

# MAX8863

## Pin-Compatible, Low-Dropout, 120 mA Linear Regulator

Delivering up to 120 mA, the MAX8863 is a fixed output, low-dropout linear regulator that operates from a +2.5 V to +6.0 V input range. The 50  $\mu$ A supply current remains independent of load, making these devices ideal for battery-operated portable equipment.

The output of the MAX8863 is preset at 3.15 V, 2.84 V, 2.80 V or 1.80 V. (Other output voltage options are available – contact ON Semiconductor for more information.) The MAX8863 is pin-compatible with the Maxim MAX8863 LDO and is available in the SOT-23-5 package.

### Features

- Low Cost
- Pin-Compatible with MAX8863
- Stable with Any Type of Capacitors
- Low, 55 mV Dropout Voltage @ 50 mA  $I_{OUT}$
- Low, 50  $\mu$ A Operating Supply Current (Even in Dropout)
- 140  $\mu$ sec (Typ.) Turn-On Response Time from  $\overline{SHDN}$
- Low, 350  $\mu$ V<sub>RMS</sub> Output Noise
- Miniature External Components
- Thermal Overload Protection
- Output Current Limit
- Low-Power Shutdown Mode

### Applications

- Cordless, PCS, and Cellular Telephones
- PCMCIA Cards
- Modems
- Hand-Held Instruments
- Palmtop Computers
- Electronic Planners

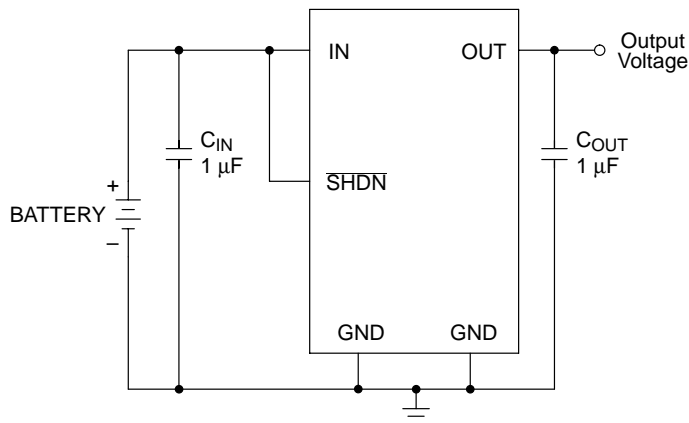
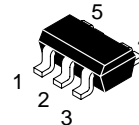


Figure 1. Typical Application



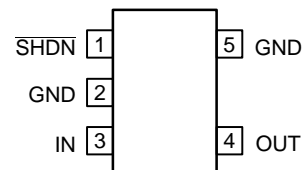
ON Semiconductor™

<http://onsemi.com>



SOT-23  
EUK SUFFIX  
CASE 1212

### PIN CONNECTIONS



(Top View)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 9 of this data sheet.

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 9 of this data sheet.

# MAX8863

## ABSOLUTE MAXIMUM RATINGS\*

Rating	Symbol	Value	Unit
Input Voltage	–	6.5	V
Output Short-Circuit Duration	–	Infinite	–
SET to GND	–	– 0.3 to +6.5	V
SHDN to GND	–	– 6.5 to + 6.5	V
SHDN to IN	–	–6.5 to + 0.3	V
Output Voltage	–	–0.3 to $V_{IN} + 0.3$	V
Continuous Power Dissipation ( $T_A = +70^{\circ}\text{C}$ ) SOT–23–5 (Derate 7.1 mW/ $^{\circ}\text{C}$ above $+70^{\circ}\text{C}$ )	–	571	mW
Operating Temperature Range	$T_A$	–40 to 85	$^{\circ}\text{C}$
Storage Temperature Range	$T_{stg}$	–65 to +160	$^{\circ}\text{C}$
Lead Temperature (Soldering, 10 Sec.)	–	+300	$^{\circ}\text{C}$
ESD Withstand Voltage Human Body Model (Note 1.)	$V_{ESD}$	> 2000	V
Latch-Up Performance (Note 2.)	$I_{LATCH-UP}$	420 240	mA
	Positive	420	
	Negative	240	

\*Stresses above 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 above 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** ( $V_{IN} = +3.6\text{ V}$ ,  $\text{GND} = 0\text{ V}$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified. Typical values are at  $T_A = +25^{\circ}\text{C}$ .) (Note 3.)

