19-0990; Rev 0; 9/07

Low-Noise 500mA LDO Regulators in a 2mm x 2mm TDFN Package

General Description

The MAX8902A/MAX8902B low-noise linear regulators deliver up to 500mA of output current with only 16µV$_{RMS}$ of output noise in a 100kHz bandwidth. These regulators maintain their output voltage over a wide input range, requiring only 100mV of input-to-output headroom at full load.

These LDOs maintain a low 80µA typical supply current, independent of the load current and dropout voltage. The regulator control circuitry includes a programmable soft-start circuit and short circuit, reverse current, and thermal overload protection. Other features include a shutdown input and a power-OK output (MAX8902B only).

The MAX8902A output voltage can be set to 1.5V, 1.8V, 2.0V, 2.5V, 3.0V, 3.1V, 3.3V, 4.6V, or 4.7V using the SELA and SELB inputs. The MAX8902B output voltage can be set between 0.6V and 5.3V with an external resistor voltage divider.

Applications

Notebook Computers

MP3 and Portable Media Players

Wireless Headphones

GPS Portable Navigation Devices

Smartphones

Features

- **1.7V to 5.5V Input Voltage Range**
- **0.6V to 5.3V Output Voltage Range**
- **16µV$_{RMS}$ Output Noise, 10Hz to 100kHz**
- **80µA Operating Supply Current**
- **92dB PSRR at 5kHz**
- **Guaranteed 500mA Output Current**
- **±1.5% Output Accuracy Over Load, Line, and Temperature**
- **100mV (max) Dropout at 500mA Load**
- **< 1µA Shutdown Supply Current**
- **700mA Short-Circuit Protection**
- **Thermal-Overload Protection**
- **Output-to-Input Reverse Current Protection**
- **2mm x 2mm x 0.8mm TDFN Package**

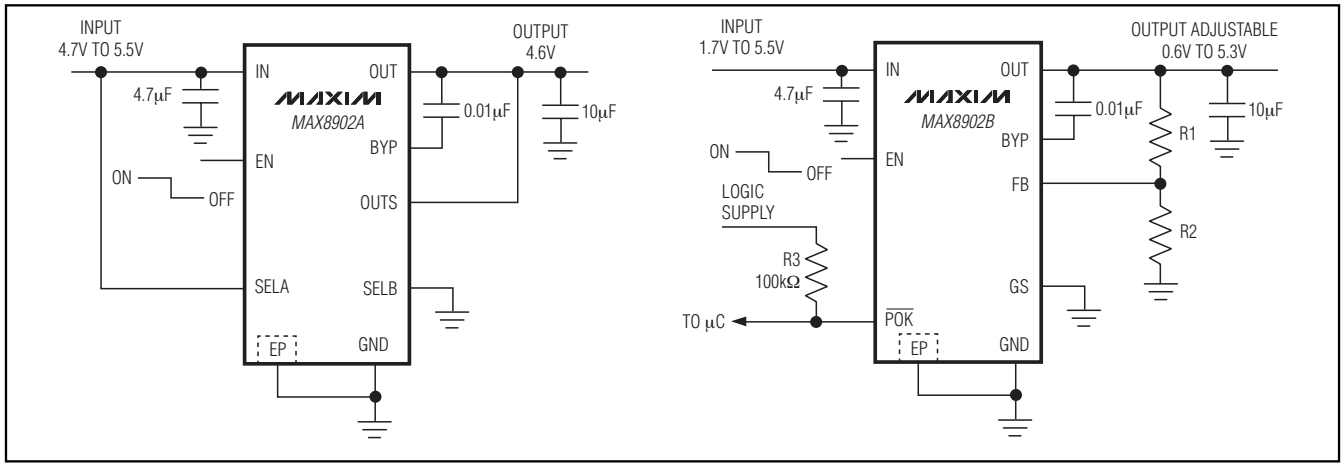
Ordering Information

PART	FEATURES	TOP MARK	PKG CODE
MAX8902AATA+	Pin-selectable output voltage	ABG	T822-1
MAX8902BATA+	Adjustable output voltage	ABH	T822-1

+Denotes a lead-free, RoHS-compliant package.

Note: *All devices are in an 8-pin, 2mm x 2mm TDFN package with an exposed paddle and operate over the -40°C to +125°C automotive temperature range.*

Typical Operating Circuits



Pin Configurations appear at end of data sheet.

