150mA, Low-Dropout Linear Regulator with Power-OK Output

ABSOLUTE MAXIMUM RATINGS

IN, $\overline{\text{SHDN}}$, POK to GND ....-7V to +7V
$\overline{\text{SHDN}}$ to IN ....-7V to +0.3V
OUT to GND ....-0.3V to (V_{IN} + 0.3V)
Output Short-Circuit Duration ....Indefinite
Continuous Power Dissipation (T_A = +70°C)
5-Pin SOT23 (derate 7.1mW/°C above +70°C)..........571mW

Operating Temperature Range ....-40°C to +85°C
Junction Temperature ....+150°C
θ_{JA} ....+140°C/W
Storage Temperature Range ....-65°C to +150°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} = $V_{OUT(NOMINAL)}$ + 1V, $\overline{\text{SHDN}}$ = IN, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage	V_{IN}			2.5		6.5	V
Output Voltage Accuracy		T_A = +25°C, I_{OUT} = 100µA		-1.0		1.0	%
		T_A = -40°C to +85°C	I_{OUT} = 100µA	-2		2	
			I_{OUT} = 100µA to 120mA	-3		2	
Maximum Output Current	I_{OUT}			150			mA
Current Limit	I_{LIM}			160	390		mA
Ground Pin Current	I_Q	I_{OUT} = 100µA			85	180	µA
		I_{OUT} = 150mA			100		
Dropout Voltage (Note 2)	V_{IN} - V_{OUT}	I_{OUT} = 100µA			0.1		mV
		I_{OUT} = 50mA			50		
		I_{OUT} = 100mA			110	220	
		I_{OUT} = 150mA			165		
Line Regulation	ΔV_{LNR}	V_{IN} = 2.5V or (V_{OUT} + 0.1V) to 6.5V, I_{OUT} = 1mA		-0.15	0	0.15	%/V
Load Regulation	ΔV_{LDR}	I_{OUT} = 100µA to 120mA, C_{OUT} = 1µF			0.01		%/mA
Output Voltage Noise		C_{OUT} = 10µF, f = 10Hz to 100kHz			170		μV_{RMS}
Output Voltage AC Power-Supply Rejection Ratio	PSRR	f = 100Hz			60		dB
SHUTDOWN							
Shutdown Supply Current	I_{OFF}	$\overline{\text{SHDN}}$ = GND	T_A = +25°C		0.005	1	µA
			T_A = +85°C		0.02		
$\overline{\text{SHDN}}$ Input Threshold	V_{IH}	V_{IN} = 2.5V to 5.5V		2.0			V
	V_{IL}					0.4	
$\overline{\text{SHDN}}$ Input Bias Current	$I_{\overline{SHDN}}$	$\overline{\text{SHDN}}$ = IN or GND	T_A = +25°C		0	100	nA
			T_A = +85°C		0.05		

ELECTRICAL CHARACTERISTICS (continued)

($V_{IN} = V_{OUT(NOMINAL)} + 1V$, $\overline{SHDN}$ = IN, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER-OK OUTPUT							
Power-OK Voltage Threshold	V_{POK}	1 - $V_{OUT}/V_{OUT(NOMINAL)}$ 100, I_{OUT} = 0, V_{OUT} falling, V_{OUT} ≥ 2.5V		-3	-5	-8	%
		1 - $V_{OUT}/V_{OUT(NOMINAL)}$ 100, $I_{OUT} = I_{LIM}$, V_{OUT} falling, V_{OUT} < 2.5V	T_A = 0°C to +85°C	-8.5	-10.5	-13.5	
			T_A = -40°C to +85°C	-7		-15	
		In dropout, V_{OUT} falling, V_{OUT} ≥ 2.5V			-5.3		
		Hysteresis, I_{OUT} = 0			1		
POK Output Voltage Low	V_{OL}	I_{SINK} = 1mA				0.4	V
POK Output Leakage Current		0 ≤ V_{POK} ≤ 6.5V, V_{OUT} in regulation				1	µA
THERMAL PROTECTION							
Thermal Shutdown Temperature	T_{SHDN}				170		°C
Thermal Shutdown Hysteresis	ΔT_{SHDN}				20		°C

