19-0005; Rev 2; 6/97

MAXIM

10µA, Low-Dropout, Precision Voltage References

General Description

The MAX872/MAX874 precision 2.5V and 4.096V micropower voltage references consume a maximum of only 10µA and operate from supply voltages up to 20V. The combination of ultra-low quiescent current and low 200mV dropout makes them ideal for battery-powered equipment. They source and sink up to 500µA with only 200mV input voltage headroom, which makes the 2.5V MAX872 ideal for use with a 3V supply and the 4.096V MAX874 ideal for use with a 5V supply.

Initial accuracy of 0.2% at +25°C (±5mV for the MAX872, ±8mV for the MAX874) and low 40ppm/°C max drift make these references suitable for a wide range of precision applications.

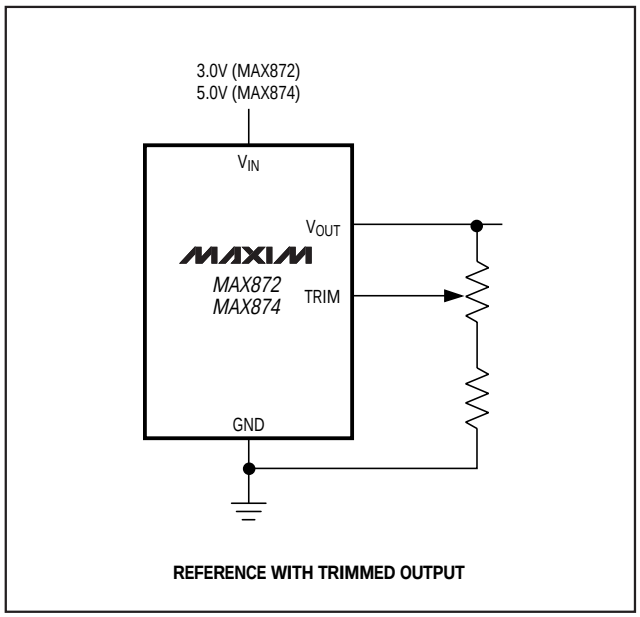
Applications

Hand-Held Instruments

Battery-Operated Equipment

Power Supplies

Typical Operating Circuit



REFERENCE WITH TRIMMED OUTPUT

Features

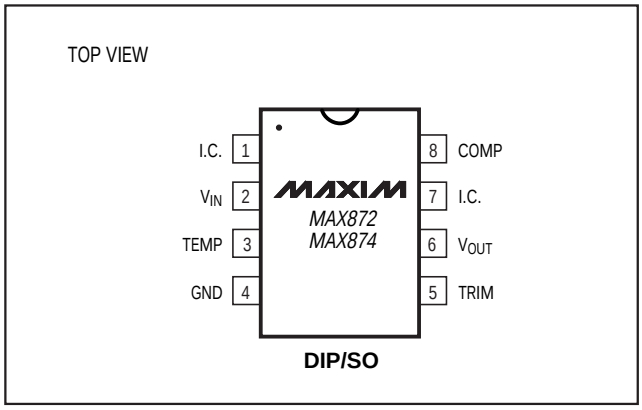
- **Output Voltage**
  2.500V ±0.2% (MAX872)
  4.096V ±0.2% (MAX874)
- **Wide Operating Voltage Range**
  2.7V to 20V (MAX872)
  4.3V to 20V (MAX874)
- **10µA Max Supply Current**
- **40ppm/°C Max Drift Over Extended Temp. Range**
- **Line Regulation Over Temp.**
  20µV/V (MAX872)
  75µV/V (MAX874)
- **Load Regulation Over Temp.**
  0.6mV/mA Max (MAX872)
  1.0mV/mA Max (MAX874)
- **±500µA Sink/Source Current**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX872CPA	0°C to +70°C	8 Plastic DIP
MAX872CSA	0°C to +70°C	8 SO
MAX872C/D	0°C to +70°C	Dice*
MAX872EPA	-40°C to +85°C	8 Plastic DIP
MAX872ESA	-40°C to +85°C	8 SO
MAX874CPA	0°C to +70°C	8 Plastic DIP
MAX874CSA	0°C to +70°C	8 SO
MAX874C/D	0°C to +70°C	Dice*
MAX874EPA	-40°C to +85°C	8 Plastic DIP
MAX874ESA	-40°C to +85°C	8 SO

