5V/3.3V or Adjustable, Low-Dropout, Low I_Q, 200mA Linear Regulators

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (IN or OUT to GND).......................-0.3V to +12V
Output Short-Circuit Duration 1min
Continuous Output Current 300mA
$\overline{LBO}$ Output Current 50mA
$\overline{LBO}$ Output Voltage and LBI,
SET, STBY, OFF Input Voltages ....-0.3V to the greater of (IN + 0.3V) or (OUT + 0.3V)
Continuous Power Dissipation (T_J = +70°C)
Plastic DIP (derate 9.09mW/°C above +70°C) 727mW
High-Power SO (derate 18.75mW/°C above +70°C) 1.5W
CERDIP (derate 8.00mW/°C above +70°C).................640mW
Operating Temperature Ranges
MAX88_C_A ....0°C to +70°C
MAX88_E_A ....-40°C to +85°C
Junction Temperature ....+150°C
Storage Temperature Range ....-65°C to +160°C
Lead Temperature (soldering, 10s) ....+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

(V_{IN} = 6V (MAX883) or V_{IN} = 4.3V (MAX882/MAX884), C_{OUT} = 2.2µF, STBY or OFF = V_{IN}, SET = GND, LBI = V_{IN}, T_J = -40°C to +85°C, unless otherwise noted. Typical values are at T_J = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}	SET = OUT, R_L = 1kΩ	MAX88_C_A	2.7		11.5	V
			MAX88_E_A	2.9		11.5	
			MAX88_MJA	3.0		11.5	
Output Voltage (Note 2)	V_{OUT}	MAX883, 6.0V ≤ V_{IN} ≤ 11.5V	I_{OUT} = 100µA - 250mA, 0°C ≤ T_J ≤ +85°C	4.75	5.00	5.25	V
			I_{OUT} = 100µA - 250mA, -40°C ≤ T_J ≤ +85°C	4.65		5.35	
		MAX882/MAX884, 4.3V ≤ V_{IN} ≤ 11.5V	I_{OUT} = 100µA - 200mA, 0°C ≤ T_J ≤ +85°C	3.15	3.30	3.45	
			I_{OUT} = 100µA - 200mA, -40°C ≤ T_J ≤ +85°C	3.07		3.53	
Load Regulation	ΔV_{LDR}	I_{OUT} = 1mA to 200mA	MAX883C_A/E_A		60	100	mV
			MAX883MJA			150	
		I_{OUT} = 1mA to 150mA	MAX882, MAX884		30	100	
Line Regulation	ΔV_{LNR}	(V_{OUT} + 0.5V) < V_{IN} < 11.5V, I_{OUT} = 10mA			10	40	mV
Dropout Voltage (Note 3)	ΔV_{DO}	MAX883	I_{OUT} = 100mA		110	220	mV
			I_{OUT} = 200mA		220	440	
		MAX882/MAX884	I_{OUT} = 100mA		160	320	
			I_{OUT} = 200mA		320	640	
Quiescent Current	I_Q	SET = OUT, V_{IN} = 6V	MAX88_C_A/E_A		11	15	µA
			MAX88_MJA			30	
		V_{IN} = 11.5V	MAX88_C_A/E_A		15	25	
			MAX88_MJA			40	

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = 6V (MAX883) or V_{IN} = 4.3V (MAX882/MAX884), C_{OUT} = 2.2µF, STBY or OFF = V_{IN}, SET = GND, LBI = V_{IN}, T_J = -40°C to +85°C, unless otherwise noted. Typical values are at T_J = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
STBY Quiescent Current (Note 4)	$I_{Q\ STBY}$	STBY = 0, V_{IN} = 6V, SET = OUT	MAX882C_A/E_A		7	15	µA
			MAX882MJA			30	
		STBY = 0, V_{IN} = 11.5V, SET = OUT	MAX882C_A/E_A		10	25	
			MAX882MJA			40	
OFF Quiescent Current	$I_{Q\ OFF}$	OFF = 0, R_L = 1kΩ, V_{IN} = 11.5V MAX883/MAX884	MAX88_C_A		0.01	1	µA
			MAX88_E_A			5	
			MAX88_MJA			10	
Minimum Load Current	$I_{OUT(MIN)}$	V_{IN} = 11.5V, SET = OUT	MAX88_C_A			1	µA
			MAX88_E_A			3	
			MAX88_MJA			10	
Foldback Current Limit (Note 5)	ILIM	V_{OUT} < 0.8V			170		mA
		V_{OUT} > 0.8V and V_{IN} - V_{OUT} > 0.7V			430		
Thermal Shutdown Temperature	T_{SD}				+160		°C
Thermal Shutdown Hysteresis	ΔT_{SD}				10		°C
Reverse-Current-Protection (Note 6)	ΔV_{RTH}	V_{OUT} = 4.5V	MAX883_A		6	20	mV
		V_{OUT} = 3.0V	MAX882_A, MAX884_A		6	20	
Reverse Leakage Current	I_{RVL}	MAX882: V_{IN} = 0, STBY = 0, V_{OUT} = 3.0V			7		µA
		MAX883/MAX884: V_{IN} = 0, OFF = 0, V_{OUT} = 3.0V			0.01		
Startup Overshoot	V_{OSH}	R_L = 1kΩ, C_{OUT} = 2.2µF					% of V_{OUT}
Time Required to Exit OFF or STBY Modes	T_{START}	V_{IN} = 9V, R_L = 33Ω, OFF from 0 to V_{IN}, 0% to 95% of V_{OUT}			200		µs
Dual Mode SET Threshold	$V_{SET\ TH}$	For internal feedback			65	30	mV
		For external feedback		150	65		
SET Reference Voltage	V_{SET}	SET = OUT, R_L = 1kΩ	0°C ≤ T_J ≤ +85°C	1.16	1.20	1.24	V
			-40°C ≤ T_J ≤ +85°C	1.12		1.28	
SET Input Leakage Current	I_{SET}	V_{SET} = 1.5V or 0			±0.01	±50	nA
LBI Threshold Voltage	V_{LBI}	LBI signal falling	0°C ≤ T_J ≤ +85°C	1.15	1.20	1.25	V
			-40°C ≤ T_J ≤ +85°C	1.11		1.29	
LBI Hysteresis	ΔV_{LBI}				7		mV
LBI Input Leakage Current	I_{LBI}	V_{LBI} = 1.5V			±0.01	±50	nA
$\overline{LBO}$ Output Low Voltage	$V_{\overline{LBOL}}$	$I_{\overline{LBO}}$ sink = 1.2mA, V_{LBI} = 1V, 3V < V_{IN} < 11.5V, SET = OUT			90	250	mV
$\overline{LBO}$ Output Leakage Current	$I_{\overline{BLO}\ LKG}$	V_{LBI} = V_{IN}, V_{LBO} = V_{IN}			0.01	0.1	µA
OUT Leakage Current	$I_{OUT\ LKG}$	V_{IN} = 11.5V, V_{OUT} = 2V, SET = OUT	MAX88_C_A		0.01	1	µA
			MAX88_E_A			3	
			MAX88_MJA			10	