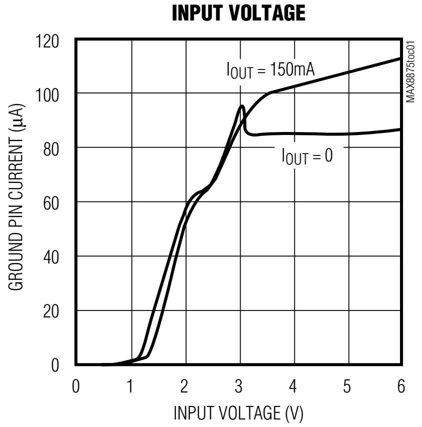
Note 1: Limits are 100% production tested at T_A = +25°C. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods.

Note 2: Dropout voltage is defined as $V_{IN} - V_{OUT}$, when V_{OUT} is 100mV below the value of V_{OUT} for $V_{IN} = V_{OUT}$ + 0.5V. Applies only for output voltages ≥ 2.5V.

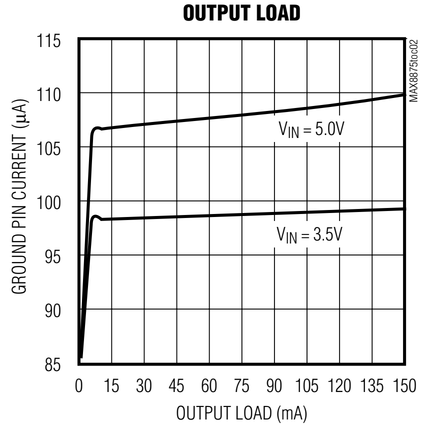
Typical Operating Characteristics

(MAX8875EUK30, V_{IN} = +3.6V, $C_{IN} = C_{OUT}$ = 1µF, $\overline{SHDN}$ = IN, T_A = +25°C, unless otherwise noted.)

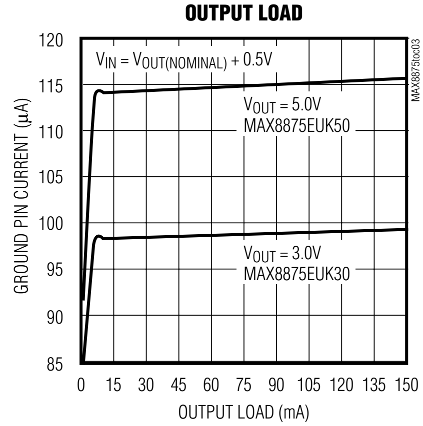
GROUND PIN CURRENT vs. INPUT VOLTAGE



GROUND PIN CURRENT vs. OUTPUT LOAD



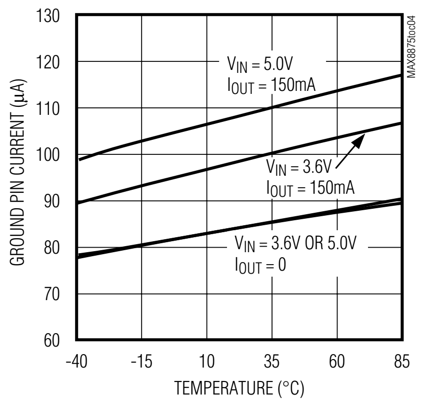
GROUND PIN CURRENT vs. OUTPUT LOAD



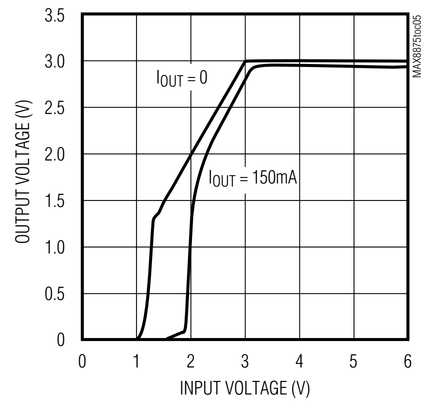
Typical Operating Characteristics (continued)

(MAX8875EUK30, V_{IN} = +3.6V, C_{IN} = C_{OUT} = 1µF, $\overline{SHDN}$ = IN, T_A = +25°C, unless otherwise noted.)

