FS8860 1.0A Adjustable and Fixed Voltage LDO Linear Regulator

General Description

The FS8860 is a low-dropout linear regulator that operates the input voltage from +2.5V to +7.0V and delivers 1.0A load current.

The FS8860 is available in two types, either fixed or adjustable output voltage. The output voltage of the fixed types is preset at an internally trimmed voltage 1.8V, 2.5V, 3.3V, or can be made with options of the output range from 1.3V to 4.5V in 100mV increments. The FS8860-19Cx and FS8860-29Cx are the exceptions, which have output voltage 1.85V and 2.85V respectively. The output range of the adjustable types is from 1.25V to 5V.

The FS8860 consists of a 1.25V reference, an error amplifier, and a P-channel pass transistor allows the low 65μA (Typ.) ground pin current. Other features include short-circuit protection and thermal shutdown protection.

Features

- **Low dropout voltage 700mV at 1.0A typ.**
- **Adjustable output voltage (FS8860-Cx) or fixed output voltage (FS8860-xxCx) preset at 1.8V, 2.5V, or 3.3V**
- **High output voltage accuracy**
  - **Fixed output voltage : ±35mV**
  - **Adjustable output voltage : ±50mV**
- **Small output capacitor**
- **Output current limit**
- **Thermal overload shutdown protection**
- **SOT-223, TO-220, TO-252 and TO-263 Package**

Applications

Active SCSI Terminators
High Efficiency Linear Regulators
Monitor Microprocessor
Low Voltage Micro-Controllers
Post Regulator for Switching Power

Ordering Information

FS8860-xx x x

Package / Pin Out

G：SOT-223	1.IN	2.GND	3.OUT
H：SOT-223	1.GND	2.IN	3.OUT
J：SOT-223	1.GND	2.OUT	3.IN
X：SOT-223	1.OUT	2.GND	3.IN
M：TO-220	1.IN	2.GND	3.OUT
N：TO-220	1.GND	2.IN	3.OUT
O：TO-220	1.GND	2.OUT	3.IN
P：TO-252	1.IN	2.GND	3.OUT
Q：TO-252	1.GND	2.IN	3.OUT
R：TO-252	1.GND	2.OUT	3.IN
S：TO-263	1.IN	2.GND	3.OUT
T：TO-263	1.GND	2.IN	3.OUT
U：TO-263	1.GND	2.OUT	3.IN
Z：TO-263	1.OUT	2.GND	3.IN

Note : For the adjustable voltage types, the GND pin is replaced with the ADJ pin

Temperature Range
C：Commercial Standard

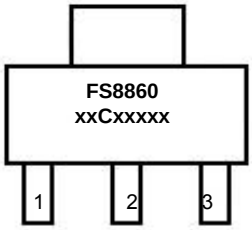
Output Voltage (Fixed voltage types only)

13 : 1.3V	24 : 2.4V	35 : 3.5V
14 : 1.4V	25 : 2.5V	36 : 3.6V
15 : 1.5V	26 : 2.6V	37 : 3.7V
16 : 1.6V	27 : 2.7V	38 : 3.8V
17 : 1.7V	28 : 2.8V	39 : 3.9V
18 : 1.8V	29 : 2.85V	40 : 4.0V
19 : 1.85V	30 : 3.0V	41 : 4.1V
20 : 2.0V	31 : 3.1V	42 : 4.2V
21 : 2.1V	32 : 3.2V	43 : 4.3V
22 : 2.2V	33 : 3.3V	44 : 4.4V
23 : 2.3V	34 : 3.4V	45 : 4.5V

The output voltages other than the preset value are available by order.