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = 6V (MAX883) or V_{IN} = 4.3V (MAX882/MAX884), C_{OUT} = 2.2µF, STBY or OFF = V_{IN}, SET = GND, LBI = V_{IN}, T_J = -40°C to +85°C, unless otherwise noted. Typical values are at T_J = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
STBY Threshold Voltage	V_{STBY}	STBY signal falling, MAX882_A	1.15	1.20	1.25	V
STBY Hysteresis	ΔV_{STBY}	MAX882_A		7		mV
STBY Input Leakage Current	I_{STBY}	V_{STBY} = V_{IN} or 0, MAX882_A		±0.01	±50	nA
OFF Threshold Voltage	$V_{IL\ OFF}$	In off mode, MAX883_A, MAX884_A			0.4	V
	$V_{IH\ OFF}$	In on mode, SET = OUT, V_{IN} < 6V, MAX883_A, MAX884_A	2.0			
		In on mode, SET = OUT, 6V < V_{IN} < 11.5V, MAX883_A, MAX884_A	3.0			
OFF Input Leakage Current	I_{OFF}	V_{OFF} = V_{IN} or 0		±0.01	±50	nA
Output Noise	e_n	10Hz to 10kHz, SET = OUT, R_L = 1kΩ, C_{OUT} = 2.2µF (Note 7)		250		μV_{RMS}

Note 1: Electrical specifications are measured by pulse testing and are guaranteed for a junction temperature (T_J) within the operating temperature range, unless otherwise noted. Specifications to -40°C are guaranteed by design and not production tested.

Note 2: (V_{IN} - V_{OUT}) is limited to keep the product (I_{OUT} x (V_{IN} - V_{OUT})) from exceeding the package power dissipation limits. See Figure 5. Therefore, the combination of high output current and high supply voltage is not tested.

Note 3: Dropout Voltage is (V_{IN} - V_{OUT}) when V_{OUT} falls to 100mV below its nominal value at V_{IN} = (V_{OUT} + 2V). For example, the MAX883 is tested by measuring the V_{OUT} at V_{IN} = 7V, then V_{IN} is lowered until V_{OUT} falls 100mV below the measured value. The difference (V_{IN} - V_{OUT}) is then measured and defined as ΔV_{DO}.

Note 4: Since standby mode inhibits the output but keeps all biasing circuitry alive, the Standby Quiescent Current is similar to the normal operating quiescent current.

Note 5: Foldback Current Limit was characterized by pulse testing to remain below the maximum junction temperature (not production tested).

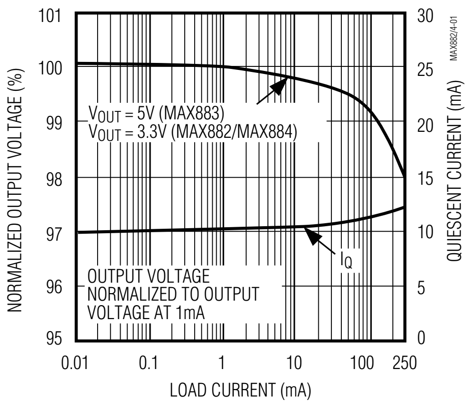
Note 6: The Reverse-Current Protection Threshold is the output/input differential voltage (V_{OUT} - V_{IN}) at which reverse-current protection switchover occurs and the pass transistor is turned off. See the section *Reverse-Current Protection* in the *Detailed Description.*

Note 7: Noise is tested using a bandpass amplifier with two poles at 10Hz and two poles at 10kHz.

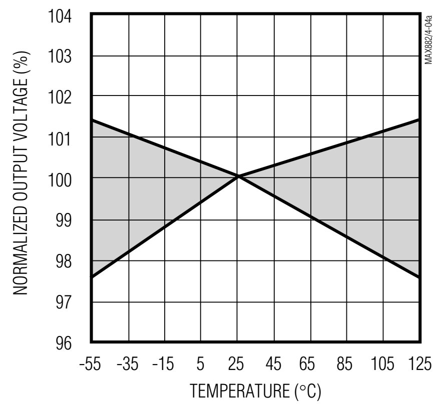
Typical Operating Characteristics

(V_{IN} = 7V for MAX883, V_{IN} = 5.3V for MAX882/MAX884, OFF or STBY = V_{IN}, SET = GND, LBI = V_{IN}, $\overline{LBO}$ = OPEN, C_{IN} = C_{OUT} = 2.2µF, R_L = 1kΩ, T_A = +25°C, unless otherwise noted.)

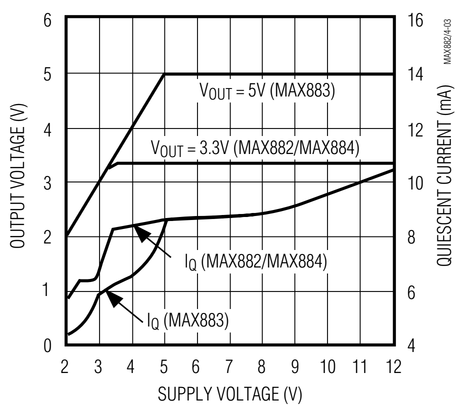
OUTPUT VOLTAGE AND QUIESCENT CURRENT vs. LOAD CURRENT