** Dice are specified at +25°C only.*

Pin Configuration



DIP/SO

ABSOLUTE MAXIMUM RATINGS

Supply Voltage 24V
Output Short-Circuit Duration .....Continuous to Either Supply
C_{COMP} Input.....-0.3V to V_{OUT}
TRIM Input .....-0.3V to (V_{IN} + 0.3V)
TEMP Output .....-0.3V to (V_{IN} + 0.3V)
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

Operating Temperature Ranges
MAX87_C__ .....0°C to +70°C
MAX87_E__ .....-40°C to +85°C
Storage Temperature Range .....-65°C to +150°C
Junction Temperature Range (T_j) .....-65°C to +160°C
Lead Temperature (soldering, 10sec) .....+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—MAX872

(V_{IN} = 2.7V, I_L = 0mA, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}		2.495	2.500	2.505	V
Output Voltage Noise	e_n	0.1Hz to 10Hz		60		µVp-p
Line Regulation	V_{OUT}/V_{IN}	V_{IN} = 4.5V to 20V		4	12	µV/V
		V_{IN} = 2.7V to 5.5V		80	250	
Load Regulation (Note 1)	V_{OUT}/I_{OUT}	Sourcing 0mA to 0.5mA		0.2	0.5	mV/mA
		Sinking 0mA to -0.5mA		4	12	
Quiescent Supply Current	I_Q			6.5	10	µA
Change in Supply Current vs. V_{IN}	I_Q/V_{IN}	V_{IN} = 2.7V to 20V		0.35	0.55	µA/V
Short-Circuit Output Current	I_{SC}	V_{OUT} short to GND		6	15	mA
		V_{OUT} short to V_{IN}		3	9	
TEMP Voltage	V_{TEMP}			690		mV
V_{OUT} Adjustment Range	V_{ADJ}	$V_{OUT} \geq V_{OUT}$ + 0.2V	+75/-20	+100/-25		mV

ELECTRICAL CHARACTERISTICS—MAX874

(V_{IN} = 4.3V, I_L = 0mA, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}		4.088	4.096	4.104	V
Output Voltage Noise	e_n	0.1Hz to 10Hz		90		µVp-p
Line Regulation	V_{OUT}/V_{IN}	V_{IN} = 4.3V to 20V		15	75	µV/V
Load Regulation (Note 1)	V_{OUT}/I_{OUT}	Sourcing 0mA to 0.5mA		0.15	0.9	mV/mA
		Sinking 0mA to -0.5mA		6	15	
Quiescent Supply Current	I_Q			6.5	10	µA
Change in Supply Current vs. V_{IN}	I_Q/V_{IN}	V_{IN} = 4.3V to 20V		0.35	0.55	µA/V
Short-Circuit Output Current	I_{SC}	V_{OUT} short to GND		6	15	mA
		V_{OUT} short to V_{IN}		5	25	
TEMP Voltage	V_{TEMP}			690		mV
V_{OUT} Adjustment Range	V_{ADJ}	$V_{OUT} \geq V_{OUT}$ + 0.2V	±150	±200		mV

ELECTRICAL CHARACTERISTICS—MAX872C

(V_{IN} = 2.7V, I_L = 0mA, T_A = 0°C to +70°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}		2.4905		2.5095	V
Output Voltage Temperature Coefficient	TCV_{OUT}			20	40	ppm/°C
Line Regulation	V_{OUT}/V_{IN}	V_{IN} = 4.5V to 20V			20	µV/V
		V_{IN} = 2.7V to 5.5V			300	
Load Regulation (Note 1)	V_{OUT}/I_{OUT}	Sourcing 0mA to 0.4mA			0.6	mV/mA
		Sinking 0mA to -0.4mA			15	
Quiescent Supply Current	I_Q				15	µA
Change in Supply Current vs. V_{IN}	I_Q/V_{IN}	V_{IN} = 2.7V to 20V			0.7	µA/V
V_{OUT} Adjustment Range	V_{ADJ}	$V_{IN} \geq V_{OUT}$ + 0.2V	+75/-20			mV
TEMP Output Temperature Coefficient	TCV_{TEMP}			2.3		mV/°C