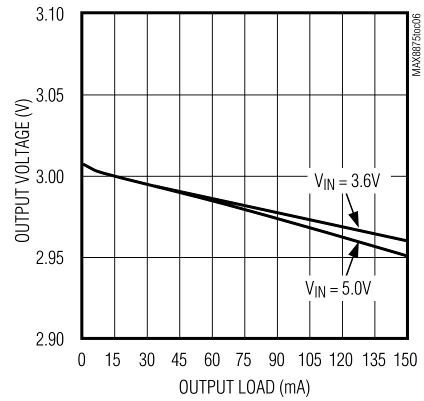
GROUND PIN CURRENT vs. TEMPERATURE



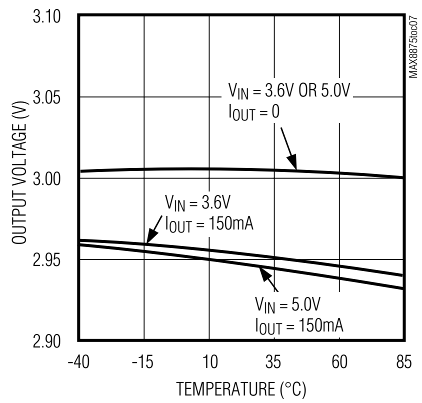
OUTPUT VOLTAGE vs. INPUT VOLTAGE



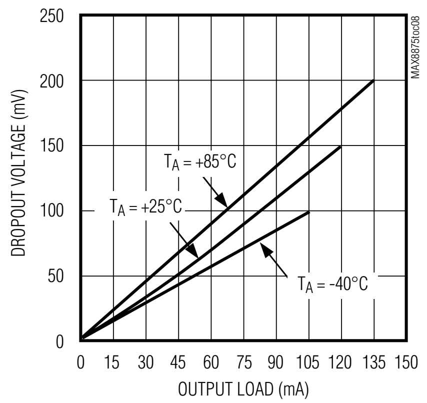
OUTPUT VOLTAGE vs. OUTPUT LOAD



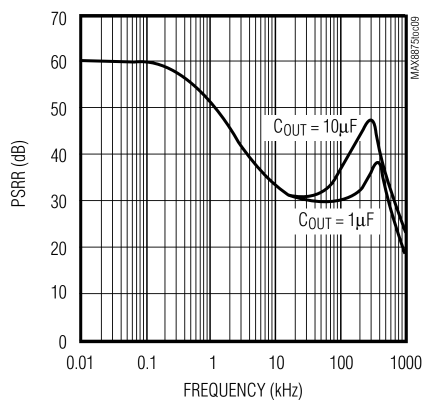
OUTPUT VOLTAGE vs. TEMPERATURE



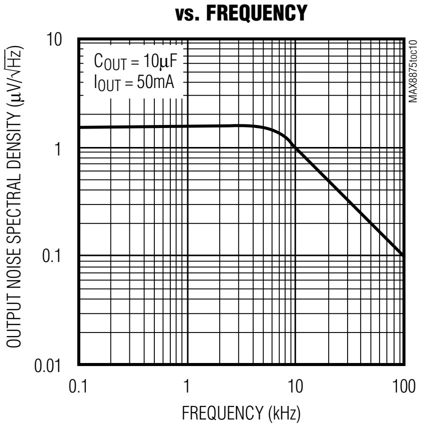
DROPOUT VOLTAGE vs. OUTPUT LOAD



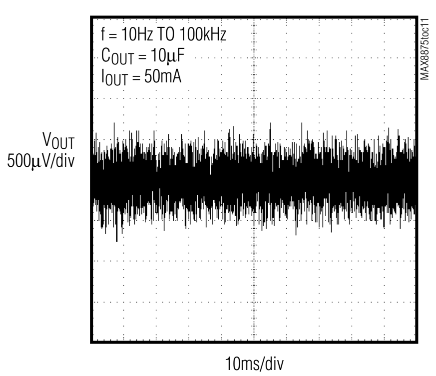
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



