1.425V to 3.6V Input, 2A, 0.2V Dropout LDO Regulators

ABSOLUTE MAXIMUM RATINGS

IN, EN, POK (MAX8527), POR (MAX8528),
FB to GND ....-0.3V to +4.0V
OUT to GND ....-0.3V to (IN + 0.3V)
Output Short-Circuit Duration....................................Continuous
Continuous Power Dissipation (T_A = +70°C,
EP soldered to PC board ground)
14-Pin TSSOP (derate 20.8mW/°C above +70°C)..............1.7W

Operating Temperature Range ....-40°C to +85°C
Junction Temperature..+150°C
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

(Circuit of Figure 1: V_{IN} = +1.8V, V_{OUT} = +1.5V, EN = IN, I_{OUT} = 2mA, T_A = -40°C to +85°C, unless otherwise noted.) (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
IN					
Input Voltage Range		1.425		3.600	V
Input Undervoltage Lockout	V_{IN} rising, 70mV hysteresis	1.32	1.35	1.38	V
OUT					
Output Voltage Range		0.5		3.4	V
Load Regulation	I_{OUT} = 2mA to 2A		0.08		%/A
Line Regulation	V_{IN} = 1.425V to 3.6V, V_{OUT} = 1.225V, I_{OUT} = 2mA	-0.15	0	+0.15	%/V
Dropout Voltage (V_{IN} - V_{OUT})	V_{IN} = 1.425V, I_{OUT} = 2A, V_{FB} = 480mV		100	200	mV
Current Limit	V_{IN} = 3.6V, V_{OUT} = 3V, V_{FB} = 480mV	3.2	4	4.8	A
Output Shutdown Leakage	V_{IN} = 3.6V, V_{OUT} = 0V, V_{EN} = 0V		0.5	50	µA
FB					
FB Threshold Accuracy	I_{OUT} = 20mA, T_A = +85°C	497	500	503	mV
	V_{OUT} = 1.225V to 3V, V_{IN} = (V_{OUT} + 0.2V) to 3.6V, I_{OUT} = 2mA to 2A	493		507	
FB Input Bias Current	V_{FB} = 0.5V, V_{IN} = 3.6V		0.001	1	µA

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MAX8526/MAX8527/MAX8528

ELECTRICAL CHARACTERISTICS (continued)

(Circuit of Figure 1: V_{IN} = +1.8V, V_{OUT} = +1.5V, EN = IN, I_{OUT} = 2mA, T_A = -40°C to +85°C, unless otherwise noted.) (Note 1)