ELECTRICAL CHARACTERISTICS—MAX874C

(V_{IN} = 4.3V, I_L = 0mA, T_A = 0°C to +70°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}		4.0805		4.1115	V
Output Voltage Temperature Coefficient	TCV_{OUT}			20	40	ppm/°C
Line Regulation	V_{OUT}/V_{IN}	V_{IN} = 4.3V to 20V			75	µV/V
Load Regulation (Note 1)	V_{OUT}/I_{OUT}	Sourcing 0mA to 0.4mA			1.0	mV/mA
		Sinking 0mA to -0.4mA			25	
Quiescent Supply Current	I_Q				15	µA
Change in Supply Current vs. V_{IN}	I_Q/V_{IN}	V_{IN} = 4.3V to 20V			0.7	µA/V
V_{OUT} Adjustment Range	V_{ADJ}	$V_{IN} \geq V_{OUT}$ + 0.2V	±150			mV
TEMP Output Temperature Coefficient	TCV_{TEMP}			2.3		mV/°C

Note 1: If the load current exceeds 300µA, connect a minimum of 1000pF from V_{OUT} to GND. Note that if a capacitor larger than 1000pF is used, a compensation capacitor of $C_{OUT}/100$ must be connected from V_{OUT} to COMP.

ELECTRICAL CHARACTERISTICS—MAX872E

(V_{IN} = 2.7V, I_L = 0mA, T_A = -40°C to +85°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}		2.488		2.512	V
Output Voltage Temperature Coefficient	TCV_{OUT}			20	40	ppm/°C
Line Regulation	V_{OUT}/V_{IN}	V_{IN} = 4.5V to 20V			20	µV/V
		V_{IN} = 2.7V to 5.5V			300	
Load Regulation	V_{OUT}/I_{OUT}	Sourcing 0mA to 0.30mA			0.6	mV/mA
		Sinking 0mA to -0.30mA			15	
Quiescent Supply Current	I_Q				15	µA
Change in Supply Current vs. V_{IN}	I_Q/V_{IN}	V_{IN} = 2.7V to 20V			0.7	µA/V
V_{OUT} Adjustment Range	V_{ADJ}	$V_{IN} \geq V_{OUT}$ + 0.2V	+75/-20			mV
TEMP Output Temperature Coefficient	TCV_{TEMP}			2.3		mV/°C

ELECTRICAL CHARACTERISTICS—MAX874E

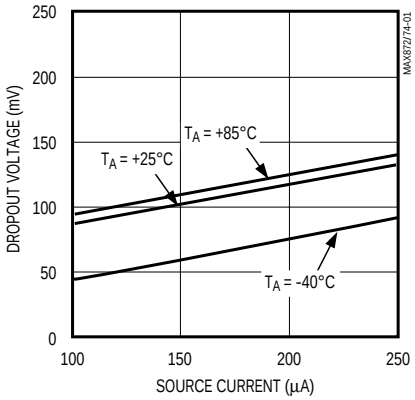
(V_{IN} = 4.3V, I_L = 0mA, T_A = -40°C to +85°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage	V_{OUT}		4.077		4.115	V
Output Voltage Temperature Coefficient	TCV_{OUT}			20	40	ppm/°C
Line Regulation	V_{OUT}/V_{IN}	V_{IN} = 4.3V to 20V			75	µV/V
Load Regulation	V_{OUT}/I_{OUT}	Sourcing 0mA to 0.30mA			1.0	mV/mA
		Sinking 0mA to -0.30mA			25	
Quiescent Supply Current	I_Q				15	µA
Change in Supply Current vs. V_{IN}	I_Q/V_{IN}	V_{IN} = 4.3V to 20V			0.7	µA/V
V_{OUT} Adjustment Range	V_{ADJ}	$V_{IN} \geq V_{OUT}$ + 0.2V	±150			mV
TEMP Output Temperature Coefficient	TCV_{TEMP}			2.3		mV/°C