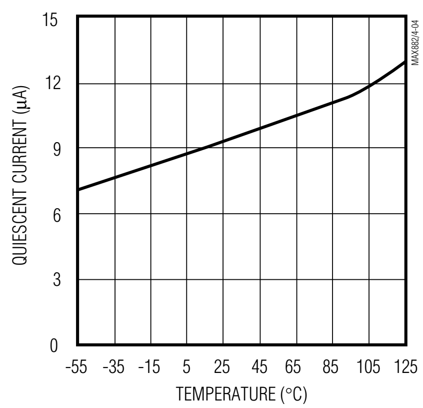
OUTPUT VOLTAGE vs. TEMPERATURE



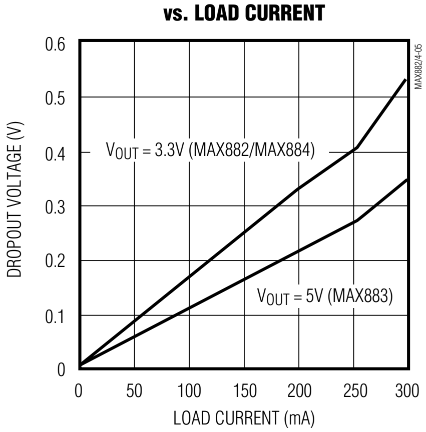
OUTPUT VOLTAGE AND QUIESCENT CURRENT vs. SUPPLY VOLTAGE



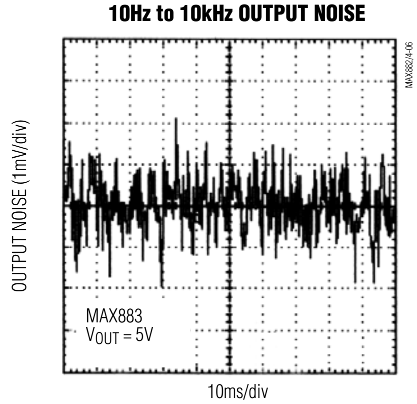
QUIESCENT CURRENT vs. TEMPERATURE



DROPOUT VOLTAGE vs. LOAD CURRENT



10Hz to 10kHz OUTPUT NOISE

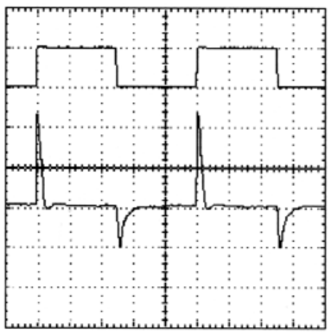


5V/3.3V or Adjustable, Low-Dropout, Low I_Q, 200mA Linear Regulators

Typical Operating Characteristics (continued)

(V_{IN} = 7V for MAX883, V_{IN} = 5.3V for MAX882/MAX884, OFF or STBY = V_{IN}, SET = GND, LBI = V_{IN}, $\overline{LBO}$ = OPEN, C_{IN} = C_{OUT} = 2.2µF, R_L = 1kΩ, T_A = +25°C, unless otherwise noted.)

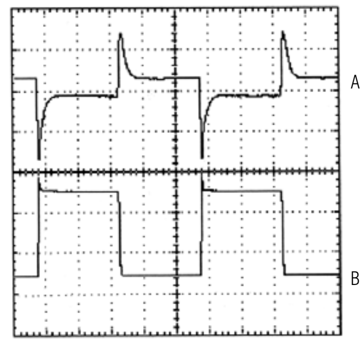
LINE-TRANSIENT RESPONSE



500µs/div

MAX883: V_{OUT} = 5V, C_{IN} = 0µF, t_R = 15µs, t_F = 13µs
A: V_{IN} = 8V (HIGH) / V_{IN} = 7V (LOW)
B: OUTPUT VOLTAGE (100mV/div)

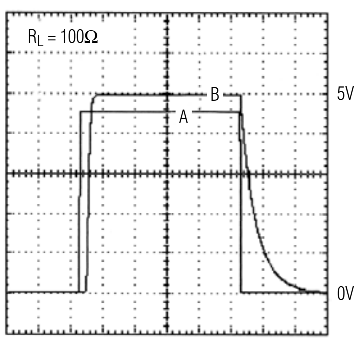
LOAD-TRANSIENT RESPONSE



1ms/div

MAX883: V_{OUT} = 5V, t_R = 24µs, t_F = 44µs
A: OUTPUT VOLTAGE (100mV/div)
B: I_{OUT} = 250mA (HIGH) / I_{OUT} = 50mA (LOW)

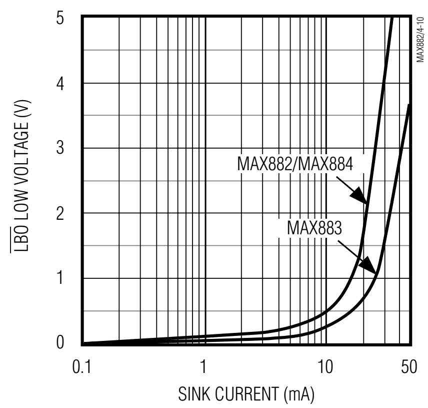
OVERSHOOT AND TIME EXITING SHUTDOWN MODE



500µs/div

A: $\overline{OFF}$ PIN VOLTAGE (1V/div):
RISE TIME = 9µs
B: MAX883 OUTPUT VOLTAGE (1V/div):
DELAY = 135µs, RISE TIME = 67µs,
OVERSHOOT = 0%

$\overline{LBO}$ LOW VOLTAGE vs. SINK CURRENT



Pin Description

PIN		NAME	DESCRIPTION
MAX882	MAX883/ MAX884		
1	1	$\overline{\text{LBO}}$	Low-Battery Output is an open-drain output that goes low when LBI is less than 1.2V. Connect to IN or OUT through a pull-up resistor. $\overline{\text{LBO}}$ is undefined during shutdown mode (MAX883/MAX884).
2	2	SET	Feedback for setting the output voltage. Connect to GND to set the output voltage to the preselected 3.3V or 5V. Connect to an external resistor network for adjustable-output operation.
3, 6	3, 6	GND	Ground pins—also function as heatsinks in the SO package. All GND pins must be soldered to the PC board for proper power dissipation. Connect to large copper pads or planes to channel heat from the IC.
4	4	OUT	Regulator Output. Fixed or adjustable from 1.25V to 11.0V. Sources up to 200mA. Bypass with a 2.2µF capacitor.
5	5	IN	Regulator Input. Supply voltage can range from 2.7V to 11.5V.
7	—	STBY	Standby. Active-low comparator input. Connect to GND to disable the output or to IN for normal operation. A resistor network (from IN) can be used to set a standby mode threshold.
—	7	OFF	Shutdown. Active-low logic input. In OFF mode, supply current is reduced below 1µA and V_{OUT} = 0.
8	8	LBI	Low-Battery comparator Input. Tie to IN when not used.

Detailed Description

The MAX882/MAX883/MAX884 are micropower, low-dropout linear regulators designed primarily for battery-powered applications. They feature Dual Mode operation, allowing a fixed output of 5V for the MAX883 and 3.3V for the MAX882/MAX884, or an adjustable output from 1.25V to 11V. These devices supply up to 200mA while requiring less than 15µA quiescent current. As illustrated in Figure 1, they consist of a 1.20V reference, error amplifier, MOSFET driver, p-channel pass transistor, dual-mode comparator, and feedback voltage-divider.