Characteristics	Test Conditions	Symbol	Min	Typ	Max	Unit
Input Voltage (Note 4.)	$V_{OUT} \geq 2.5\text{ V}$ $V_{OUT} = 1.8\text{ V}$	$V_{IN}$	$V_{OUT} + 0.5\text{ V}$ 2.7	– –	6.0 6.0	V
Output Voltage	$0\text{ mA} \leq I_{OUT} \leq 50\text{ mA}$	$V_{OUT}$				V
	T		3.05	3.15	3.25	
	S		2.75	2.84	2.93	
	R		2.70	2.80	2.88	
	Q		1.745	1.80	1.85	
Maximum Output Current	–	$I_{OUT}$	120	–	–	mA
Current Limit (Note 5.)	–	$I_{LIM}$	–	280	–	mA
Input Current	$I_{OUT} = 0$	$I_{IN}$	–	50	90	$\mu\text{A}$
Dropout Voltage (Note 6.)	$I_{OUT} = 1.0\text{ mA}$ $I_{OUT} = 50\text{ mA}$ $I_{OUT} = 100\text{ mA}$	–	– – –	1.1 55 110	– 120 240	mV
Line Regulation	$V_{IN} = V_{OUT} + 0.5\text{ V}$ to $6.0\text{ V}$ $I_{OUT} = 1.0\text{ mA}$	$\Delta V_{LNR}$	–0.10 –	.001 –	0.10 –	%/V
Load Regulation	$I_{OUT} = 0\text{ mA}$ to $50\text{ mA}$	$\Delta V_{LDR}$	–	0.01	0.040	%/mA
Output Voltage Noise	10 Hz to 1.0 MHz $C_{OUT} = 1.0\text{ }\mu\text{F}$ $C_{OUT} = 100\text{ }\mu\text{F}$	–	– –	350 220	– –	$\mu\text{V}_{RMS}$
Wake Up Time (from Shutdown Mode)	$V_{IN} = 3.6\text{ V}$ $C_{IN} = 1.0\text{ }\mu\text{F}$ , $C_{OUT} = 1.0\text{ }\mu\text{F}$ $I_L = 30\text{ mA}$ , (See Fig. 1)	$t_{WK}$	–	10	–	$\mu\text{sec}$
Settling Time (from Shutdown Mode)	$V_{IN} = 3.6\text{ V}$ $C_{IN} = 1.0\text{ }\mu\text{F}$ , $C_{OUT} = 1.0\text{ }\mu\text{F}$ $I_L = 30\text{ mA}$ , (See Fig. 1)	$t_S$	–	140	–	$\mu\text{sec}$

1. Tested to EIA/JESD22–A114–A
2. Tested to EIA/JESD78
3. Limits are 100% production tested at  $T_A = +25^{\circ}\text{C}$ . Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) Methods.
4. Guaranteed by line regulation test.
5. Not tested. For design purposes, the current limit should be considered 150 mA minimum to 410 mA maximum.
6. The dropout voltage is defined as ( $V_{IN} - V_{OUT}$ ) when  $V_{OUT}$  is 100 mV below the value of  $V_{OUT}$  for  $V_{IN} = V_{OUT} + 2.0\text{ V}$ .

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**ELECTRICAL CHARACTERISTICS (continued)** ( $V_{IN} = +3.6\text{ V}$ ,  $GND = 0\text{ V}$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified. Typical values are at  $T_A = +25^\circ\text{C}$ .) (Note 7.)

Characteristics	Test Conditions	Symbol	Min	Typ	Max	Unit
<b>Shutdown</b>						
SHDN Input Threshold	–	$V_{IH}$ $V_{IL}$	2.0 –	– –	– 0.4	V
SHDN Input Bias Current	$V_{SHDN} = V_{IN}$ $T_A = +25^\circ\text{C}$ $T_A = T_{MAX}$	$I_{SHDN}$	– –	0 50	100 –	nA
Shutdown Supply Current	$V_{OUT} = 0\text{ V}$ $T_A = +25^\circ\text{C}$ $T_A = T_{MAX}$	$I_{QSHDN}$	– –	.002 0.02	1.0 –	$\mu\text{A}$
Shutdown to Output Discharge Delay	$C_{OUT} = 1.0\ \mu\text{F}$ , No Load to 10% of $V_{OUT}$	–	–	1.0	–	msec

## Thermal Protection

Thermal Shutdown Temperature	–	$T_{SHDN}$	–	170	–	$^\circ\text{C}$
Thermal Shutdown Hysteresis	–	$\Delta T_{SHDN}$	–	20	–	$^\circ\text{C}$

7. Limits are 100% production tested at  $T_A = +25^\circ\text{C}$ . Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) Methods.