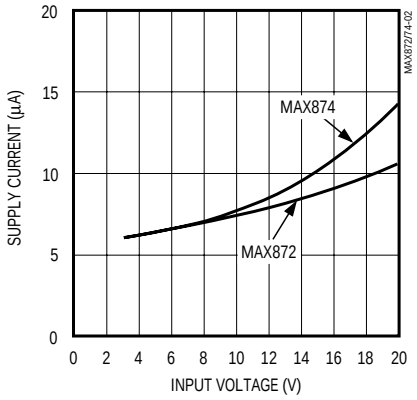
Typical Operating Characteristics

(V_{IN} = 3V (MAX872), V_{IN} = 5V (MAX874), no load, T_A = +25°C, unless otherwise noted.)

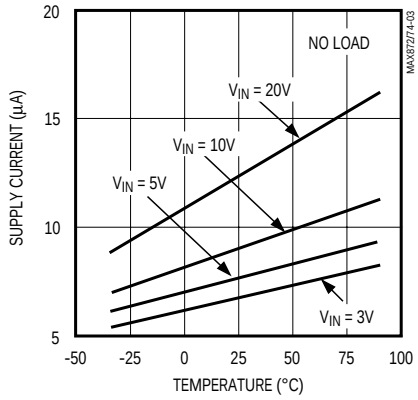
DROPOUT VOLTAGE vs. SOURCE CURRENT



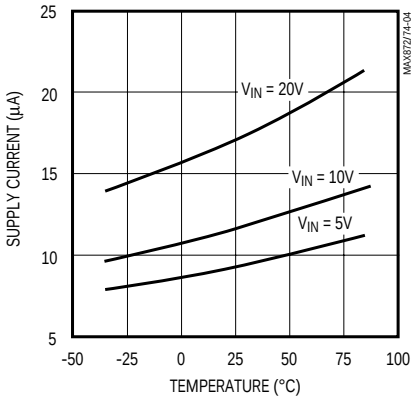
SUPPLY CURRENT vs. INPUT VOLTAGE



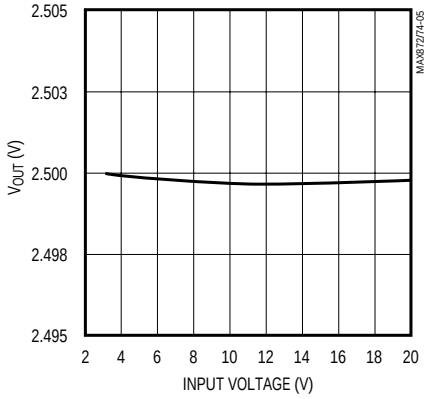
MAX872 SUPPLY CURRENT vs. TEMPERATURE



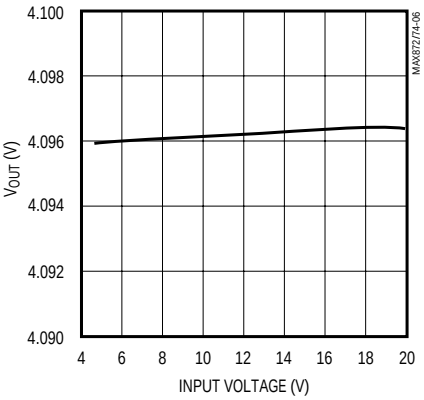
MAX874 SUPPLY CURRENT vs. TEMPERATURE



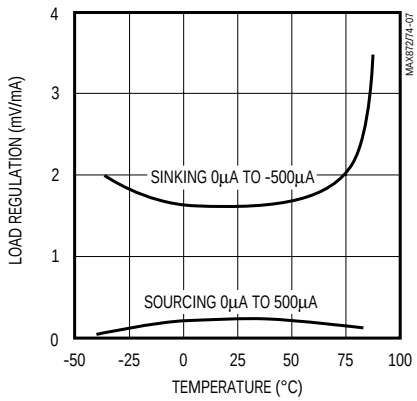
MAX872 OUTPUT VOLTAGE vs. INPUT VOLTAGE