The 1.20V reference is connected to the error amplifier's inverting input. The error amplifier compares this reference with the selected feedback voltage and amplifies the difference. The MOSFET driver reads the error signal and applies the appropriate drive to the p-channel pass transistor. If the feedback voltage is lower than the reference, the pass transistor's gate is pulled lower, allowing more current to pass and increasing the output voltage. If the feedback voltage is too high, the pass transistor gate is pulled up, allowing less current to pass to the output.

The output voltage is fed back through either an internal resistor voltage-divider connected to the OUT pin, or an external resistor network connected to the SET pin. The dual-mode comparator examines the SET pin voltage and selects the feedback path used. If the SET pin is below 65mV, internal feedback is used and the output voltage is regulated to 5V for the MAX883 or 3.3V for the MAX882/MAX884. Additional blocks include a foldback current limiter, reverse-current protection, a thermal sensor, shutdown or standby logic, and a low-battery-detection comparator.

Internal p-Channel Pass Transistor

The MAX882/MAX883/MAX884 feature a 200mA P-channel MOSFET pass transistor. This provides several advantages over similar designs using PNP pass transistors, including longer battery life.

The p-channel MOSFET requires no base drive, which reduces quiescent current considerably. PNP-based regulators waste large amounts of current in dropout when the pass transistor saturates. They also use high base-drive currents under large loads. The MAX882/MAX883/MAX884 do not suffer from these problems and consume only 11µA of quiescent current during light loads, heavy loads, and dropout.

Output Voltage Selection

The MAX882/MAX883/MAX884 feature Dual Mode operation. In preset voltage mode, the MAX883's output is set to 5V and the MAX882/MAX884's output is set to 3.3V, using internal trimmed feedback resistors. Select this mode by connecting SET to ground.

In preset voltage mode, impedances between SET and ground should be less than 100kΩ. Otherwise, spurious conditions could cause the voltage at SET to exceed the 65mV dual-mode threshold.

5V/3.3V or Adjustable, Low-Dropout, Low IQ, 200mA Linear Regulators

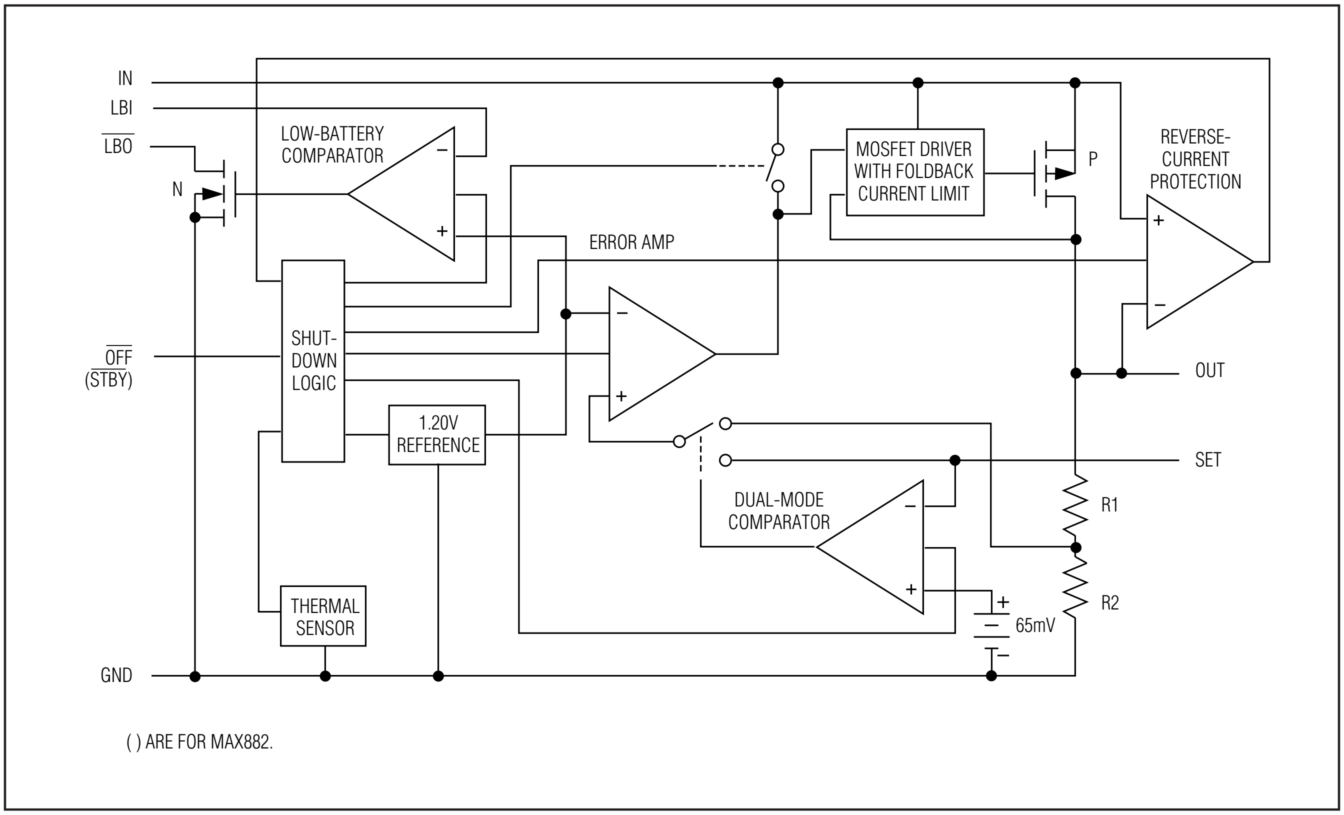


Figure 1. MAX882/MAX883/MAX884 Functional Diagram

In adjustable mode, the user selects an output voltage in the 1.25V to 11V range by connecting two external resistors, used as a voltage-divider, to the SET pin (Figure 2).

The output voltage is set by the following equation:

$$V_{OUT} = V_{SET}\left(1 + \frac{R1}{R2}\right)$$

where V_{SET} = 1.20V.

To simplify resistor selection:

$$R1 = R2\left(\frac{V_{OUT}}{V_{SET}} - 1\right)$$

Since the input bias current at SET is nominally zero, large resistance values can be used for R1 and R2 to minimize power consumption without losing accuracy. Up to 1.5MΩ is acceptable for R2. Since the V_{SET} tolerance is less than ±40mV, the output can be set using fixed resistors instead of trim pots.

Standby Mode (MAX882)

The MAX882 has a standby feature that disconnects the input from the output when STBY is brought low, but keeps all other circuitry awake. In this mode, V_{OUT} drops to 0, and the internal biasing circuitry (including the low-battery comparator) remains on. The maximum quiescent current during standby is 15µA. STBY is a comparator input with the other input internally tied to the reference voltage. Use a resistor network as shown in Figure 3 to set a standby-mode threshold voltage for undervoltage lockout. Connect STBY to IN for normal operation.