## PIN DESCRIPTION

Pin Number	Symbol	Description
1	$\overline{\text{SHDN}}$	Active–Low Shutdown Input. A logic low reduces the supply current to 0.1 nA. A logic low also causes the output voltage to discharge to GND. Connect to IN for normal operation.
2	GND	Ground. This pin also functions as a heatsink. Solder to large pads or the circuit board ground plane to maximize thermal dissipation.
3	IN	Regulator Input. Supply voltage can range from +2.5 V (+2.7 V for $V_{OUT} = 1.8\text{ V}$ ) to +6.0 V. Bypass with 1.0 $\mu\text{F}$ to GND (see <i>Capacitor Selection and Regulator Stability</i> ).
4	OUT	Regulator Output. Sources up to 120 mA. Bypass with a 1.0 $\mu\text{F}$ , < 1.0 $\Omega$ typical ESR capacitor to GND.
5	GND	Connect to GND.

**DETAILED DESCRIPTION**

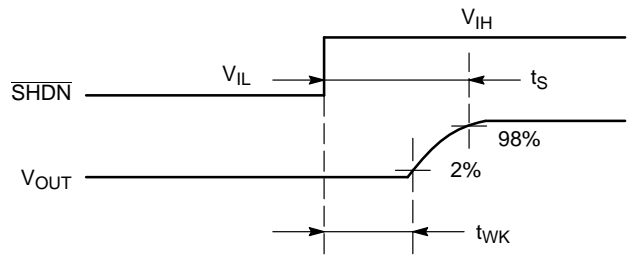
The MAX8863 is a fixed output, low-dropout, low-quiescent current linear regulator designed specifically for portable, battery-operated equipment such as cellular phones, cordless phones, and modems. A 1.20 V reference, error amplifier, MOSFET driver, P-channel pass transistor, comparator, and internal feedback voltage divider comprise the MAX8863 (see Figure 3).

The bandgap reference is connected to the error amplifier's inverting input. The error amplifier then compares the reference with the selected feedback voltage and amplifies the difference. The MOSFET driver, reading the error signal, applies the correct drive to the P-channel pass transistor. If the feedback voltage is lower than the reference, the pass-transistor is pulled lower to allow more current through, and to increase the output voltage. Conversely, if the feedback voltage is higher than the reference, the pass-transistor is pulled up, which allows less current through to the output.

**Turn On Response**

The turn on response is defined as two separate response categories, **Wake Up Time ( $t_{WK}$ )** and **Settling Time ( $t_S$ )**.

The MAX8863 has a fast Wake Up Time (10  $\mu$ sec typical) when released from shutdown. See Figure 2 for the **Wake Up Time** designated as  $t_{WK}$ . The **Wake Up Time** is defined as the time it takes for the output to rise to 2.0% of the  $V_{OUT}$  value after being released from shutdown.