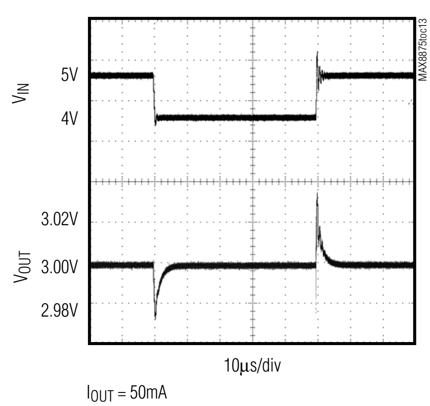
OUTPUT NOISE SPECTRAL DENSITY vs. FREQUENCY



OUTPUT NOISE

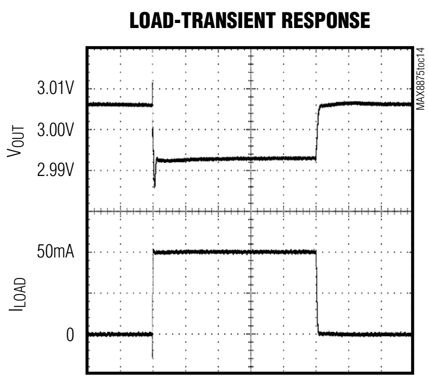


LINE-TRANSIENT RESPONSE

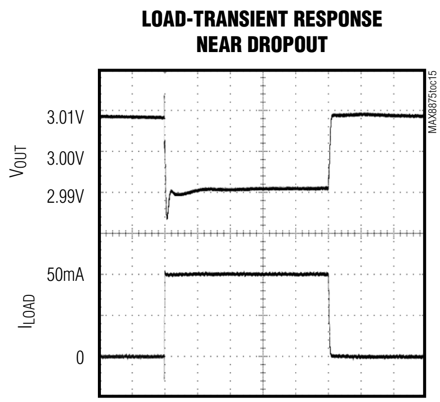


Typical Operating Characteristics (continued)

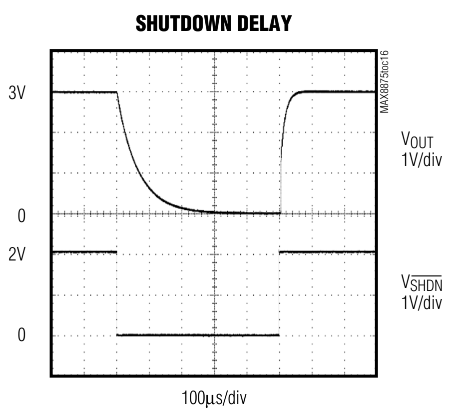
(MAX8875EUK30, V_{IN} = +3.6V, C_{IN} = C_{OUT} = 1µF, $\overline{SHDN}$ = IN, T_A = +25°C, unless otherwise noted.)



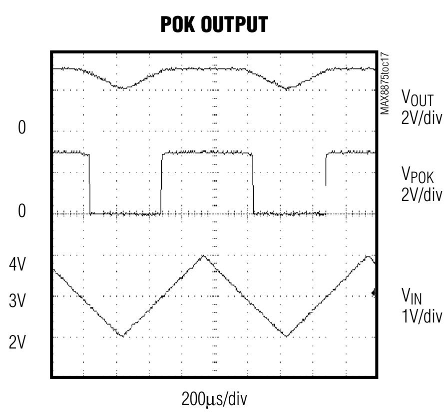
$V_{IN} = V_{OUT} + 0.5V$, I_{OUT} = 0 TO 50mA



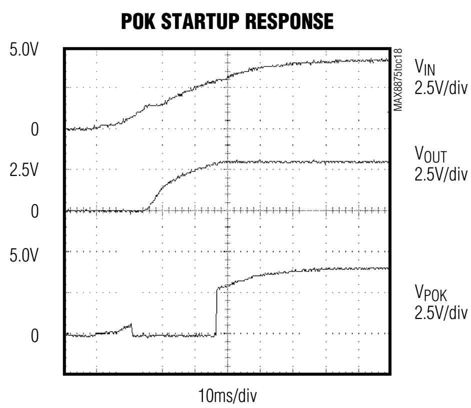
$V_{IN} = V_{OUT} + 0.1V$, I_{OUT} = 0 TO 50mA