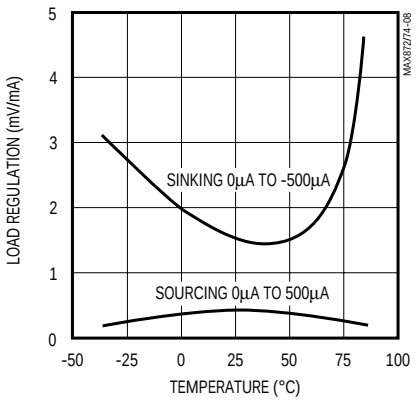
MAX874 OUTPUT VOLTAGE vs. INPUT VOLTAGE



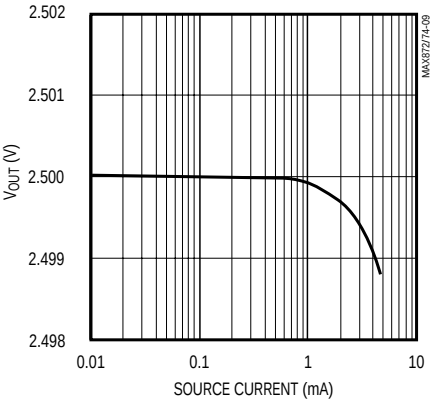
MAX872 LOAD REGULATION vs. TEMPERATURE



MAX874 LOAD REGULATION vs. TEMPERATURE



MAX872 OUTPUT VOLTAGE vs. SOURCE CURRENT

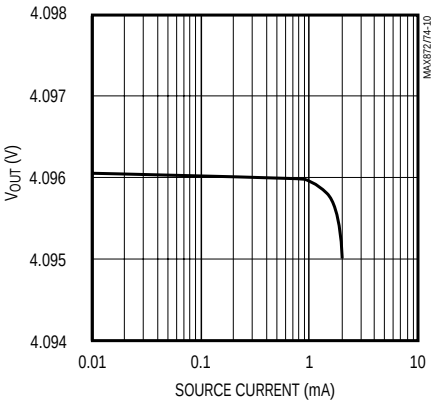


10µA, Low-Dropout, Precision Voltage References

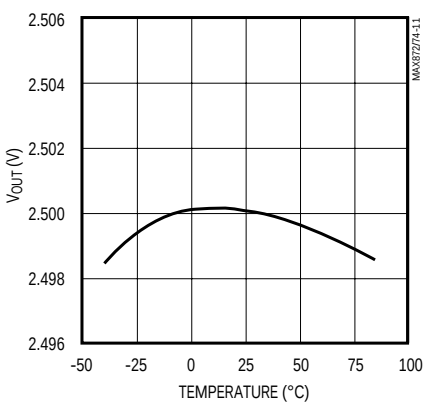
Typical Operating Characteristics (continued)

(V_{IN} = 3V (MAX872), V_{IN} = 5V (MAX874), no load, T_A = +25°C, unless otherwise noted.)

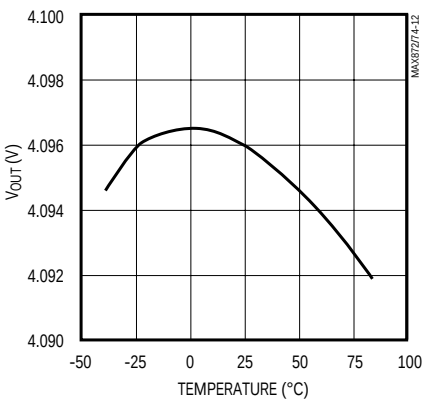
MAX874
OUTPUT VOLTAGE vs. SOURCE CURRENT