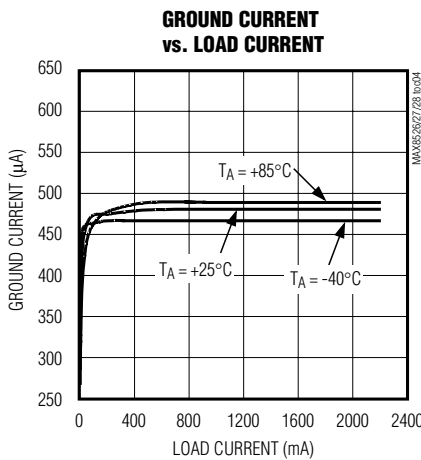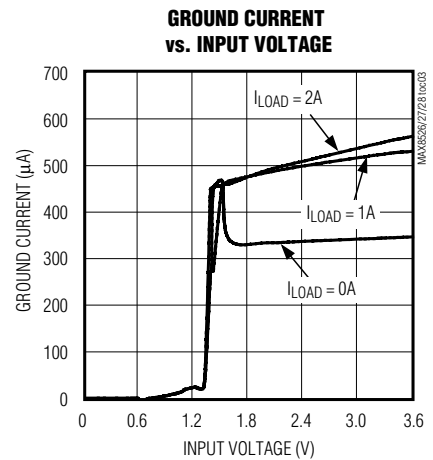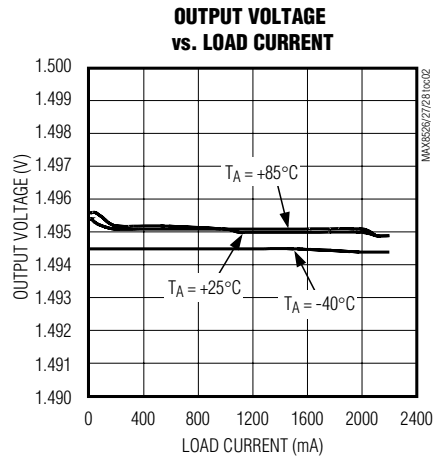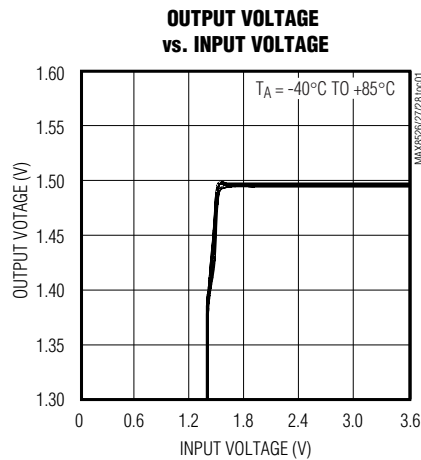| PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
GND						
GND Supply Current	V_{IN} = 3.6V, V_{OUT} = 3V, I_{OUT} = 20mA			440		μA
	Dropout, V_{IN} = 3.6V, V_{FB} = 480mV			500	800	
GND Shutdown Current	V_{IN} = 3.6V, EN = GND			0.5	50	μA
POK (MAX8527 Only)						
Power-OK Threshold	V_{FB} moving out of regulation, V_{HYS} = 10mV, IN = 1.425V to 3.6V	FB high	540	550	560	mV
		FB low	440	450	460	
POK Output Voltage Low	V_{FB} = 0.4V or 0.6V, I_{POK} = 2mA			25	200	mV
POK Output Current High	V_{POK} = 3.6V			0.001	1	μA
POK Fault Delay Time	From FB to POK		25	50	100	μs
POR (MAX8528 Only)						
Power-On Reset Threshold	V_{FB} falling, V_{HYS} = 10mV, V_{IN} = 1.425V to 3.6V		440	450	460	mV
POR Output Voltage Low	V_{FB} = 0.4V or 0.6V, I_{POR} = 2mA			25	200	mV
POR Output Current High	V_{POR} = 3.6V			0.001	1	μA
POR Rising Delay Time	From FB to POR		105	150	210	ms
EN						
Enable Input Threshold	V_{IN} = 1.425V to 3.6V	EN rising			1.2	V
		EN falling	0.4			
Enable Input Bias Current	V_{EN} = 0 or 3.6V		-1		+1	μA
THERMAL SHUTDOWN						
Thermal-Shutdown Threshold	Output on or off	T_J rising		+165		°C
		T_J falling		+150		
OUTPUT TRANSIENT						
Load Transient	I_{OUT} = 20mA to 2A to 20mA, t_{RISE} = t_{FALL} = 1μs			3		%
Line Transient	δV_{IN} = 0.5V, t_{RISE} = t_{FALL} = 5μs			3		%

Note 1: Specifications to T_A = -40°C are guaranteed by design, not production tested.
Note 2: Measurements at high current are pulse tested, such that the junction temperature is ambient temperature. Minimum supply voltage for output accuracy must be at least 1.425V.
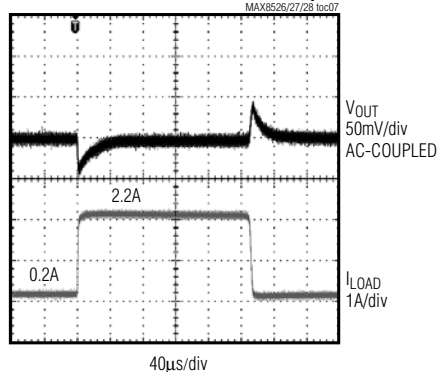
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1.425V to 3.6V Input, 2A, 0.2V Dropout LDO Regulators

_____Typical Operating Characteristics

(Typical values are: V_{IN} = +1.8V, V_{OUT} = +1.5V, I_{OUT} = 2A, C_{OUT} =10µF, C_{IN} = 2.2µF, and T_A = +25°C, unless otherwise noted.)