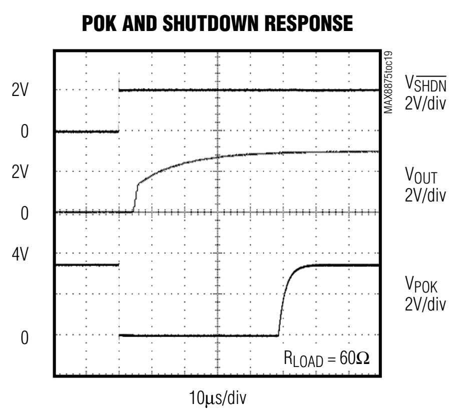
MAX8875EUK30, $R_{OUT} = 60\Omega$



$R_{POK} = 100k\Omega$



$R_{POK} = 100k\Omega$



$R_{POK} = 100k\Omega$

150mA, Low-Dropout Linear Regulator with Power-OK Output

Pin Description

PIN	NAME	FUNCTION
1	IN	Regulator Input. Supply voltage can range from 2.5V to 6.5V. Bypass with 1µF to GND (see the *Capacitor Selection and Regulator Stability* section).
2	GND	Ground. This pin also functions as a heatsink. Solder to a large pad or the circuit-board ground plane to maximize power dissipation.
3	$\overline{SHDN}$	Active-Low Shutdown Input. A logic low reduces the supply current to below 1µA. Connect to IN for normal operation.
4	POK	Power-OK Output. Active-low, open-drain output indicates an out-of-regulation condition. Connect a 100k pull-up resistor to OUT for logic levels. If not used, leave this pin unconnected.
5	OUT	Regulator Output. Fixed 5.0V, 3.3V, 3.0V, 2.7V, 2.5V, or 1.5V output. Sources up to 150mA. Bypass with 1µF (<0.2Ω typical ESR) ceramic capacitor to GND for V_{OUT} ≥ 2.5V. Bypass with 3.3µF (<0.2Ω typ ESR) ceramic capacitor to GND for V_{OUT} = 1.5V.

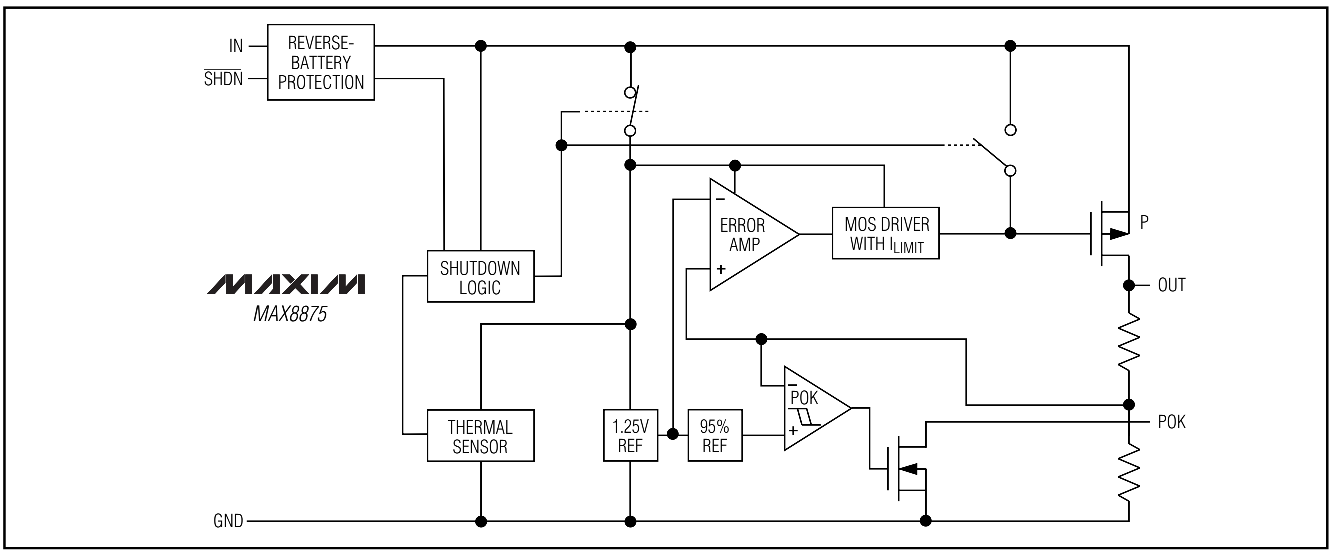


Figure 1. Functional Diagram

Detailed Description

The MAX8875 is a low-dropout, low-quiescent-current linear regulator designed primarily for battery-powered applications. The device supplies loads up to 150mA and is available with preset output voltages of 1.5V, 2.5V, 2.7V, 3.0V, 3.3V, or 5.0V. As illustrated in Figure 1, the MAX8875 consists of a 1.25V reference, error amplifier, P-channel pass transistor, power-OK comparator, and internal feedback voltage divider.