Low-Noise 500mA LDO Regulators in a 2mm x 2mm TDFN Package

ABSOLUTE MAXIMUM RATINGS

BP, EN, IN, OUT, SELA, SELB, $\overline{POK}$ to GND, GS to GND, FB, OUTS to GND .....-0.3V to +6.0V
Output Short-Circuit Duration.....Continuous
Continuous Power Dissipation (T_A = +70°C)
8-Pin, 2mm x 2mm TDFN
(derate 11.9mW/°C above +70°C).....953.5mW

Operating Temperature Range .....-40°C to +125°C
Junction Temperature.....-40°C to +150°C
Storage Temperature.....-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_{EN} = 5V, OUTS = OUT, circuit of Figure 2 (MAX8902A) and Figure 3 (MAX8902B), T_A = -40°C to +125°C, unless otherwise noted.) (Note 1)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
IN						
Input Voltage Range			1.7		5.5	V
Input Undervoltage Lockout	V_{IN} rising, 100mV typical hysteresis		1.5	1.6	1.7	V
OUT						
Output Voltage Range	$V_{IN} \geq V_{OUT}$ + 0.1V		0.6		5.3	V
Output Voltage Accuracy	V_{IN} = 1.7V to 5.5V for $V_{OUT} \leq$ 1.4V V_{IN} = (V_{OUT} + 0.3V) to 5.5V for V_{OUT} > 1.4V I_{OUT} = 0.1mA to 500mA		-1.5		+1.5	%
Load Regulation	I_{OUT} = 0.1mA to 500mA			0.02		%
Line Regulation	V_{IN} = 1.7V to 5.5V for $V_{OUT} \leq$ 1.4V V_{IN} = (V_{OUT} + 0.3V) to 5.5V for V_{OUT} > 1.4V I_{OUT} = 200mA			0.04		%
Dropout Voltage (Note 2)	I_{OUT} = 500mA	$V_{IN} \geq$ 3.6V, $T_A \leq$ +85°C		50	100	mV
		$V_{IN} \geq$ 3.6V, $T_A \leq$ +125°C			120	
		V_{IN} = 1.7V		150		
Current Limit	V_{OUT} = 95% of regulation, V_{IN} = V_{OUT} + 0.5V		600	700	800	mA
Output Noise	I_{OUT} = 100mA, f = 10Hz to 100kHz, C_{BP} = 0.01µF			16		μV_{RMS}
Power-Supply Rejection Ratio	I_{OUT} = 10mA	f = 5kHz		92		dB
		f = 10kHz		85		
		f = 100kHz		62		
OUTS (MAX8902A Only)						
OUTS Input Bias Current	In regulation		0.5		7.0	µA
FB (MAX8902B Only)						
FB Threshold Accuracy	V_{IN} = 1.7V to 5.5V, I_{OUT} = 0.1mA to 500mA		0.591	0.600	0.609	V
FB Input Bias Current	V_{FB} = 0.6V	T_A = +25°C	-0.1	0.02	+0.1	µA
		T_A = -40°C		0.03		
BP						
BP Capacitor Range	Regulator remains stable		1		100	nF
BP Startup Current	From BP to GND during startup			50		µA

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = V_{EN} = 5V, OUTS = OUT, circuit of Figure 2 (MAX8902A) and Figure 3 (MAX8902B), T_A = -40°C to +125°C, unless otherwise noted.) (Note 1)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
GND						
GND Supply Current	I_{OUT} = 0mA	T_A < +85°C		80	120	µA
		T_A < +125°C			160	
GND Shutdown Current	V_{IN} = 5.5V, EN = 0V	T_A = +25°C		0.001	+1	µA
		T_A = +85°C		0.01		
SELA/SELB (MAX8902A Only)						
Select Input Resistance	When shorted to GND or V_{IN}				500	Ω
	When open		1			MΩ
Select Input Capacitance	When open				10	pF
EN						
Enable Input Threshold	V_{IN} = 1.7V to 5.5V	EN rising		0.8	1.2	V
		EN falling, T_A < +85°C	0.4	0.7		
		EN falling, T_A < +125°C	0.38	0.7		
Enable Input Bias Current	V_{EN} = 0V to 5.5V	T_A = +25°C	-1	0.001	+1	µA
		T_A = +85°C		0.01		
$\overline{POK}$ (MAX8902B Only)						
$\overline{POK}$ Threshold	OUT voltage when $\overline{POK}$ switches	OUT rising	88	91	94	%
		OUT falling		88		%
$\overline{POK}$ Voltage, Low	$I_{\overline{POK}}$ = 1mA			10	100	mV
$\overline{POK}$ Leakage Current	$\overline{POK}$ = 5.5V, V_{EN} = 0V	T_A = +25°C	-1	0.001	+1	µA
		T_A = +85°C		0.01		
THERMAL SHUTDOWN						
Thermal Shutdown Threshold	T_J rising			165		°C
	T_J falling			150		
OUTPUT TRANSIENT						
Load Transient	I_{OUT} = 50mA to 500mA to 50mA, t_{RISE} = t_{FALL}= 1µs			25		mV_{p-p}
Line Transient	V_{IN} = 4V to 5V to 4V, t_{RISE} = t_{FALL} = 5µs, I_{OUT} = 500mA			3		mV_{p-p}
IN-to-OUT Reverse Voltage Turnoff Threshold	IN falling below OUT			10		mV