OFF Mode (MAX883/MAX884)

A low-logic input on the OFF pin shuts down the MAX883/MAX884. In this mode, the pass transistor, control circuit, reference, and all biases are turned off, and the supply current is reduced to less than 1µA. $\overline{\text{LBO}}$ is undefined in OFF mode. Connect OFF to IN for normal operation.

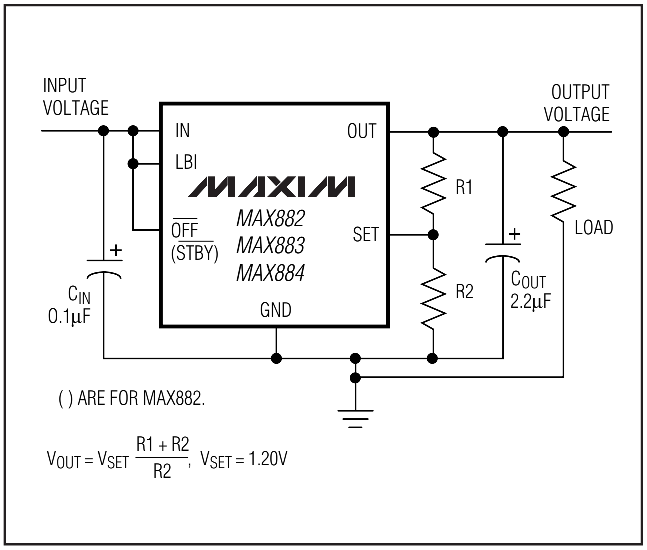


Figure 2. Adjustable Output Using External Feedback Resistors

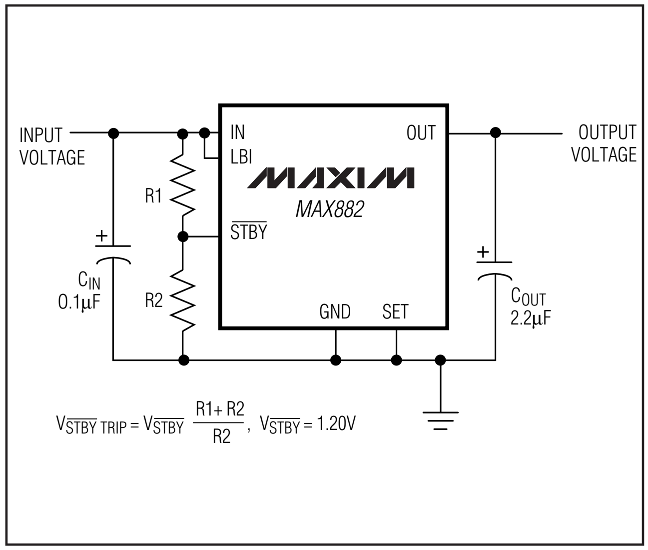


Figure 3. Setting an Undervoltage Lockout Threshold Using STBY

Foldback Current Limiting

The MAX882/MAX883/MAX884 also include a foldback current limiter. It monitors and controls the pass transistor's gate voltage, estimating the output current and limiting it to 430mA for output voltages above 0.8V and (V_{IN} - V_{OUT}) > 0.7V. If the output voltage drops below 0.8V, implying a short-circuit condition, the output current is limited to 170mA. The output can be shorted to ground for 1min without damaging the device if the package can dissipate (V_{IN} x 170mA) without exceeding T_J = +150°C. When the output is greater than 0.8V and (V_{IN} - V_{OUT}) < 0.7V (dropout operation), no current limiting is allowed, to provide maximum load drive.

Thermal Overload Protection

Thermal overload protection limits total power dissipation in the MAX882/MAX883/MAX884. When the junction temperature exceeds T_J = +160°C, the thermal sensor sends a signal to the shutdown logic, turning off the pass transistor and allowing the IC to cool. The thermal sensor turns the pass transistor on again after the IC's junction temperature cools by 10°C, resulting in a pulsed output during thermal overload conditions.

Thermal overload protection is designed to protect the MAX882/MAX883/MAX884 if fault conditions occur. It is not intended to be used as an operating mode. Prolonged operation in thermal-shutdown mode may reduce the IC's reliability. For continual operation, do not exceed the absolute maximum junction temperature rating of T_J = +150°C.

Power Dissipation and Operating Region

Maximum power dissipation of the MAX882/MAX883/MAX884 depends on the thermal resistance of the case and PC board, the temperature difference between the die junction and ambient air, and the rate of air flow. The power dissipation across the device is $P = I_{OUT} (V_{IN} - V_{OUT})$. The resulting power dissipation is as follows:

$$P = \frac{(T_J - T_A)}{(\theta_{JB} + \theta_{BA})}$$

where (T_J - T_A) is the temperature difference between the MAX882/MAX883/MAX884 die junction and the surrounding air, θ_{JB} (or θ_{JC}) is the thermal resistance of the package chosen, and θ_{BA} is the thermal resistance through the PC board, copper traces, and other materials to the surrounding air.

The 8-pin small-outline package for the MAX882/MAX883/MAX884 features a special lead frame with a lower thermal resistance and higher allowable power dissipation. This package's thermal resistance package is θ_{JB} = 53°C/W, compared with θ_{JB} = 110°C/W for an 8-pin plastic DIP package and θ_{JB} = 125°C/W for an 8-pin ceramic DIP package.

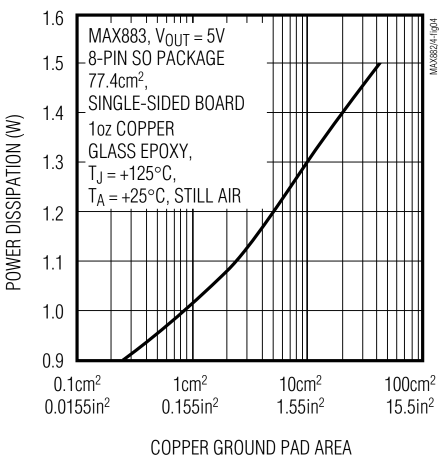


Figure 4. Typical Maximum Power Dissipation vs. Ground Pad Area

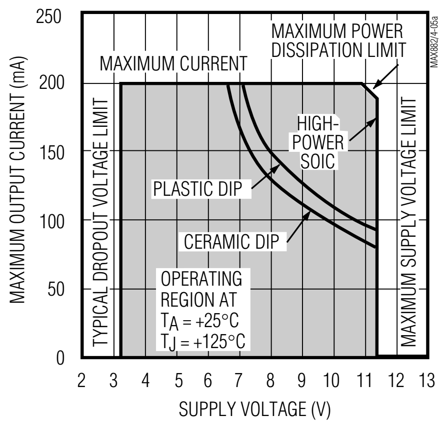


Figure 5a. Safe Operating Regions: MAX882/MAX884 Maximum Output Current vs. Supply Voltage

The GND pins of the MAX882/MAX883/MAX884 SOIC package perform the dual function of providing an electrical connection to ground and channeling heat away. Connect all GND pins to ground using a large pad or ground plane. Where this is impossible, place a copper plane on an adjacent layer. For a given power dissipation, the pad should exceed the associated dimensions in Figure 4.

