMJA | 8 CERDIP** | 7 | 5V ±2.0mV |
| MAX875BMJA | 8 CERDIP** | 20 | 5V ±3.0mV |
| TEMP. RANGE 0°C to +70°C | | | |
| MAX876 ACPA | 8 Plastic DIP | 7 | 10V ±3.0mV |
| MAX876BCPA | 8 Plastic DIP | 20 | 10V ±5.0mV |
| MAX876ACSA | 8 SO | 7 | 10V ±3.0mV |
| MAX876BCSA | 8 SO | 20 | 10V ±5.0mV |
| MAX876BC/D | Dice* | 20 | 10V ±5.0mV |

| PART | PIN-PACKAGE | TEMPCO (ppm/°C max) | V _{OUT} AT +25°C |
|------------------------------------|---------------|---------------------------|---------------------------------|
| TEMP. RANGE -40°C TO +85°C | | | |
| MAX876AEPA | 8 Plastic DIP | 7 | 10V ±3.0mV |
| MAX876BEPA | 8 Plastic DIP | 20 | 10V ±5.0mV |
| MAX876AESA | 8 SO | 7 | 10V ±3.0mV |
| MAX876BESA | 8 SO | 20 | 10V ±5.0mV |
| TEMP. RANGE -55°C TO +125°C | | | |
| MAX876AMJA | 8 CERDIP** | 7 | 10V ±3.0mV |
| MAX876BMJA | 8 CERDIP** | 20 | 10V ±5.0mV |

* Dice are tested at T_A = +25°C only.

** Contact factory for availability and processing to MIL-STD-883.

Chip Topography



SUBSTRATE CONNECTED TO GND;
TRANSISTOR COUNT: 76.

* MAKE NO CONNECTION TO THESE PADS

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