OUTPUT VOLTAGE vs. INPUT VOLTAGE

OUTPUT VOLTAGE vs. LOAD CURRENT

GROUND CURRENT vs. INPUT VOLTAGE

GROUND CURRENT vs. LOAD CURRENT

DROPOUT VOLTAGE vs. LOAD CURRENT

LINE-TRANSIENT RESPONSE (V_{IN} = 1.8V TO 2.5V, I_{OUT} = 2A)
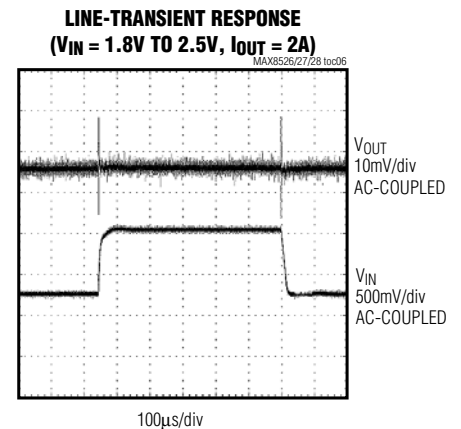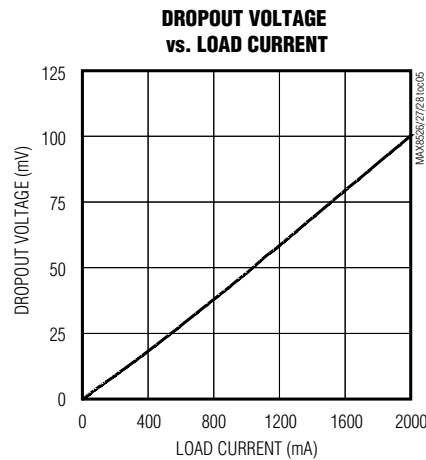
LOAD-TRANSIENT RESPONSE (I_{LOAD} = 0.2A TO 2.2A; C_{IN} = 220µF ELECTROLYTIC CAP CLOSE TO IN)

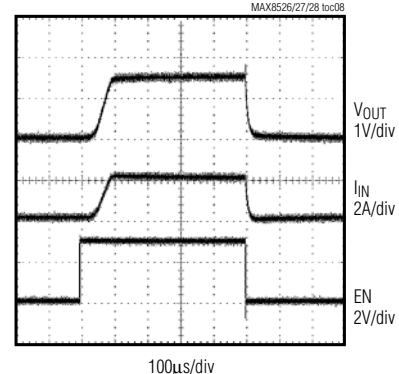**SHUTDOWN RESPONSE**

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Typical Operating Characteristics (continued)

(Typical values are: V_{IN} = +1.8V, V_{OUT} = +1.5V, I_{OUT} = 2A, C_{OUT} =10µF, C_{IN} = 2.2µF, and T_A = +25°C, unless otherwise noted.)

PSRR vs. FREQUENCY (MAX8526)