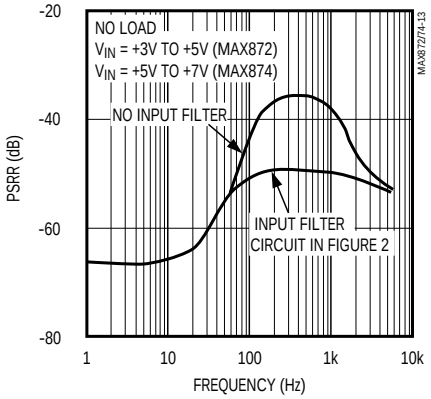
MAX872
OUTPUT VOLTAGE vs. TEMPERATURE



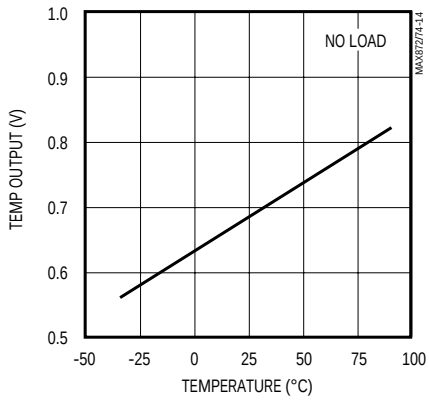
MAX874
OUTPUT VOLTAGE vs. TEMPERATURE



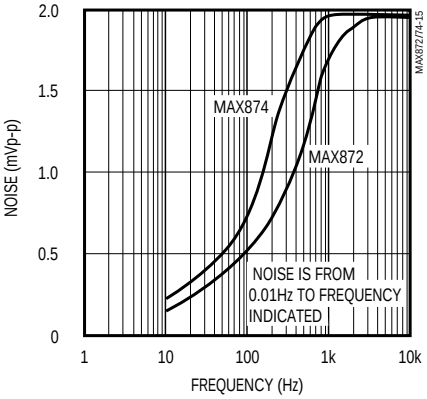
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



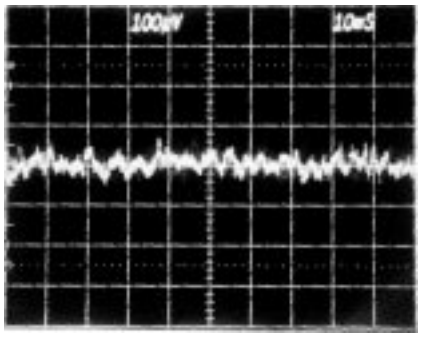
TEMP OUTPUT vs. TEMPERATURE



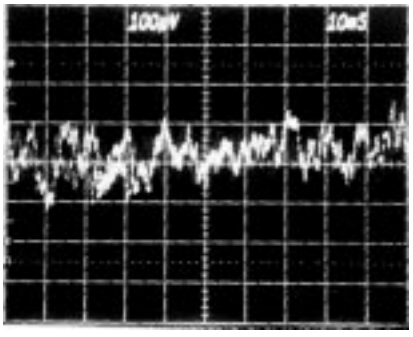
NOISE vs. FREQUENCY



MAX872
1Hz TO 100Hz NOISE



MAX874
1Hz TO 100Hz NOISE



Pin Description

PIN	NAME	FUNCTION
1, 7	I.C.	Internal Connection. Make no connection to this pin
2	V_{IN}	Input Voltage
3	TEMP	Temperature-Proportional Output Voltage. Generates an output voltage proportional to junction temperature.
4	GND	Ground
5	TRIM	Output Voltage Trim. Connect to the center of a voltage divider for output trimming. Otherwise make no connection.
6	V_{OUT}	Reference Output
8	COMP	Compensation Input. Connect $C_{LOAD}/100$ capacitor from V_{OUT} to COMP to provide capacitive load compensation.

Applications Information

Trimming the Output Voltage

The MAX872/MAX874's output voltage is trimmed for 0.2% tolerance at +25°C. If additional V_{OUT} trimming is desired, connect a potentiometer to TRIM, as shown in Figures 1a and 1b. Adjusting V_{OUT} away from its factory-trimmed voltage typically changes the output voltage tempco by 7ppm/°C per 100mV.

Reducing Input Ripple with an Input Filter

The Power-Supply Rejection Ratio vs. Frequency graph in the *Typical Operating Characteristics* shows ripple rejection between 10Hz and 2kHz. As input RC filter with a pole less than 10Hz, as shown in Figure 2, further attenuates input ripple with this band. The voltage drop across the input resistor (due to supply and load current) slightly increases the dropout voltage. The increase is given by $[(I_{LOAD} + I_{SUPPLY}) \bullet R]$.