The 1.25V bandgap reference is connected to the error amplifier's inverting input. The error amplifier compares this reference with the feedback voltage and amplifies the difference. If the feedback voltage is lower than the reference voltage, the pass-transistor gate is pulled lower, which allows more current to pass to the output and increases 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 feeds back through an internal resistor voltage divider connected to the OUT pin.

Additional blocks include a current limiter, reverse-battery protection, thermal sensor, and shutdown logic.

Output Voltage

The MAX8875 is supplied with factory-set output voltages of 1.5V, 2.5V, 2.7V, 3.0V, 3.3V, or 5.0V. The part number's two-digit suffix identifies the nominal output voltage. For example, the MAX8875EUK33 has a preset output voltage of 3.3V (see *Output Voltage Selector Guide*).

Internal P-Channel Pass Transistor

The MAX8875 features a 1.1Ω (typ) 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 significantly. PNP-based regulators waste considerable current in dropout when the pass transistor saturates. They also use high base-drive currents under large loads. The MAX8875 does not suffer from these problems and consumes only 100µA of quiescent current whether in dropout, light-load, or heavy-load applications (see *Typical Operating Characteristics*).

Power-OK Output (POK)

When the output voltage goes out of regulation—as during dropout, current limit, or thermal shutdown—POK goes low. POK is an open-drain N-channel MOSFET. To obtain a logic-level output, connect a pull-up resistor from POK to OUT. To minimize current consumption, make this resistor as large as practical. A 100kΩ resistor works well for most applications. A capacitor to GND may be added to generate a power-on-reset (POR) delay. The POK function is not active during shutdown. POK also provides a power-on-reset function that can operate down to $V_{IN} \le 1V$. See POK Startup Response in the *Typical Operating Characteristics*.

Current Limit

The MAX8875 includes a current limiter that monitors and controls the pass transistor's gate voltage, limiting the output current to 390mA (typ). For design purposes, consider the current limit to be 160mA min to 600mA max. The output can be shorted to ground for an indefinite period of time without damaging the part.

Thermal-Overload Protection

When the junction temperature exceeds T_J = +170°C, the thermal sensor signals the shutdown logic, turning off the pass transistor and allowing the IC to cool. The thermal sensor will turn the pass transistor on again after the IC's junction temperature cools by 20°C, resulting in a pulsed output during continuous thermal-overload conditions.Thermal-overload protection is designed to protect the MAX8875 in the event of fault conditions. For continuous operation, do not exceed the absolute maximum junction-temperature rating of T_J = +150°C.

Operating Region and Power Dissipation

The MAX8875's maximum power dissipation depends on the thermal resistance of the case and circuit 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 maximum power dissipation is:

$$P_{MAX} = (T_J - T_A) / (\theta_{JB} + \theta_{BA})$$

where $T_J - T_A$ is the temperature difference between the MAX8875 die junction and the surrounding air, θ_{JB} (or θ_{JC}) is the thermal resistance of the package, and θ_{BA} is the thermal resistance through the printed circuit board, copper traces, and other materials to the surrounding air.

The MAX8875's ground pin (GND) performs the dual function of providing an electrical connection to system ground and channeling heat away. Connect GND to the system ground using a large pad or ground plane.

Reverse-Battery Protection

The MAX8875 has a unique protection scheme that limits the reverse supply current to 1mA when either V_{IN} or $V_{\overline{SHDN}}$ falls below ground. The circuitry monitors the polarity of these two pins and disconnects the internal circuitry and parasitic diodes when the battery is reversed. This feature prevents device damage.