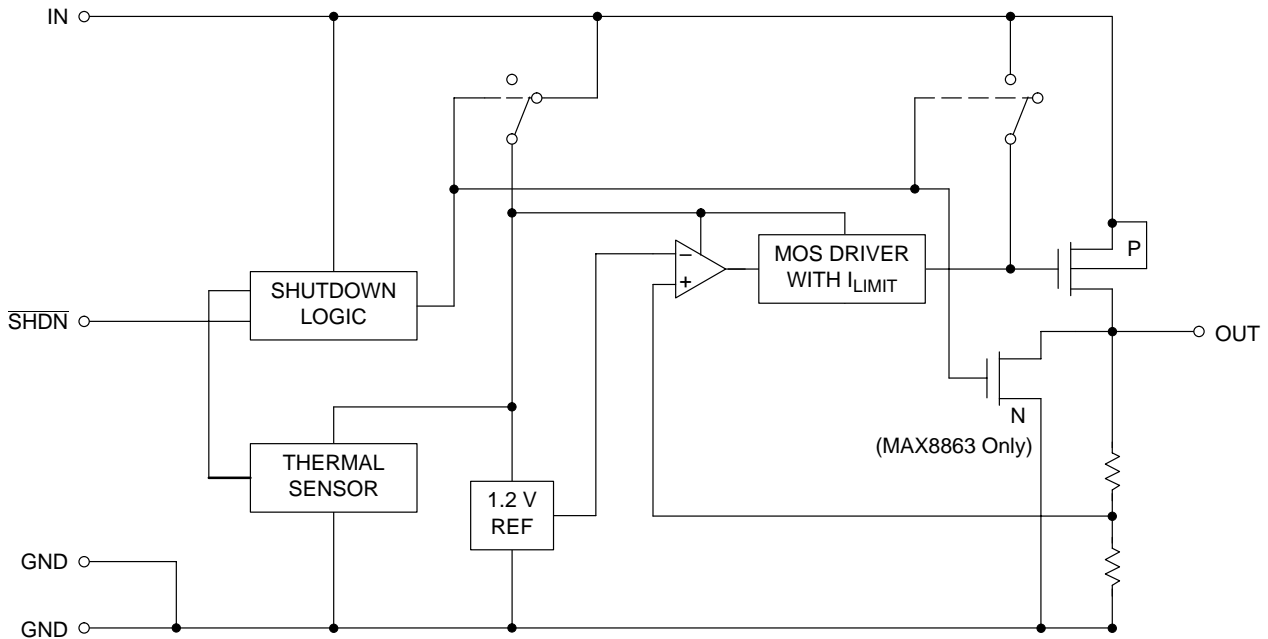


**Figure 2. Wake Up Response Time**

The total turn on response is defined as the **Settling Time ( $t_S$ )**, see Figure 2. **Settling Time** (inclusive with  $t_{WK}$ ) is defined as the condition when the output is within 2.0% of its fully enabled value (140  $\mu$ sec typical) when released from shutdown. The settling time of the output voltage is dependent on load conditions and output capacitance on  $V_{OUT}$  (RC response).

**Internal P-Channel Pass Transistor**

Featuring a 1.1  $\Omega$  P-channel MOSFET pass transistor, the MAX8863 offers longer battery life than similar designs using PNP pass transistors, which waste current in dropout when the pass transistor saturates. PNP-based regulators also use high base-drive currents under large loads. The P-channel MOSFET, however, does not require a base drive current, which reduces quiescent current. The MAX8863 uses only 50  $\mu$ A of quiescent current.



**Figure 3. Functional Block Diagram**

## Shutdown

Low input on  $\overline{\text{SHDN}}$  shuts down the MAX8863 by turning off the pass transistor, control circuit, reference, and all biases. This reduces the supply current to 0.1 nA, typical. For normal operation, connect  $\overline{\text{SHDN}}$  to IN. When the MAX8863 is placed in shutdown mode, the output voltage is actively discharged to ground.

## Current Limit

The current limiter on the MAX8863 monitors and controls the pass transistor's gate voltage. It estimates the output current, limiting it to 280 mA. The current limit should be considered 150 mA (min) to 410 mA (max) for design purposes. The output can be shorted to ground indefinitely without damaging the device.

## Thermal Overload Protection

The MAX8863 features thermal overload protection, which limits total power dissipation. The thermal sensor signals the shutdown logic to turn off the pass transistor when the junction temperature exceeds  $T_J = +170^\circ\text{C}$ . This allows the IC's junction temperature to cool by  $20^\circ\text{C}$  before the thermal sensor turns the pass transistor back on. This results in a pulsed output during continuous thermal overload conditions.

This feature is designed to protect the MAX8863 during thermal events. High load currents and high input-output differential voltages may cause a momentary overshoot of 2.0% to 8.0% for 200 msec when the load is removed. This can be avoided by raising the minimum load current from  $0\ \mu\text{A}$  ( $+125^\circ\text{C}$ ) to  $100\ \mu\text{A}$  ( $+150^\circ\text{C}$ ). The maximum junction temperature rating of  $+150^\circ\text{C}$  should not be exceeded for continuous operation.

## Operating Region and Power Dissipation

The MAX8863's maximum power dissipation depends on the thermal resistance of the case and circuit board, the rate of air flow, and the temperature difference between the die junction and ambient air. The devices' power dissipation is  $P = I_{\text{OUT}}(V_{\text{IN}} - V_{\text{OUT}})$ ; resulting maximum power dissipation is:

$$P_{\text{MAX}} = (T_J - T_A)/\Theta_{\text{JA}}$$

where  $(T_J - T_A)$  is the temperature difference between the devices' die junction and the surrounding air, and  $\Theta_{\text{JA}}$  is the thermal resistance of the chosen package to the surrounding air.

The devices' GND pin provides an electrical connection to ground and channels heat away. The GND pin should be connected to ground with a large pad or ground plane.