Note 1: All devices are production tested at T_A = +25°C. Specifications over the operating temperature range are guaranteed by design and characterization.

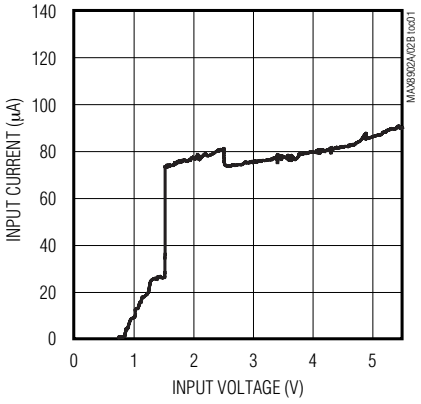
Note 2: The dropout voltage is defined V_{IN} - V_{OUT}, when V_{OUT} is 5% lower than the value of V_{OUT} when V_{IN} = V_{OUT} + 0.5V.

Low-Noise 500mA LDO Regulators in a 2mm x 2mm TDFN Package

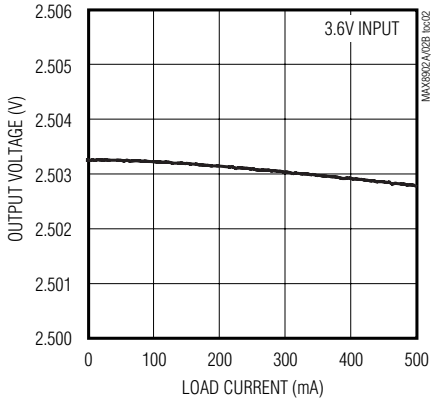
Typical Operating Characteristics

(MAX8902A, V_{IN} = 3.6V, V_{OUT} = 2.5V, T_A = +25°C, unless otherwise noted.)

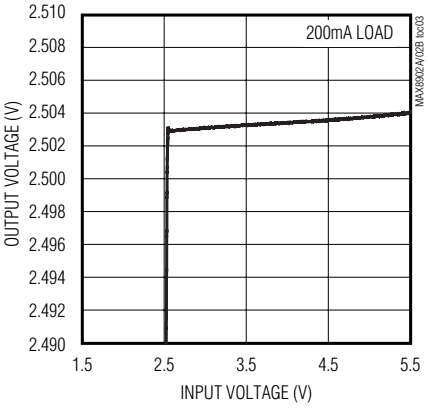
QUIESCENT CURRENT
EN = HIGH, NO LOAD



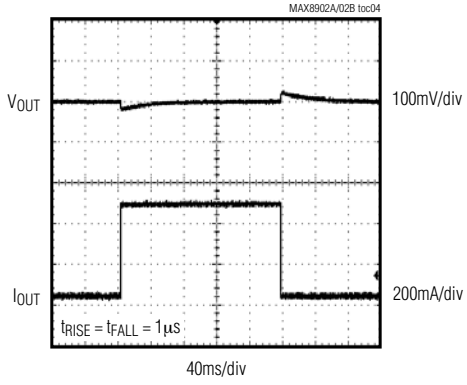
LOAD REGULATION



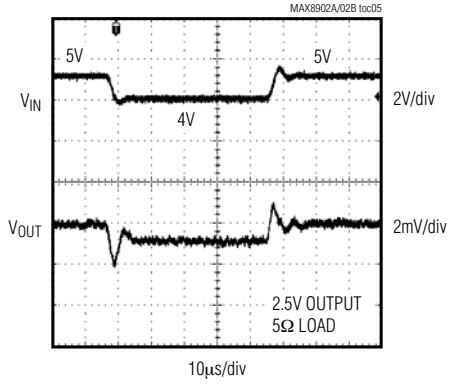
LINE REGULATION



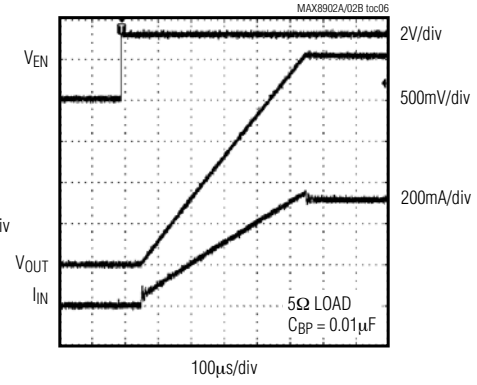
LOAD TRANSIENT RESPONSE
50mA TO 500mA TO 50mA