Applications Information

Capacitor Selection and Regulator Stability

For stable operation over the full temperature range and with load currents up to 150mA, use a 1µF (min) ceramic output capacitor with an ESR <0.2Ω for $V_{OUT} \ge 2.5V$, or an equivalent 3.3µF ceramic output capacitor for V_{OUT} = 1.5V. To reduce noise and improve load-transient response, stability, and power-supply rejection, use large output capacitor values, such as 10µF.

Note that some ceramic dielectrics exhibit large capacitance and ESR variation with temperature. With dielectrics such as Z5U and Y5V, it may be necessary to increase the capacitance by a factor of 2 or more to ensure stability at temperatures below T_A = -10°C. With X7R or X5R dielectrics, 1µF should be sufficient at all operating temperatures for $V_{OUT} \ge 2.5V$. For a pin-compatible, functionally equivalent device for use with a higher ESR output capacitor, see the MAX8885.

150mA, Low-Dropout Linear Regulator with Power-OK Output

PSRR and Operation from Sources Other than Batteries

The MAX8875 is designed to deliver low dropout voltages and low quiescent currents in battery-powered systems. Power-supply rejection is 60dB at low frequencies. See the Power-Supply Rejection Ratio vs. Frequency graph in the *Typical Operating Characteristics*.

Improve supply-noise rejection and transient response by increasing the values of the input and output bypass capacitors. The *Typical Operating Characteristics* show the MAX8875's line- and load-transient responses.

Dropout Voltage

For versions with the output voltage greater than the minimum input voltage (2.5V), the regulator's minimum input-output voltage differential (or dropout voltage) determines the lowest usable supply voltage. In battery-powered systems, this will determine the useful end-of-life battery voltage. Because the MAX8875 uses a P-channel MOSFET pass transistor, its dropout voltage is a function of drain-to-source on-resistance ($R_{DS(ON)}$) multiplied by the load current (see *Typical Operating Characteristics*):

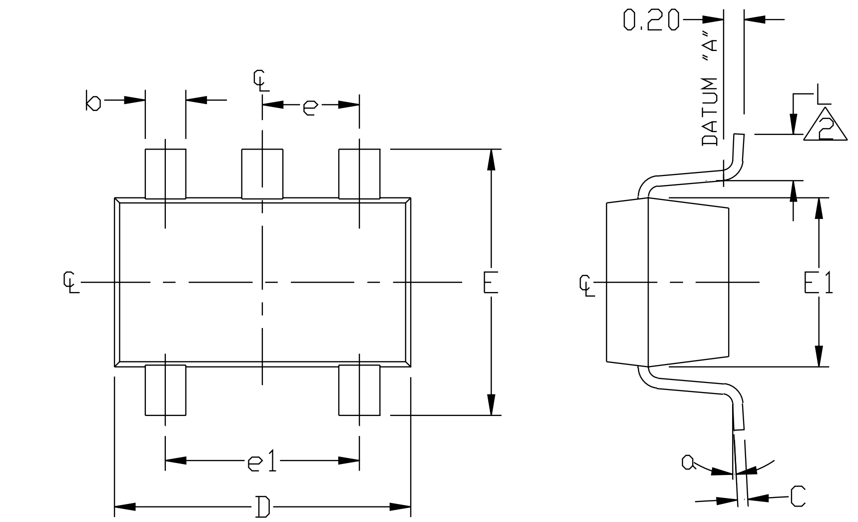
$$V_{DROPOUT} = V_{IN} - V_{OUT} = R_{DS(ON)} \times I_{OUT}$$

Chip Information

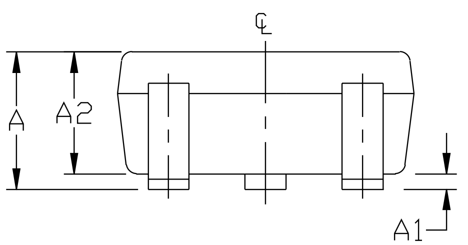
TRANSISTOR COUNT: 266

Package Information

SOT5L.EPS



SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.35	0.50
C	0.08	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.55
e	0.95 REF	
e1	1.90 REF	
a	0°	10°



NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. (△) FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.

MAXIM
PROPRIETARY INFORMATION
TITLE: PACKAGE OUTLINE, SOT23, 5L
APPROVAL | DOCUMENT CONTROL NO. 21-0057 | REV B | 1/1