## APPLICATIONS INFORMATION

### Capacitor Selection and Regulator Stability

A  $1.0\ \mu\text{F}$  capacitor on the input, and a  $1.0\ \mu\text{F}$  capacitor on the output should generally be used on the MAX8863. For better supply-noise rejection and transient response, larger input capacitor values and lower ESR should be used. If the device is several inches from the power source or if large, fast transients are expected, a higher-value input capacitor ( $10\ \mu\text{F}$ ) may be required.

Using large output capacitors may improve load-transient response, stability, and power-supply rejection. A minimum of  $1.0\ \mu\text{F}$  is recommended for stable operation over the full temperature range with load currents up to 120 mA.

### Noise

During normal operation, the MAX8863 have low ( $350\ \mu\text{V}_{\text{RMS}}$ ) output noise. The ADC's power-supply rejection specifications should be considered for applications that include analog-to-digital converters of greater than 12 bits.

### Power-Supply Rejection and Operation from Sources Other than Batteries

Power-supply rejection for the MAX8863 is 62 dB at low frequencies, rolling off above 300 Hz. Power supply noise rejection is primarily controlled by the output capacitor at frequencies of more than 20 KHz.

Supply noise rejection and transient response can be improved when operating from sources other than batteries by increasing the values of the input and output capacitors, and using passive filtering techniques.

### Load Transient Considerations

With the MAX8863, typical overshoot for step changes in the load current from 0 mA to 50 mA is 12 mV. To lessen transient spikes, increase the output capacitor's value, and decrease its ESR.

### Input-Output (Dropout) Voltage

A regulator's dropout voltage determines the lowest usable supply voltage. This determines the useful end-of-life battery voltage for battery-powered systems. Since the MAX8863 uses a P-channel MOSFET pass transistor, the devices' dropout voltage is a function of  $R_{\text{DS(ON)}}$  multiplied by the load current.