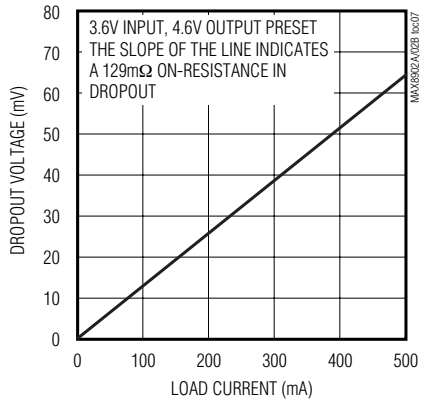
LOAD TRANSIENT RESPONSE



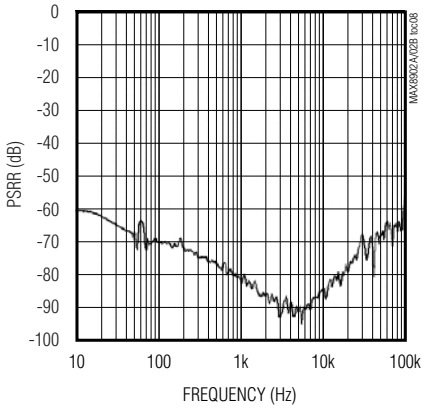
STARTUP WAVEFORM



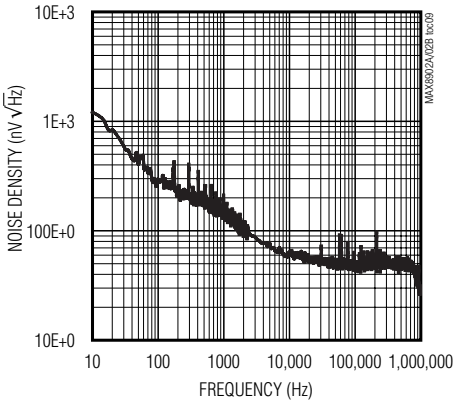
DROPOUT VOLTAGE vs. LOAD CURRENT



PSRR vs. FREQUENCY



MAX8902A LDO OUTPUT-NOISE SPECTRAL DENSITY vs. FREQUENCY



Pin Description

PIN	NAME		FUNCTION
	MAX8902A	MAX8902B	
1	IN	IN	Regulator Power Input. Connect IN to a supply from 1.7V to 5.5V. Bypass IN with a 4.7µF ceramic capacitor to GND.
2	GND	GND	Ground
3	EN	EN	Enable Input. A logic-low drives the output low through a 3kΩ resistor and reduces the supply current to less than 1µA. Drive logic-high or connect to IN for normal operation.
4	SELA	—	Output Voltage Select Input. Connect SELA to GND, IN, or leave unconnected. The states of SELA and SELB are sampled when the regulator turns on and the output voltage is set as shown in Table 2.
	—	GS	Internally used. Connect GS to GND.
5	SELB	—	Output Voltage Select Input. Connect SELB to GND, IN, or leave unconnected. The states of SELA and SELB are sampled when the regulator turns on and the output voltage is set as shown in Table 2.
	—	$\overline{POK}$	Power-OK Output. Open-drain output that goes low when the output is above 91% of the nominal regulation voltage. $\overline{POK}$ is high impedance in shutdown or when the output is below the regulation voltage.
6	OUTS	—	Output Sense Input. Connect OUTS to the load at a point where accurate regulation is required, or connect OUTS directly to OUT.
	—	FB	Feedback Input. Connect FB to the center of a resistor voltage divider connected between OUT and GND to set the output voltage. V_{FB} regulates to 0.6V.
7	BP	BP	Bypass Input. Connect a 0.01µF ceramic capacitor from BP to OUT to achieve 16µV_{RMS} output noise. Adjust the value of this capacitor to control the output slew rate during startup. Slew Rate = (5V / ms) x (0.01µF / C_{BP})
8	OUT	OUT	Regulator Output. Sources up to 500mA at the output regulation voltage. Bypass with a 10µF (< 0.03Ω ESR) capacitor to GND.
—	EP	EP	Exposed Paddle. Connect the exposed paddle to a ground plane to provide heat sinking.