Choosing the Output and Compensation Capacitors

Connecting a capacitor between Void and GND reduces load transients. If the load exceeds 300µA, connect a minimum of 1000pF from V_{OUT} to GND. The type of capacitor is not critical. If the total load capacitance from V_{OUT} to GND (C_{LOAD} = output capacitor + other capacitive load) is larger than 1000pF, connect a compensation capacitor with a value of $C_{LOAD}/100$ between COMP and V_{OUT}.

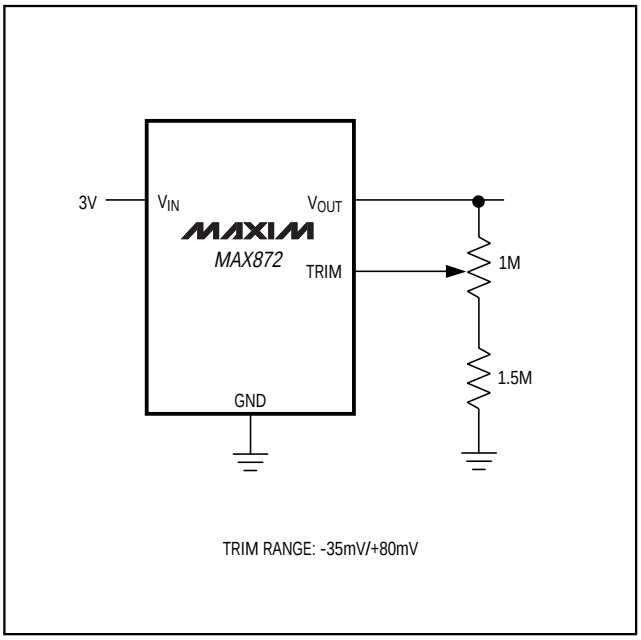


Figure 1a. Adjusting V_{OUT} with the TRIM Input on the MAX872

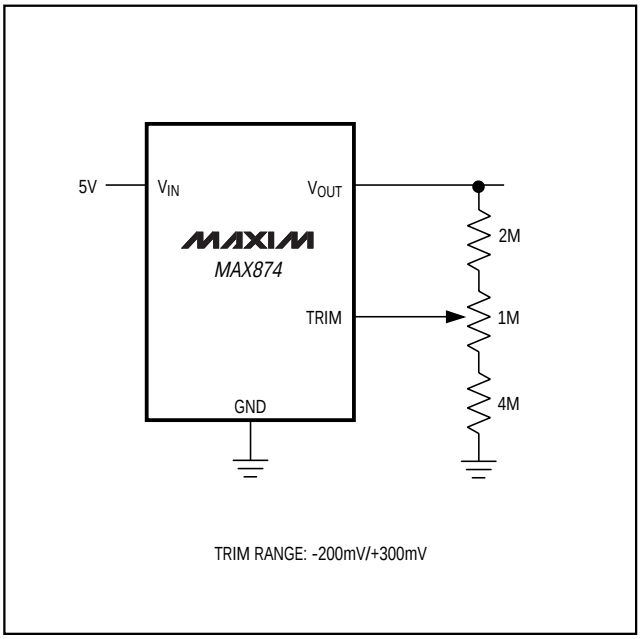


Figure 1b. Adjusting V_{OUT} with the TRIM Input on the MAX874

10µA, Low-Dropout, Precision Voltage References

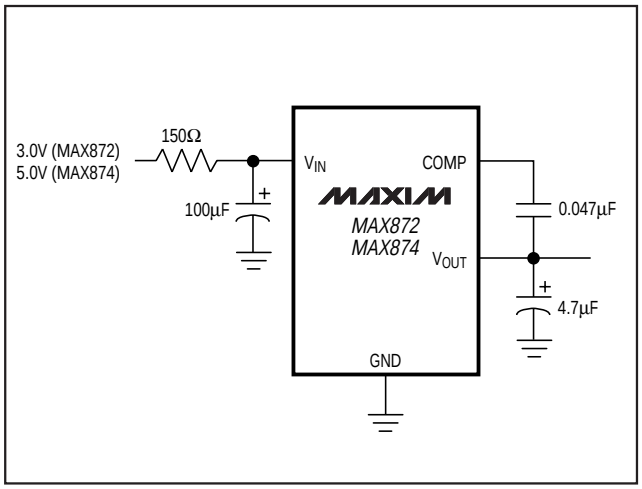


Figure 2. Input Filter Reduces Input Ripple

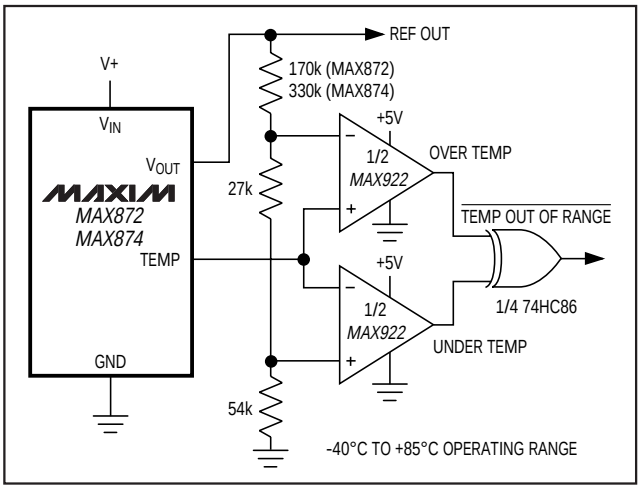


Figure 3. Operating Temperature Range Window Comparator

TEMP Output

The TEMP output provides a voltage proportional to the MAX872/MAX874 junction temperature. Since the power dissipation of the MAX872/MAX874 is <100µW typ, the junction temperature is within 0.5°C of the ambient temperature. Although it goes unused in most