FB VOLTAGE vs. TEMPERATURE

OUTPUT RIPPLE VOLTAGE

OVERCURRENT THRESHOLD vs. TEMPERATURE

SHORT-CIRCUIT CURRENT

CASE TEMPERATURE vs. LOAD CURRENT

MAX8526/MAX8527/MAX8528

$\cancel{/\Pi/}\Pi\cancel{\times}\Pi\cancel{/\Pi}$ _____ 5
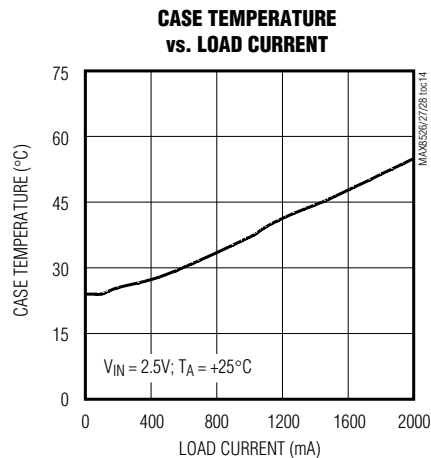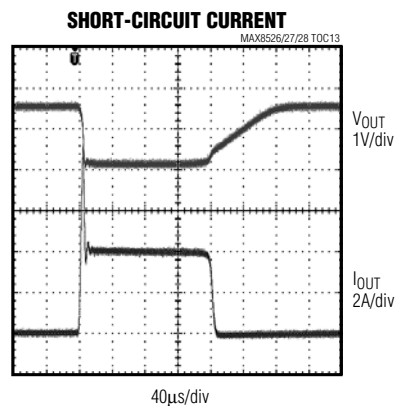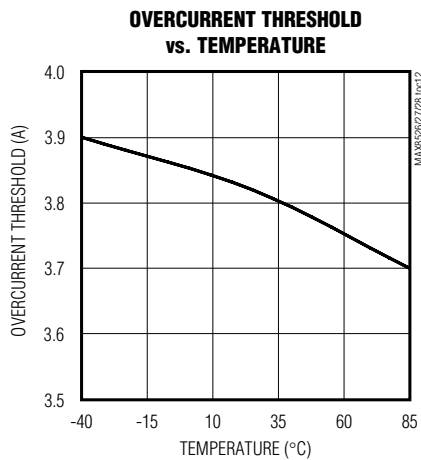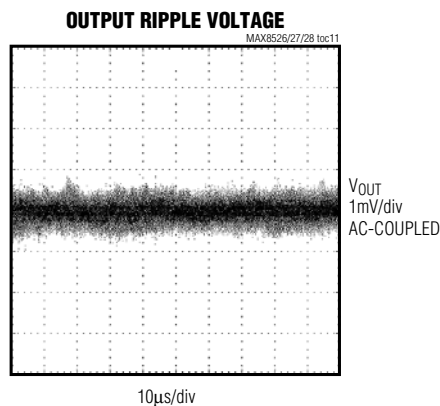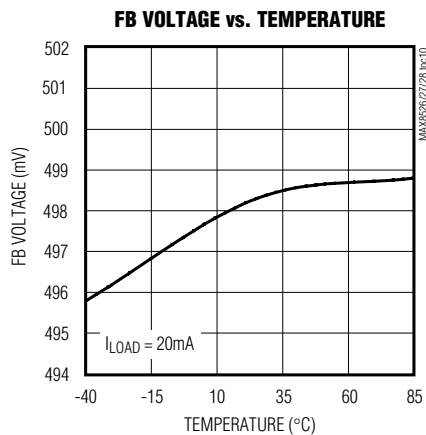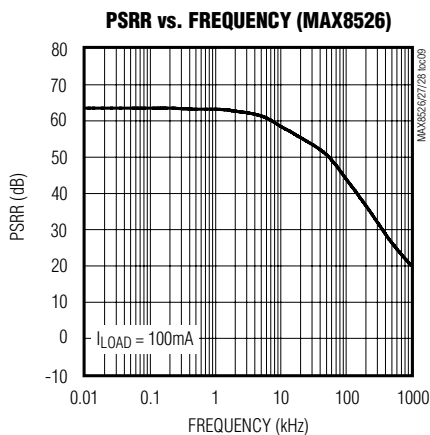
1.425V to 3.6V Input, 2A,
0.2V Dropout LDO Regulators

PIN			NAME	FUNCTION
MAX8526	MAX8527	MAX8528		
1	1	1	EN	Enable Input. Set low to place the device in low-current shutdown mode. Set high for normal operation.
2–5	2–5	2–5	IN	Regulator Input. V_{IN} can range from 1.425V to 3.6V. Bypass with a 2.2µF or higher ceramic capacitor to GND.
6, 7, 14	7, 14	6, 14	T.P.	Test Pin
8	8	8	GND	Ground
9	9	9	FB	Feedback Pin. Connect to output through a voltage-divider to set the output.
10–13	10–13	10–13	OUT	Regulator Output. Bypass with a 10µF ceramic capacitor to GND (a smaller capacitor can be used if maximum load is less than 2A, i.e., $C_{OUT} = I_{OUT}$ (max) x (1µF/200mA).
—	6	—	POK	Power-OK Output (MAX8527 Only). Open-drain output. Connect to a positive supply with a pullup resistor. If not used, leave pin unconnected. See the *Detailed Description* for more details.
—	—	7	POR	Power-On Reset Output. Open-drain output. Connect to a positive supply with a pullup resistor. If not used, leave pin unconnected. See the *Detailed Description* for more details.
—			EP	Exposed Pad on the Underside of the Package. Solder to the ground plane for proper heat dissipation.