TYPICAL CHARACTERISTICS

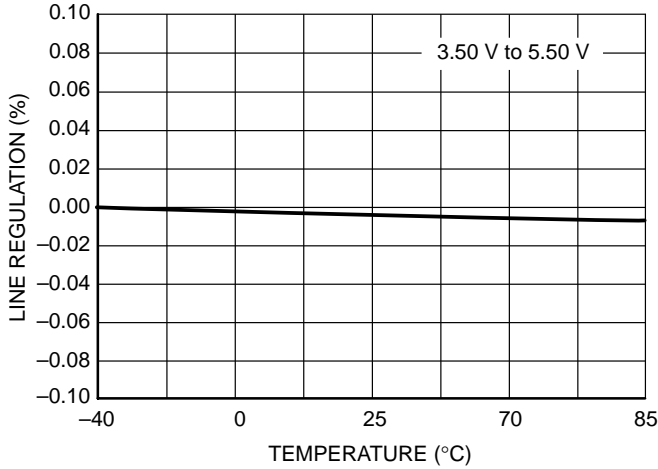


Figure 4. Line Regulation vs. Temperature

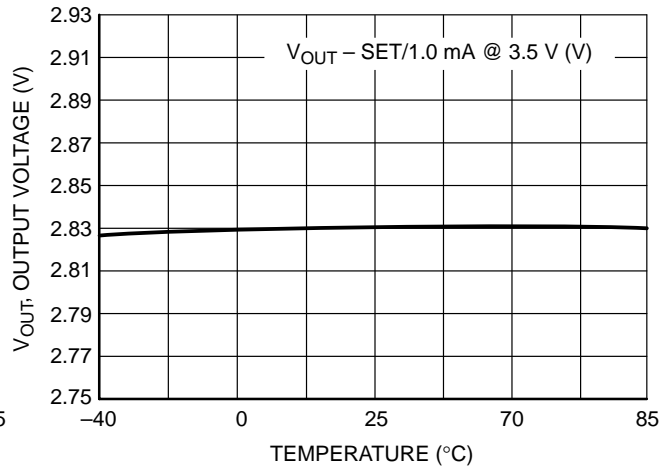


Figure 5. Output Voltage vs. Temperature

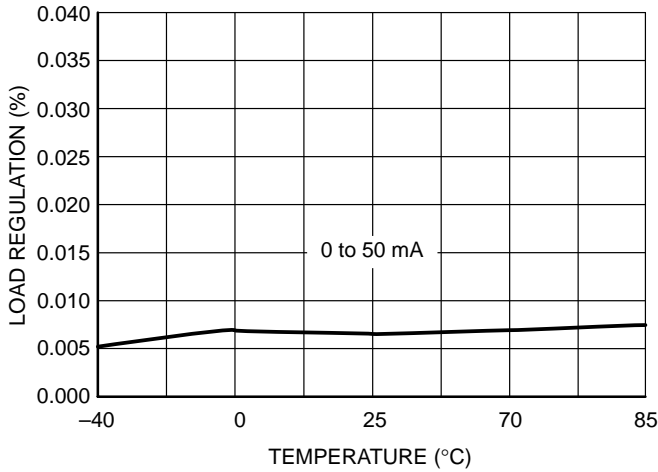


Figure 6. Load Regulation vs. Temperature

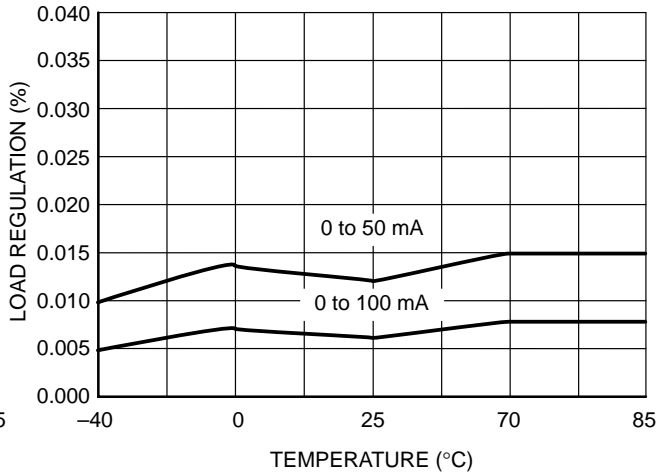


Figure 7. Load Regulation vs. Temperature

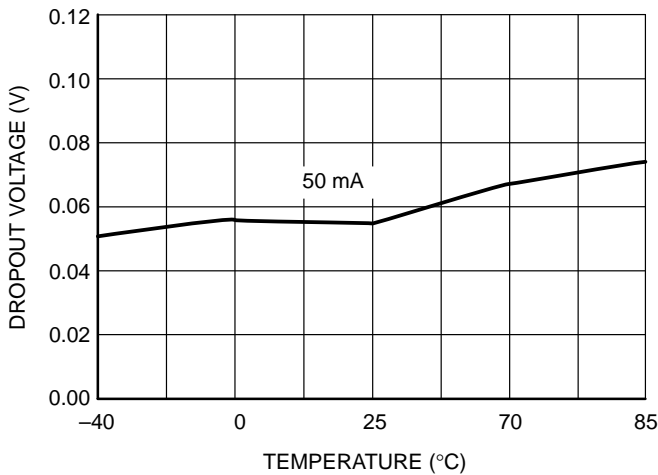


Figure 8. Dropout Voltage vs. Temperature

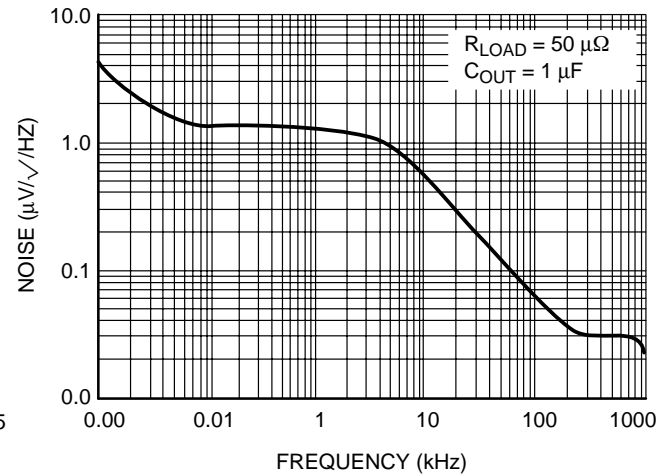


Figure 9. Output Noise vs. Frequency

TYPICAL CHARACTERISTICS

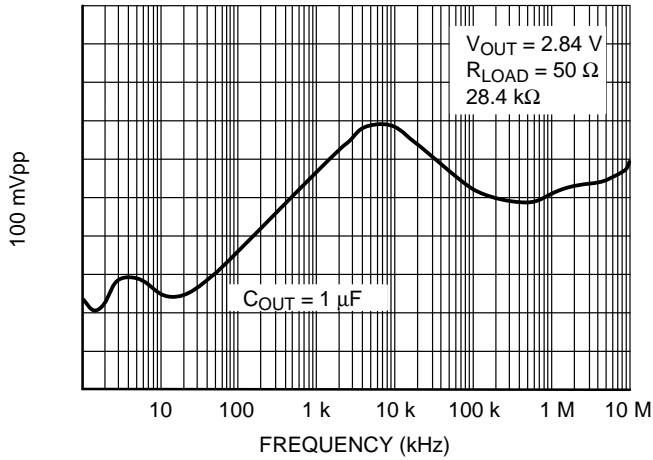


Figure 10. Power Supply Rejection Ratio

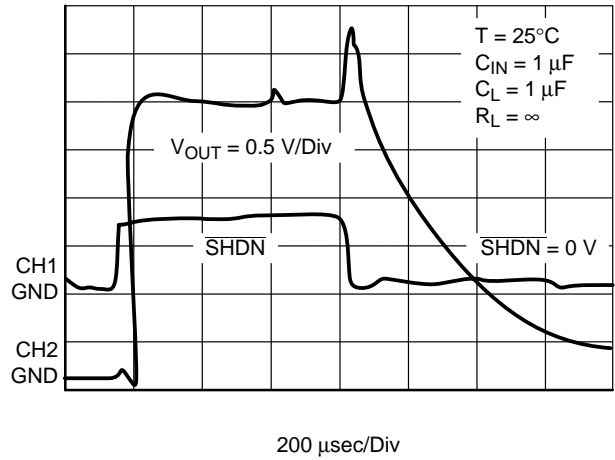


Figure 11. Shutdown Transient Response