Detailed Description

The MAX8902A/MAX8902B low-noise, low-dropout linear regulators deliver up to 500mA of output current with only 16µV_{RMS} of output noise in a 100kHz bandwidth. These regulators maintain their output voltage over a wide input range, requiring only 100mV of input-to-output headroom at full load.

The MAX8902 maintains a low 80µA typical supply current, independent of the load current and dropout voltage. The regulator control circuitry includes a programmable soft-start circuit and short circuit, reverse input, and thermal overload protection. Other features include an enable input and a power-OK ($\overline{POK}$) output (MAX8902B only). A simplified functional diagram is shown in Figure 1.

The MAX8902A output voltage can be set to 1.5V, 1.8V, 2.0V, 2.5V, 3.0V, 3.1V, 3.3V, 4.6V, or 4.7V using the SELA and SELB inputs. The MAX8902B output voltage can be set between 0.6V and 5.3V with an external resistor voltage divider.

Enable (EN)

The MAX8902A/MAX8902B include an enable input, EN. Pull EN low to shutdown the output, or drive EN high to enable the output. If shutdown is not needed, connect EN to IN.

Low-Noise 500mA LDO Regulators in a 2mm x 2mm TDFN Package

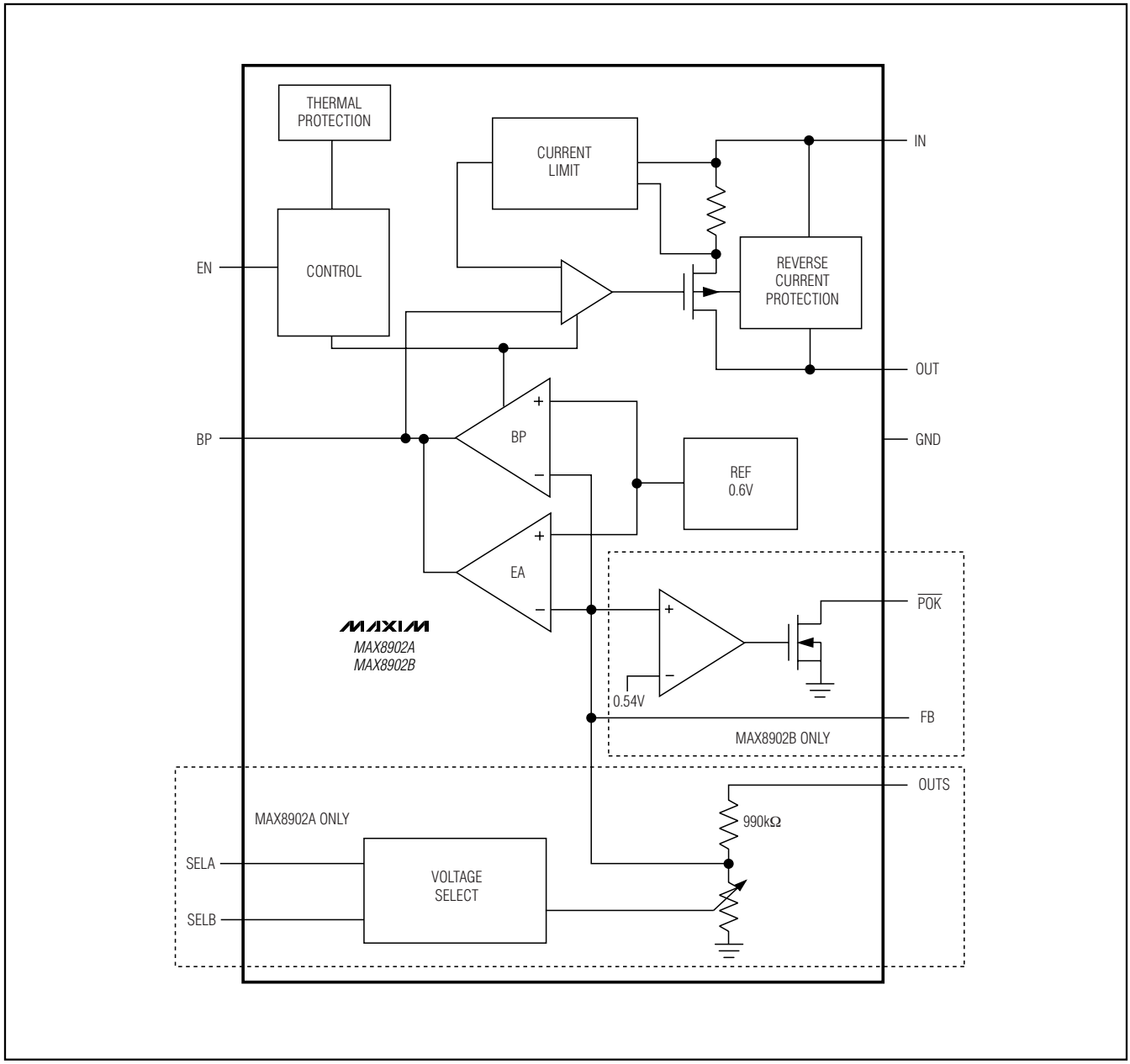


Figure 1. Simplified Functional Diagram

Bypass (BP)

The capacitor connected from BP to OUT filters the noise of the reference, feedback resistors, and regulator input stage and provides a high-speed feedback path for improved transient response. A 0.01µF capacitor rolls off input noise at approximately 32Hz.

The slew rate of the output voltage during startup is also determined by the BP capacitor. A 0.01µF capacitor sets the slew rate to 5V/ms. This startup rate results in a 50mA slew current drawn from the input at startup to charge the 10µF output capacitance.

The BP capacitor value can be adjusted from 0.001µF to 0.1µF, to change the startup slew rate according to the following formula:

$$\text{Startup slew rate} = (5V / ms) \times (0.01\mu F / C_{BP})$$

Note that this slew rate applies only at startup, and that recovery from a short circuit occurs at a slew rate approximately 500 times slower.

Also note that, being a low-frequency filter node, BP is sensitive to leakage. BP leakage currents above 10nA cause measurable inaccuracy at the output and should be avoided.

Protection Features