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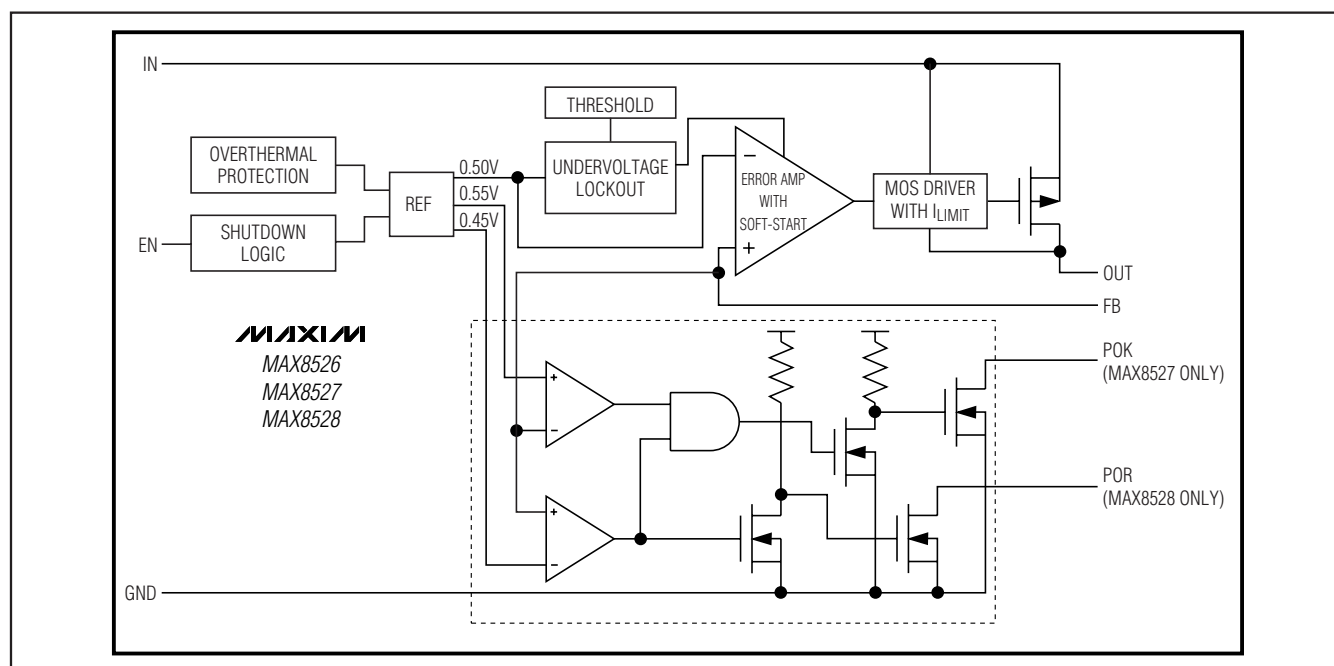
Detailed Description

The MAX8526/MAX8527/MAX8528 are low-input, low-dropout, PMOS regulators capable of delivering up to 2A of output current with as little as 200mV of headroom from input to output. The PMOS output stage can be driven from input voltages down to +1.425V without sacrificing stability or transient performance. Since this regulator has a PMOS output device, supply current is not a significant function of load or input headroom.

Internal p-Channel Pass Transistor

The MAX8526/MAX8527/MAX8528 feature a 50mΩ (typ) p-channel MOSFET pass transistor. Unlike similar designs using pnp pass transistors, p-channel MOSFETs require no base drive, which reduces quiescent current. pnp-based regulators also waste considerable current in dropout when the pass transistor saturates, and use high base-drive currents under large loads. The MAX8526/MAX8527/MAX8528 do not suffer from these problems and consume only 500µA (typ) of quiescent current under heavy loads, as well as in dropout.