Figure 4 assumes the IC is in an 8-pin small-outline package that has a maximum junction temperature of +125°C and is soldered directly to the pad; it also has a +25°C ambient air temperature and no other heat sources. Use larger pad sizes for other packages, lower junction temperatures, higher ambient temperatures, or conditions where the IC is not soldered directly to the heat-sinking ground pad. When operating C- and E-grade parts up to a T_J of +125°C, expect performance similar to M-grade specifications. For T_J between +125°C and +150°C, the output voltage may drift more.

The MAX882/MAX883/MAX884 can regulate currents up to 250mA and operate with input voltages up to 11.5V, but not simultaneously. High output currents can only be sustained when input-output differential voltages are small, as shown in Figure 5. Maximum power dissipation depends on packaging, temperature, and air flow. The maximum output current is as follows:

$$I_{OUT(MAX)} = \frac{P(T_J - T_A)}{(V_{IN} - V_{OUT})100°C}$$

where P is derived from Figure 4.

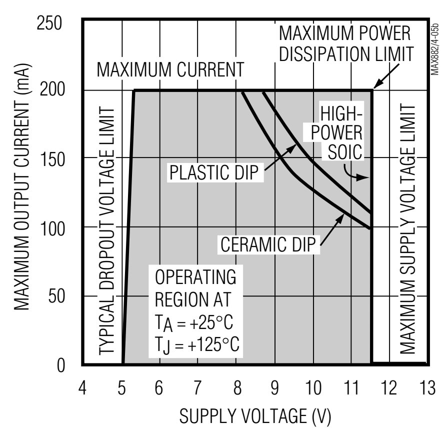


Figure 5b. Safe Operating Regions: MAX883 Maximum Output Current vs. Supply Voltage

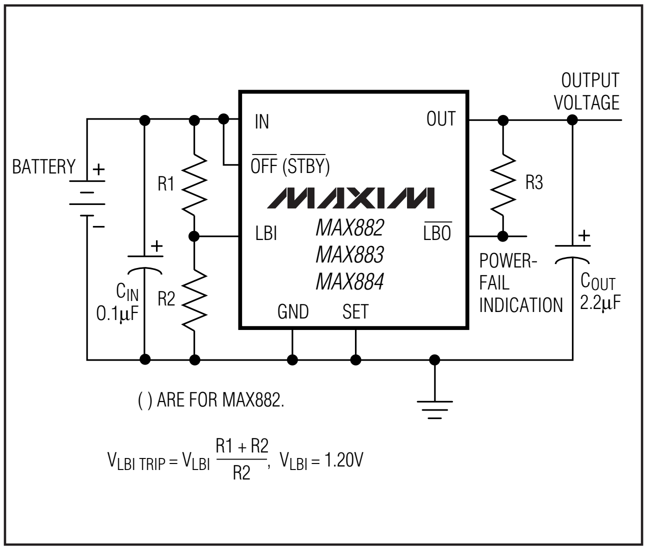


Figure 6. Using the Low-Battery Comparator to Monitor Battery Voltage

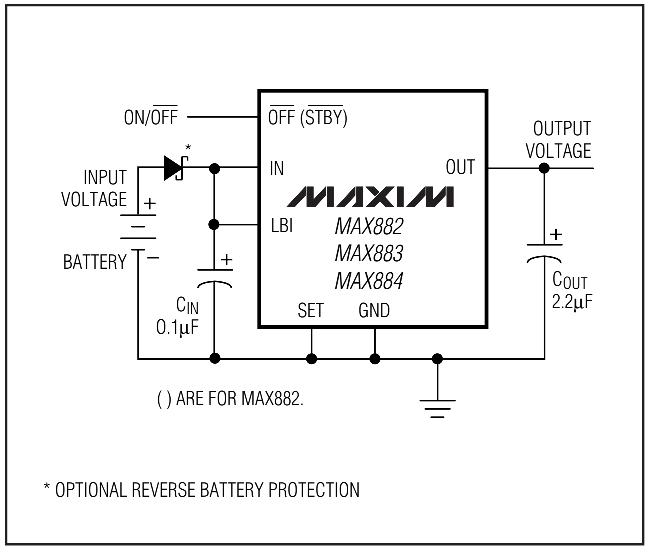


Figure 7. Typical 3.3V or 5V Linear Regulator Circuit

Reverse-Current Protection

The MAX882/MAX883/MAX884 have a unique protection scheme that limits reverse currents when the input voltage falls below the output. It monitors the voltages on IN and OUT and switches the IC's substrate and power bus to the more positive of the two. The control circuitry is then able to remain functioning and turn the pass transistor off, limiting reverse currents back through to the input of the device. In this mode, typical current into OUT to GND is 15µA at V_{OUT} = 3.3V and 50µA at V_{OUT} = 5V.

Reverse-current protection activates when the voltage on IN falls 6mV (or 20mV max) below the voltage on OUT. Before this happens, currents as high as several milliamperes can flow back through the device.

Low-Battery-Detection Comparator

The MAX882/MAX883/MAX884 provide a low-battery comparator that compares the voltage on the LBI pin to the 1.20V internal reference. $\overline{LBO}$, an open-drain output, goes low when LBI is below 1.20V. Hysteresis of 7mV has been added to the low-battery comparator to provide noise immunity during switching. $\overline{LBO}$ remains functional in standby mode for the MAX882, but is undefined in OFF mode for the MAX883 and MAX884. Tie LBI to IN when not used.

Use a resistor-divider network as shown in Figure 6 to set the low-battery trip voltage. Current into the LBI input is ±50nA (max), so R2 can be as large as 1MΩ. Add extra noise immunity by connecting a small capacitor from LBI to GND. Additional hysteresis can be added by connecting a high-value resistor from LBI to $\overline{LBO}$.

Applications Information

The MAX882/MAX883/MAX884 are series linear regulators designed primarily for battery-powered systems. Figure 7 shows a typical application.