applications, the ambient temperature information given by the TEMP output may be used to control LCD contrast, or to provide ADC gain compensation or thermal out-of-range indication. TEMP must be buffered or connected to a high-impedance input.

Operating Temperature Window Comparator

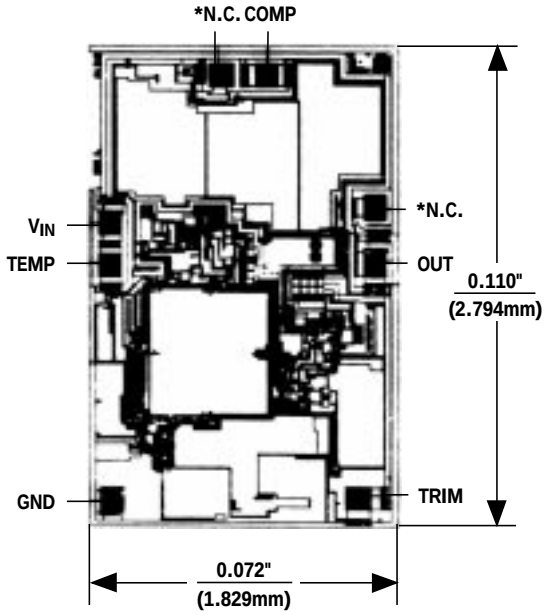
In Figure 3, a window comparator monitors the TEMP output and indicates if the temperature is out of the nominal operating range. For the resistor values shown, the circuit will indicate an out-of-range condition if the ambient temperature should rise above +85°C or dip below -40°C.

Start-Up

When the input voltage is below the factory-selected output voltage, the MAX872/MAX874 can draw excessive supply current (hundreds of microamps). If the source resistance is too high, the voltage drop across the source resistance can prevent the input voltage to the device from reaching the minimum dropout voltage. Therefore, when using the MAX872/MAX874 in low-dropout applications, ensure that the power supply has a low source resistance.

Chip Topography

MAX872/MAX874



*MAKE NO CONNECTIONS TO THESE PADS

TRANSISTOR COUNT: 89

SUBSTRATE CONNECTED TO GND.