Short-Circuit/Thermal Fault Protection

The MAX8526/MAX8527/MAX8528 are fully protected from a short circuit at the output through current-limiting and thermal-overload circuitry. In the fault condition when the output is shorted to ground, the output current is limited to 4A. Under these conditions, the part quickly heats up. When the junction temperature reaches +165°C, the thermal-overload circuitry turns off the output, allowing the part to cool down. When the junction temperature cools to +150°C, the output turns back on and tries to reestablish regulation. Current limiting and thermal protection continue until the fault is removed. For continuous operation, do not exceed the absolute maximum junction temperature rating of T_J = +150°C.
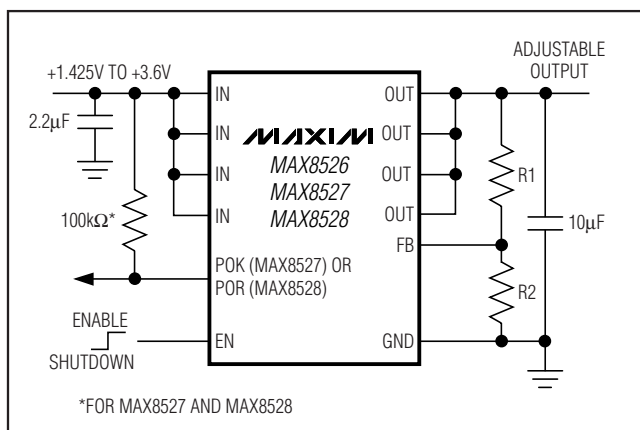
Output Voltage Selection

The MAX8526/MAX8527/MAX8528 feature an adjustable output voltage from 0.5V to 3.4V, using two external resistors connected as a voltage-divider to FB as shown in Figure 1. The output voltage is set by the following equation:

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

where typically V_{FB} = 0.5V. Choose R2 ≤ 5kΩ to optimize quiescent current, accuracy, and high-frequency power-supply rejection. To simplify resistor selection:

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

Soft-Start

Inherent soft-start limits inrush current. Peak inrush current is dependent on the value of C_{OUT} and can be calculated as follows:

$$I_{INRUSH} = I_{LOAD} + \left(\frac{C_{OUT}(\mu F)}{66} \right)$$

Shutdown Mode

The MAX8526/MAX8527/MAX8528 include an enable input. To shut down the device, pull EN to GND. For normal operation, connect the EN to IN. During shutdown, an internal 10kΩ resistor pulls down the output.

Power-OK (POK, MAX8527 Only)

The MAX8527 features a power-OK output to indicate the status of the output. POK remains high when the regulator output is within ±10% of its nominal output voltage. If the output voltage falls/rises outside this range, POK transitions low. This open-drain output requires an external pullup resistor to IN. An internal delay circuit prevents the POK from switching for 50µs (typ) after the trip threshold is initially reached. If the part is in shutdown mode, POK is low.

Power-On Reset (POR, MAX8528 Only)

The MAX8528 features a power-on reset output that transitions high 150ms (typ) after the output has risen above 90% of its final value. This open-drain output requires an external pullup resistor to IN. If the part is in shutdown mode, falls below 90% of the nominal output voltage, or experiences a short-circuit/thermal fault, POR immediately transitions low.

Figure 1. Typical Application Circuit

Operating Region and Power Dissipation

The maximum power dissipation depends on the thermal resistance of the IC package and circuit board, the temperature difference between the die junction and ambient air, and the rate of airflow. The power dissipated in the device is $P = I_{OUT} \times (V_{IN} - V_{OUT})$.

The package features an exposed thermal pad on its underside. This pad lowers the thermal resistance of the package by providing a direct heat conduction path from the die to the PC board.

Additionally, the ground pins (GND) perform the dual function of providing an electrical connection to system ground and channeling heat away. Connect the exposed backside pad and GND to the system ground using a large pad or ground plane, or multiple vias to the ground-plane layer.