Standby Mode vs. OFF Mode

STBY is a comparator input that allows the user to set the standby-mode threshold voltage, while OFF is a logic-level input. When in standby mode, the output is disconnected from the input, but the biasing circuitry (including the low-battery comparator) is kept alive, causing the device to draw approximately 7µA. Standby mode is useful in applications where a low-battery comparator function is still needed in shutdown.

A logic low at the $\overline{OFF}$ pin turns off all biasing circuitry, including the LBI/$\overline{LBO}$ comparator, and reduces supply current to less than 1µA. OFF mode is useful for maximizing battery life. There is little difference in the time it takes to exit standby mode or OFF mode.

Output Capacitor Selection and Regulator Stability

An output filter capacitor is required at the MAX882/MAX883/MAX884 OUT pin. The minimum output capacitance required for stability is 2.2µF.

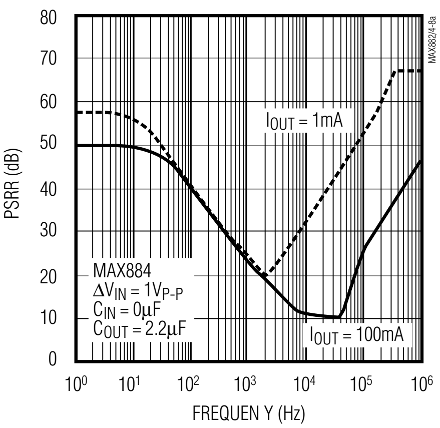


Figure 8a. Power-Supply Rejection Ratio vs. Ripple Frequency for Light and Heavy Loads

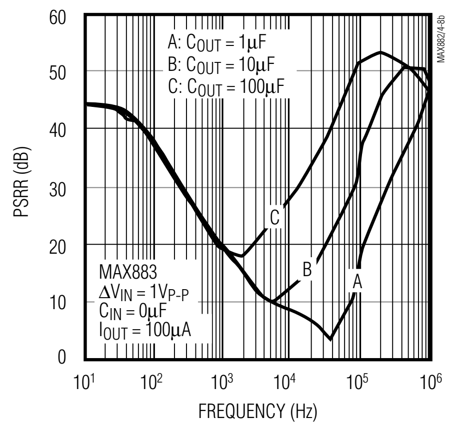


Figure 8b. Power-Supply Rejection Ratio vs. Ripple Frequency for Various Output Capacitances

The filter capacitor's size depends primarily on the desired power-up time and load-transient responses. Load-transient response is improved by using larger output capacitors.

The output capacitor's equivalent series resistance (ESR) will not affect stability as long as the minimum capacitance requirement is observed. The type of capacitor selected is not critical, but it must remain above the minimum value over the full operating temperature range.

Input Bypass Capacitor

Normally, use 0.1µF to 10µF capacitors on the MAX882/MAX883/MAX884 input. The best value depends primarily on the power-up slew rate of V_{IN}, and on load and line transients. Larger input capacitor values provide better supply-noise rejection and line-transient response, as well as improved performance, when the supply has a high AC impedance. The type of input bypass capacitor used is not critical.

Noise

The MAX882/MAX883/MAX884 exhibit up to $4mV_{p-p}$ of noise during normal operation. This is negligible in most applications. When using the MAX882/MAX883/MAX884 for applications that include analog-to-digital converters (ADCs) with resolutions greater than 12 bits, consider the ADC's power-supply rejection specifications. See the output noise plot in the *Typical Operating Characteristics* section.

PSRR and Operation from Sources Other than Batteries

The MAX882/MAX883/MAX884 are designed to achieve low dropout voltages and low quiescent currents in battery-powered systems. However, to gain these benefits, the devices must trade away power-supply noise rejection, as well as swift response to supply variations and load transients. For a 1mA load current, power-supply rejection ranges from 60dB down to 20dB at 2kHz. At higher frequencies, the circuit depends primarily on the characteristics of the output capacitor, and the PSRR increases (Figure 8).

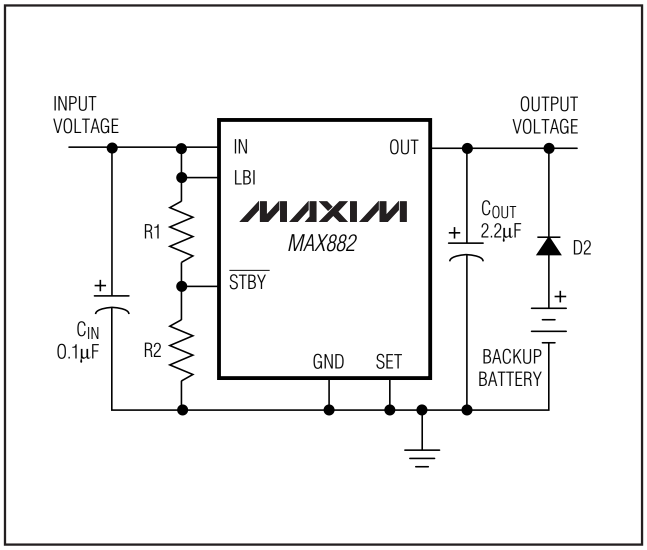


Figure 9. Short-Term Battery Backup Using the MAX882

When operating from sources other than batteries, supply-noise rejection and transient response can be improved by increasing the values of the input and output capacitors and employing passive filtering techniques. Do not use power supplies with ripple voltage exceeding 200mV at 100kHz.

Overshoot and Transient Considerations

The *Typical Operating Characteristics* section shows power-up, supply, and load-transient response graphs. On the load-transient graphs, two components of the output response can be observed: a DC shift from the output impedance due to the different load currents, and the transient response. Typical transients for step changes in the load current from 50mA to 250mA are 200mV. Increasing the output capacitor's value attenuates transient spikes.

During recovery from shutdown, overshoot is negligible if the output voltage has been given time to decay adequately. During power-up from V_{IN} = 0, overshoot is typically less than 1% of V_{OUT}.

Input-Output (Dropout) Voltage

A regulator's minimum input-output voltage differential (or dropout voltage) determines the lowest usable supply voltage. In battery-powered systems, this determines the useful end-of-life battery voltage. Because the MAX882/MAX883/MAX884 use a p-channel MOSFET pass transistor, their dropout voltage is a function of $R_{DS(ON)}$ multiplied by the load current (see *Electrical Characteristics*). Quickly stepping up the input voltage from the dropout voltage can result in overshoot.

Short-Term Battery Backup Using the MAX882

Figure 9 illustrates a scheme for implementing battery backup for 3.3V circuits using the MAX882. When the supply voltage drops below some user-specified value based on resistors R1 and R2, the standby function activates, turning off the MAX882's output. Under these conditions, the backup battery supplies power to the load. Reverse current protection prevents the battery from draining back through the regulator to the input.