The MAX8902A/MAX8902B are fully protected from an output short circuit by a current-limiting and thermal overload circuit. If the output is shorted to GND, the output current is limited to 700mA (typ). Under these conditions, the part quickly heats up. When the junction temperature reaches +165°C, a thermal limit circuit shuts off the output device. When the junction cools to +150°C, the output turns back on in an attempt to reestablish regulation. While the fault persists, the output current cycles on and off, as the junction temperature slews between +150°C and +165°C.

The MAX8902A/MAX8902B are also protected against reverse current when the output voltage is higher than the input. In the event that extra output capacitance is used at the output, a power-down transient at the input would normally cause a large reverse current through a conventional regulator. The MAX8902A/MAX8902B include a reverse voltage detector that trips when IN drops 10mV below OUT, shutting off the regulator and opening the PMOS body diode connection, preventing any reverse current.

Thermal Considerations

The MAX8902A/MAX8902B are packaged in an 8-pin, 2mm x 2mm TDFN package with an exposed paddle. The exposed paddle is the main path for heat to leave the IC, and therefore, must be connected to a ground plane with thermal vias to allow heat to dissipate from the device. Thermal properties of the IC package are given in Table 1.

Selecting the Output Voltage (MAX8902A)

The MAX8902A output can be set to one of nine voltages by shorting or opening the SELA and SELB inputs, as shown in Table 2. SELA and SELB should be connected to GND, IN, or left unconnected. Alternatively, they may be driven high, low, or open with external logic, however, the states of SELA and SELB are sampled only at startup. The regulation voltage can be set to a different level by cycling EN or IN momentarily to GND.

Table 1. 2mm x 2mm TDFN Package Thermal Characteristics

CONTINUOUS POWER DISSIPATION	953.5mW DERATE 11.9mW/°C ABOVE +70°C
θ_{JA}*	83.9°C/W
θ_{JC}	36.6°C/W

**θ_{JA} is specified according to the JESD51 standard with the part mounted on a multilayer PCB.*

Table 2. MAX8902A Output Voltages

OUTPUT VOLTAGE	SELA STATE	SELB STATE
1.5V	IN	Unconnected
1.8V	Unconnected	GND
2.0V	Unconnected	IN
2.5V	Unconnected	Unconnected
3.0V	GND	GND
3.1V	GND	IN
3.3V	GND	Unconnected
4.6V	IN	GND
4.7V	IN	IN

Setting the Output Voltage (MAX8902B)

The MAX8902B uses external feedback resistors to set the output regulation voltage as shown in Figure 3. The output can be set from 0.6V to 5.3V. Set the lower feedback resistor (R2) to 120kΩ or less to minimize FB input bias current error. Then calculate the value of the upper feedback resistor (R1) as follows:

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

where V_{FB} is the feedback regulation voltage of 0.6V.