Applications Information

Capacitor Selection and Regulator Stability

Capacitors are required at the MAX8526/MAX8527/MAX8528 inputs and outputs for stable operation over the full temperature range and with load currents up to 2A. Connect a 2.2µF capacitor between IN and ground and a 10µF capacitor with low equivalent-series-resistance (ESR) capacitor between OUT and ground for 2A output current. The input capacitor (C_{IN}) lowers the source impedance of the input supply. If input-supply source impedance is high, place a larger input capacitor close to IN to prevent V_{IN} sagging due to load transients. Smaller output capacitors can be used for output currents less than 2A. Calculate C_{OUT} as follows:
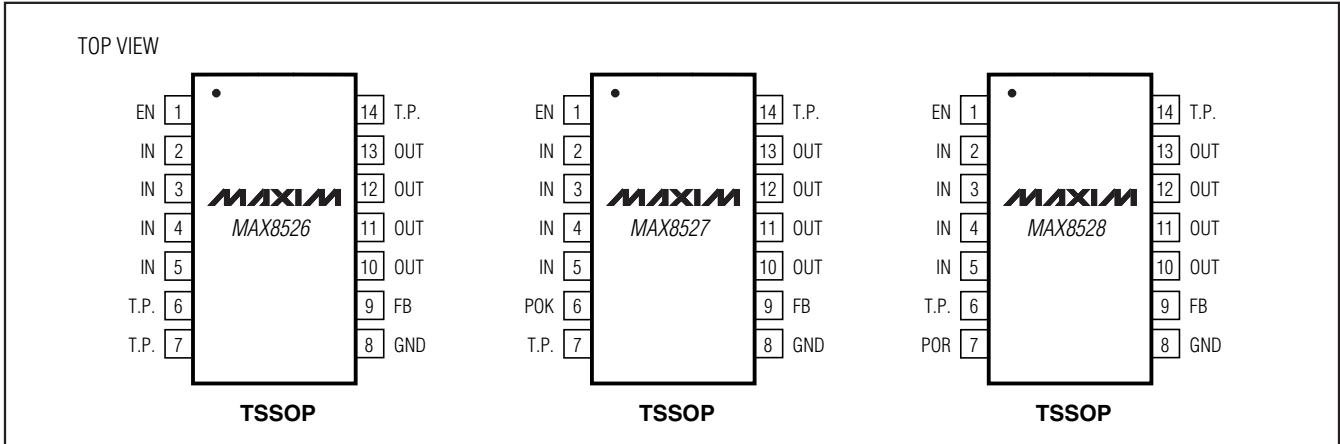
$$C_{OUT} = I_{OUT(max)} \times (1µF / 200mA)$$

Noise, PSRR, and Transient Response

The MAX8526/MAX8527/MAX8528 are designed to operate with low dropout voltages and low quiescent currents, while still maintaining good noise, transient response, and AC rejection. See the *Typical Operating Characteristics* for a plot of Power-Supply Rejection Ratio (PSRR) vs. Frequency. When operating from noisy sources, improved supply-noise rejection and transient response can be achieved by increasing the values of the input and output bypass capacitors and through passive filtering techniques. The MAX8526/MAX8527/MAX8528 load-transient response graphs (see the *Typical Operating Characteristics*) show two components of the output response: a DC shift from the output impedance due to the load current change, and the transient response. A typical transient overshoot for a step change in the load current from 20mA to 2A is 45mV. Use larger output ceramic capacitors greater than 10µF up to 100µF to attenuate the overshoot.

/MAXIM

Pin Configurations

TOP VIEW

MAX8526 (TSSOP)

Pin	Name		Pin	Name
1	EN		14	T.P.
2	IN		13	OUT
3	IN		12	OUT
4	IN		11	OUT
5	IN		10	OUT
6	T.P.		9	FB
7	T.P.		8	GND

MAX8527 (TSSOP)

Pin	Name		Pin	Name
1	EN		14	T.P.
2	IN		13	OUT
3	IN		12	OUT
4	IN		11	OUT
5	IN		10	OUT
6	POK		9	FB
7	T.P.		8	GND

MAX8528 (TSSOP)

Pin	Name		Pin	Name
1	EN		14	T.P.
2	IN		13	OUT
3	IN		12	OUT
4	IN		11	OUT
5	IN		10	OUT
6	T.P.		9	FB
7	POR		8	GND

Chip Information

TRANSISTOR COUNT: 2977

PROCESS: BiCMOS

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.
14 TSSOP	U14E-3	**21-0108**

1.425V to 3.6V Input, 2A,
0.2V Dropout LDO Regulators

**Revision History**

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	2/04	Initial release	—
1	5/05	Added lead-free versions in the _Ordering Information_ and updated the _Ordering Information_ and the _Pin Description_.	1, 6, 8
2	8/09	Added automotive version of the MAX8527.	1

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