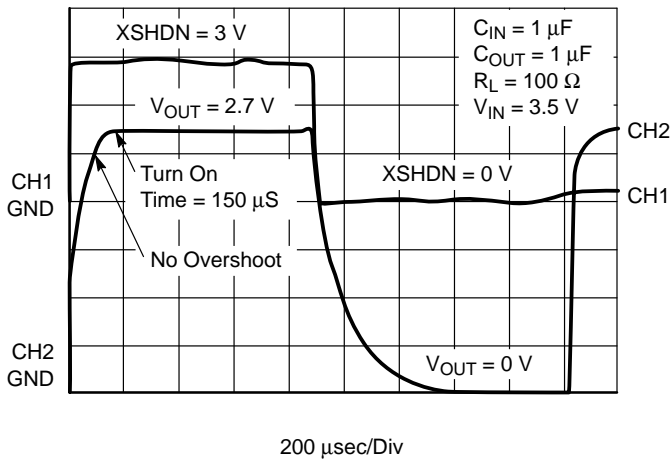


Figure 12. Shutdown Transient Response

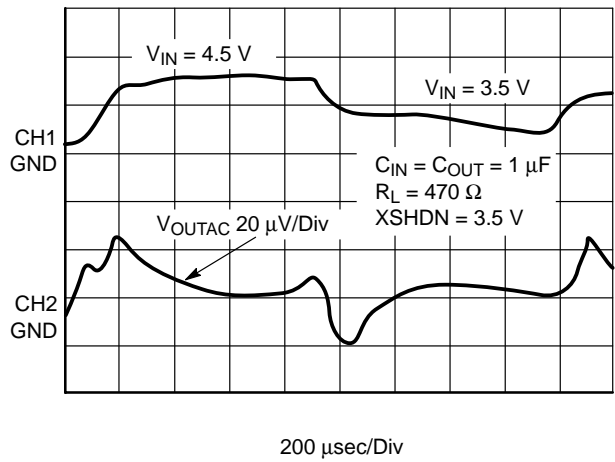


Figure 13. Line Response

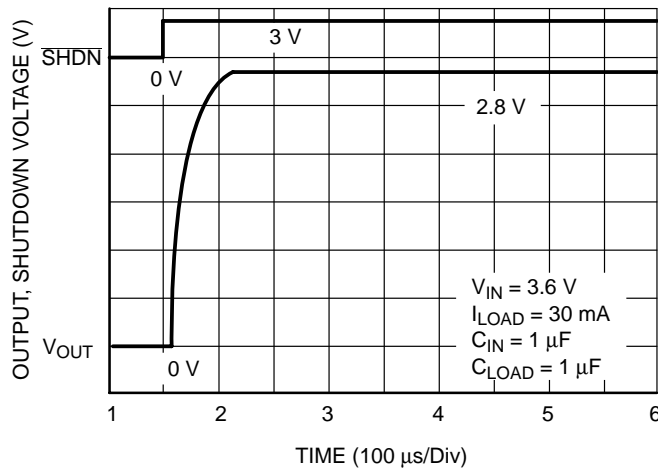
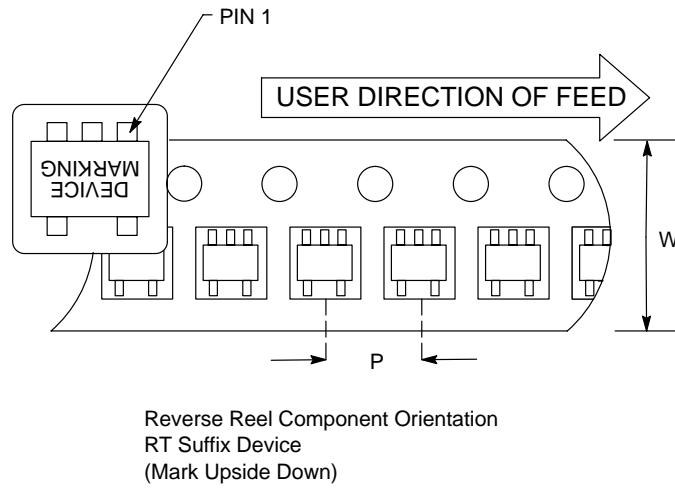
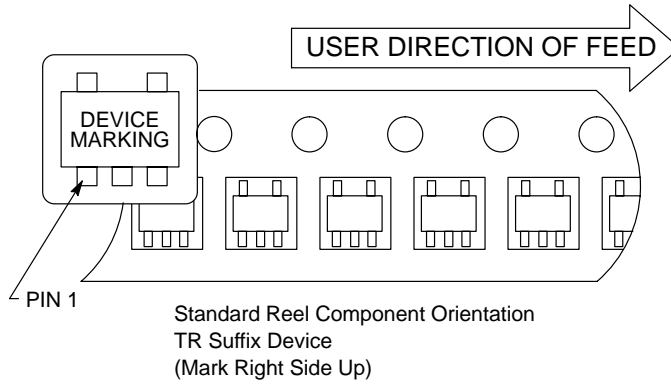


Figure 14. Wake Up Response Time

# MAX8863

## Component Taping Orientation for 5-Pin SOT-23 Devices



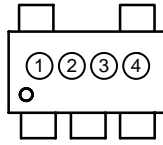
### Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
SOT-23	8 mm	4 mm	3000	7 inches



# MAX8863

## MARKING DIAGRAM



- ① and ② = Two Letter Part Number Codes  
+ Temperature Range and Voltage
- ③ = Year and Quarter Code
- ④ = Lot ID Number

## ORDERING INFORMATION

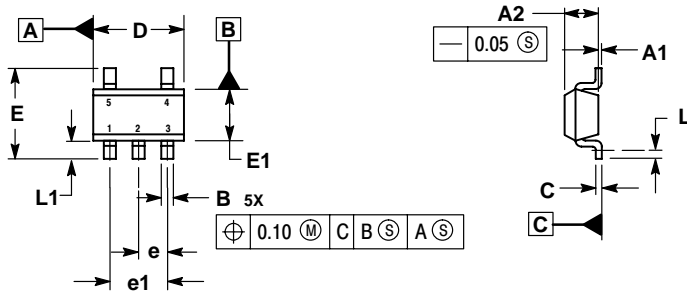
Device	Output Voltage*	Marking ① and ②	Package	Junction Temperature Range	Shipping
MAX8863QEUK-T	1.80	G4	SOT-23	-40°C to +85°C	3000 Tape & Reel
MAX8863REUK-T	2.80	G3			
MAX8863SEUK-T	2.84	G2			
MAX8863TEUK-T	3.15	G1			

\*Other output voltages are available. Please contact ON Semiconductor for details.

# MAX8863

## PACKAGE DIMENSIONS

SOT-23  
 EUK SUFFIX  
 CASE 1212-01  
 ISSUE O




NOTES:

1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DATUM C IS A SEATING PLANE.

MILLIMETERS		
DIM	MIN	MAX
A1	0.00	0.10
A2	1.00	1.30
B	0.30	0.50
C	0.10	0.25
D	2.80	3.00
E	2.50	3.10
E1	1.50	1.80
e	0.95 BSC	
e1	1.90 BSC	
L	0.20	---
L1	0.45	0.75

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