This application is limited to short-term battery backup for 3.3V circuits. The current drawn by the MAX882's OUT pin at 3.3V during reverse-current protection is typically 8µA. It should not be used with the MAX883 and MAX884, since the OFF pin is a logic input, and indeterminate inputs can cause the regulator to turn on intermittently, draining the battery.

Reverse Battery Protection

Reverse battery protection can be added by including an inexpensive Schottky diode between the battery input and the regulator circuit, as shown in Figure 7. However, the dropout voltage of the regulator will be increased by the forward voltage drop of the diode. For example, the forward voltage of a standard 1N5817 Schottky diode is typically 0.29V at 200mA.

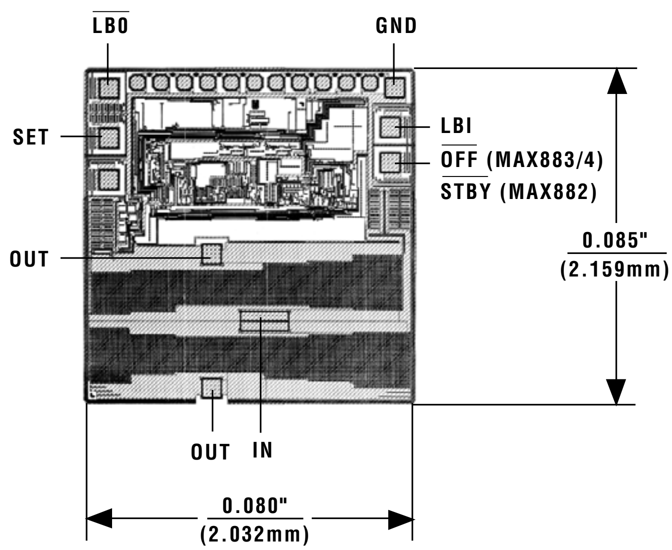
5V/3.3V or Adjustable, Low-Dropout, Low IQ, 200mA Linear Regulators

Ordering Information (continued)

PART	TEMP RANGE	PIN-PACKAGE
MAX883CPA	0°C to +70°C	8 PDIP
MAX883CSA	0°C to +70°C	8 SO
MAX883C/D	0°C to +70°C	Dice*
MAX883EPA	-40°C to +85°C	8 PDIP
MAX883ESA	-40°C to +85°C	8 SO
MAX883MPA/PR	-55°C to +125°C	8 PDIP
MAX884CPA	0°C to +70°C	8 PDIP
MAX884CSA	0°C to +70°C	8 SO
MAX884C/D	0°C to +70°C	Dice*
MAX884EPA	-40°C to +85°C	8 PDIP
MAX884ESA	-40°C to +85°C	8 SO

*Dice are tested at T_J = +25°C, DC parameters only.
**Contact factory for availability.

Chip Topography



NO DIRECT SUBSTRATE CONNECTION. THE N-SUBSTRATE IS INTERNALLY SWITCHED BETWEEN THE MORE POSITIVE OF IN OR OUT.

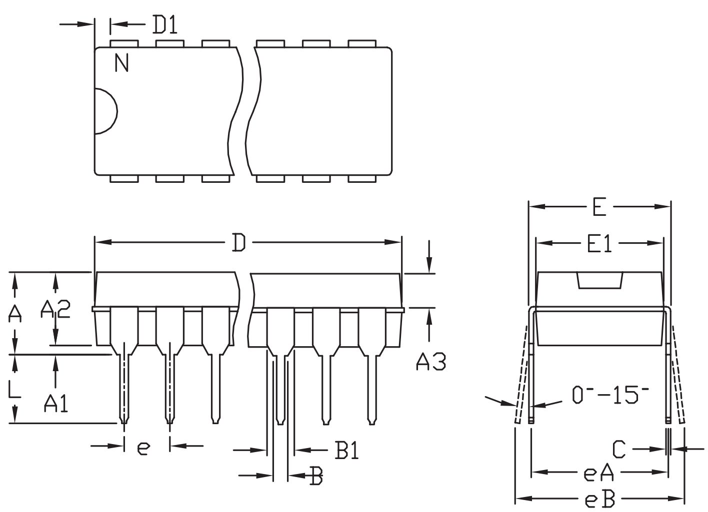
5V/3.3V or Adjustable, Low-Dropout, Low IQ, 200mA Linear Regulators

Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	DOCUMENT NO.
8 PDIP	P8-T	21-0043
8 SO	S8-6F	21-0041

PDIPN.EPS



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.180	---	4.572
A1	0.015	---	0.38	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.015	0.022	0.381	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.014	0.2	0.355
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100 BSC.		2.54 BSC.	
eA	0.300 BSC.		7.62 BSC.	
eB	0.400 BSC.		10.16 BSC.	
L	0.115	0.150	2.921	3.81

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS001
D	0.348	0.390	8.84	9.91	8	AB
D	0.735	0.765	18.67	19.43	14	AC
D	0.745	0.765	18.92	19.43	16	AA
D	0.885	0.915	22.48	23.24	18	AD
D	1.015	1.045	25.78	26.54	20	AE
D	1.14	1.265	28.96	32.13	24	AF
D	1.360	1.380	34.54	35.05	28	*5

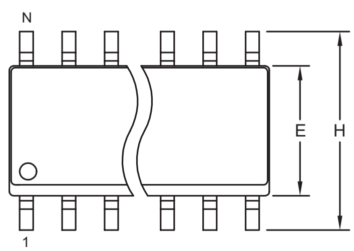
NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC MS001-XX AS SHOWN IN ABOVE TABLE
5. SIMILIAR TO JEDEC MO-058AB
6. N = NUMBER OF PINS

MAXIM 120 SAN GABRIEL DR. SUNNYVALE CA 94086 FAX (408) 737 7194 PROPRIETARY INFORMATION | TITLE: PACKAGE FAMILY OUTLINE: PDIP .300" | 1/1 | DOCUMENT CONTROL NUMBER: 21-0043 REV: D

Package Information (continued)

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

SOICN .EPS

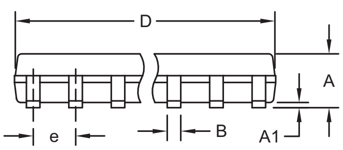


TOP VIEW

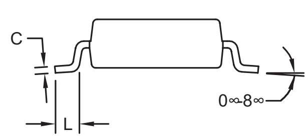
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27

VARIATIONS:

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION
TITLE:
PACKAGE OUTLINE, .150" SOIC
APPROVAL | DOCUMENT CONTROL NO. 21-0041 | REV. B | 1/1

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
3	9/08	Added information for rugged plastic product.	14
4	7/09	Revised *Ordering Information* table.	14