Power OK (MAX8902B)

The MAX8902B includes an additional open-drain output, $\overline{POK}$, that pulls low to indicate the output voltage is in regulation. During startup, $\overline{POK}$ is high impedance until the output voltage rises to 91% of its regulation level. If an overload occurs at the output, or the output is shutdown, $\overline{POK}$ is high impedance.

Low-Noise 500mA LDO Regulators in a 2mm x 2mm TDFN Package

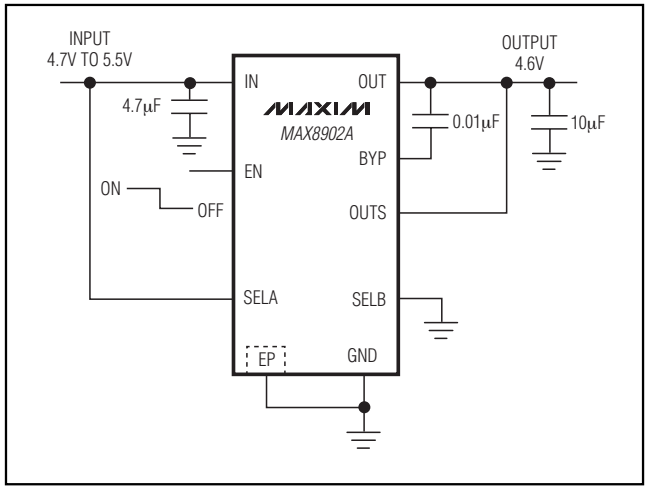


Figure 2. MAX8902A Fixed Output Application Circuit

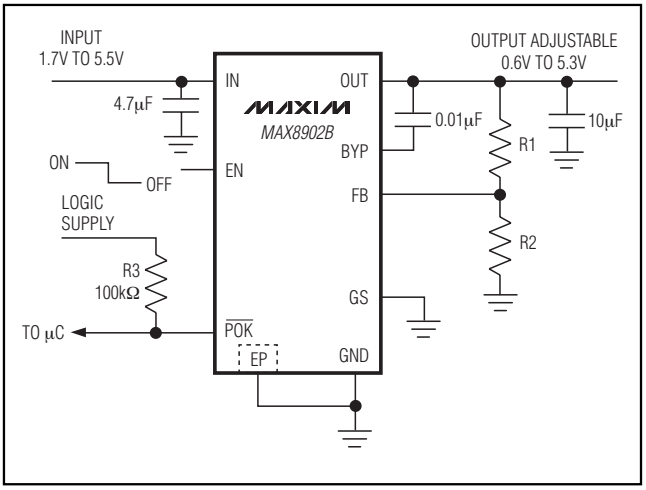


Figure 3. MAX8902B Adjustable Output Application Circuit

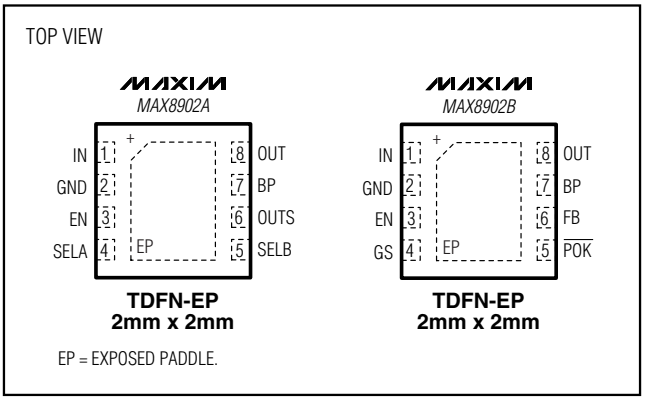
Input Capacitor

A 4.7µF ceramic capacitor is recommended for the input. Select a capacitor that maintains its capacitance over temperature and DC bias. Capacitors with X5R or X7R temperature characteristics generally perform well.

Output Capacitor

A minimum of 10µF of capacitance is required at OUT to ensure stability. Select a ceramic capacitor that maintains its capacitance over temperature and DC bias. Capacitors with X5R or X7R temperature characteristics generally perform well.

Pin Configurations



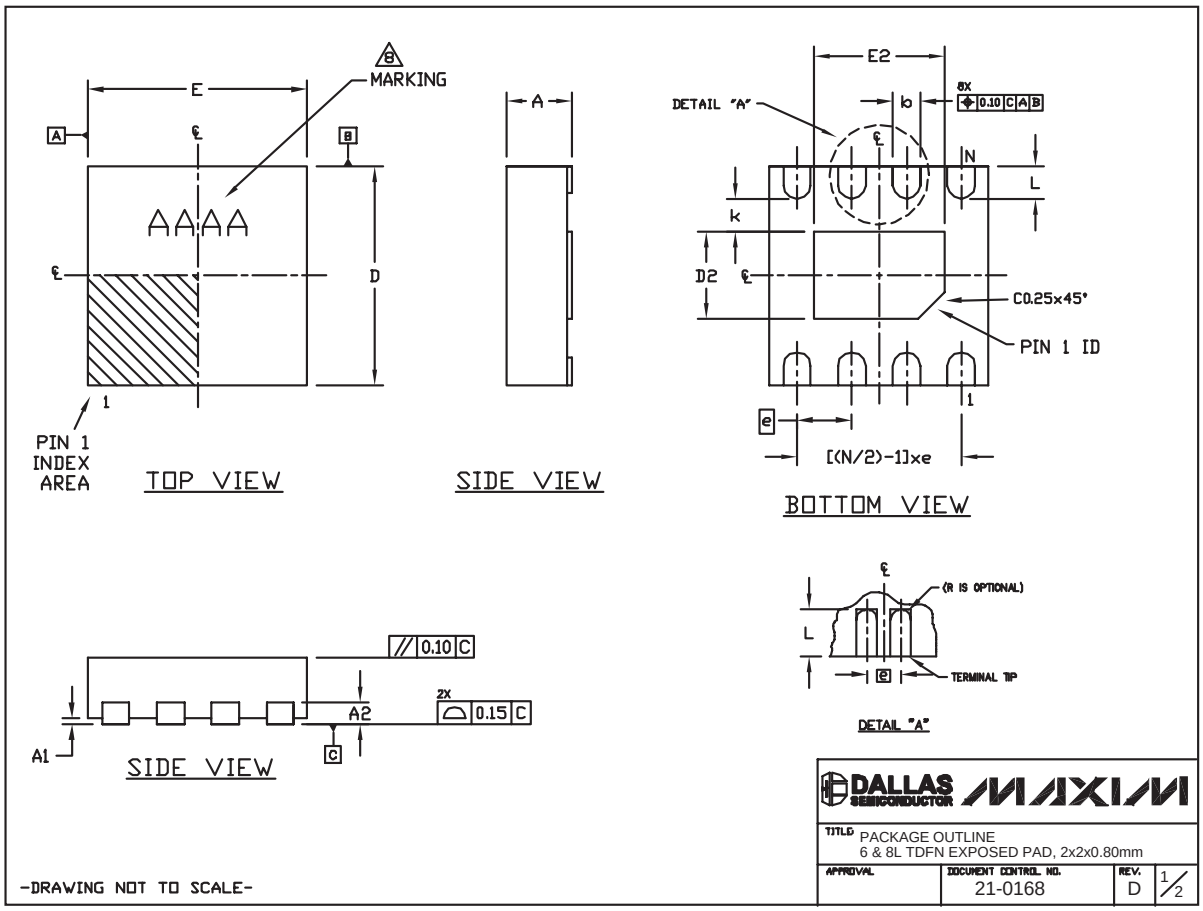
Chip Information

PROCESS: BiCMOS

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

8L TDFN EXPOSED PADS.EPS



Low-Noise 500mA LDO Regulators in a 2mm x 2mm TDFN Package

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

COMMON DIMENSIONS		
SYMBOL	MIN.	MAX.
A	0.70	0.80
D	1.90	2.10
E	1.90	2.10
A1	0.00	0.05
L	0.20	0.40
k	0.25 MIN.	
A2	0.20 REF.	

PACKAGE VARIATIONS							
PKG. CODE	N	D2	E2	e	b	r	[(N/2)-1] x e
T622-1	6	0.90±0.10	1.60±0.10	0.65 TYP.	0.30±0.05	0.150	1.30 REF
T822-1	8	0.70±0.10	1.30±0.10	0.50 TYP.	0.25±0.05	0.125	1.50 REF
T822-2	8	0.80±0.10	1.20±0.10	0.50 TYP.	0.25±0.05	0.125	1.50 REF

NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.08 mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. COMPLY TO JEDEC MO229 EXCEPT D2 AND E2 DIMENSIONS.
6. "N" IS THE TOTAL NUMBER OF LEADS.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
8. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.

-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM

TITLE: PACKAGE OUTLINE
6 & 8L TDFN EXPOSED PAD, 2x2x0.80mm

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0168	D	2/2