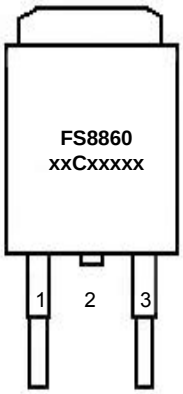
Part No.	Pin 1	Pin 2	Pin 3
FS8860 -xxCG	IN	GND	OUT
FS8860 -xxCH	GND	IN	OUT
FS8860 -xxCJ	GND	OUT	IN
FS8860 -xxCX	OUT	GND	IN

SOT-223



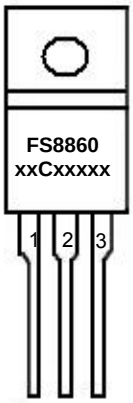
Part No.	Pin 1	Pin 2	Pin 3
FS8860 -xxCP	IN	GND	OUT
FS8860 -xxCQ	GND	IN	OUT
FS8860 -xxCR	GND	OUT	IN

TO-252



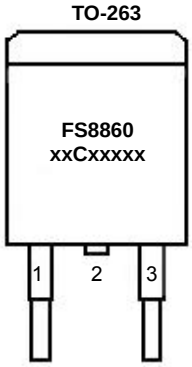
Part No.	Pin 1	Pin 2	Pin 3
FS8860 -xxCM	IN	GND	OUT
FS8860 -xxCN	GND	IN	OUT
FS8860 -xxCO	GND	OUT	IN

TO-220



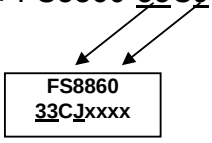
Part No.	Pin 1	Pin 2	Pin 3
FS8860 -xxCS	IN	GND	OUT
FS8860 -xxCT	GND	IN	OUT
FS8860 -xxCU	GND	OUT	IN
FS8860 -xxCZ	OUT	GND	IN

TO-263



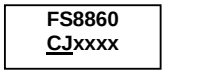
Package Marking Information

EX：FS8860-33CJ



xxxx：Date Code

EX：FS8860-CJ（ADJ）



xxxx：Date Code

Pin Description

Part NO.	Symbol	Description
FS8860-xxCG FS8860-xxCH FS8860-xxCJ FS8860-xxCX FS8860-xxCM FS8860-xxCN FS8860-xxCO FS8860-xxCP FS8860-xxCQ FS8860-xxCR FS8860-xxCS FS8860-xxCT FS8860-xxCU FS8860-xxCZ	GND/ADJ	Ground output or Adjustable output.
	IN	Regulator input.
	OUT	Regulator output.

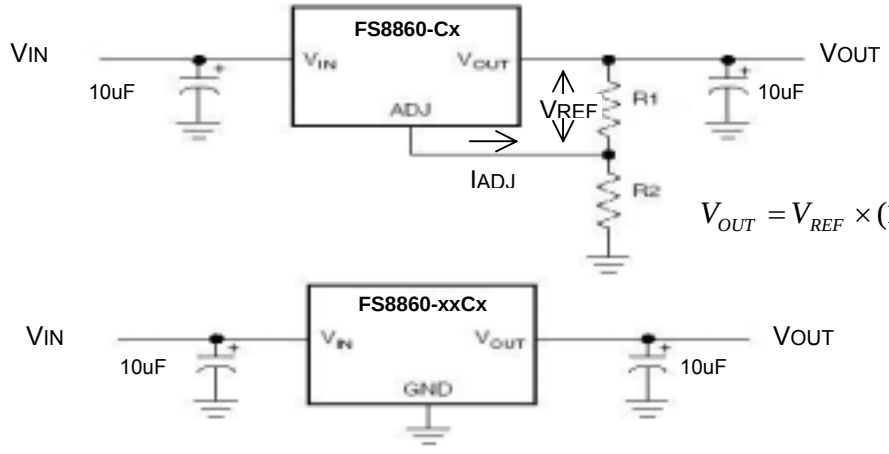
IN is the regulator input. Supply voltage can range from 2.5V to 7.0V. Bypass with a 10μF capacitor to GND.

OUT is the output voltage. Sources up to 1.0A. Bypass with a 10μF capacitor to GND.

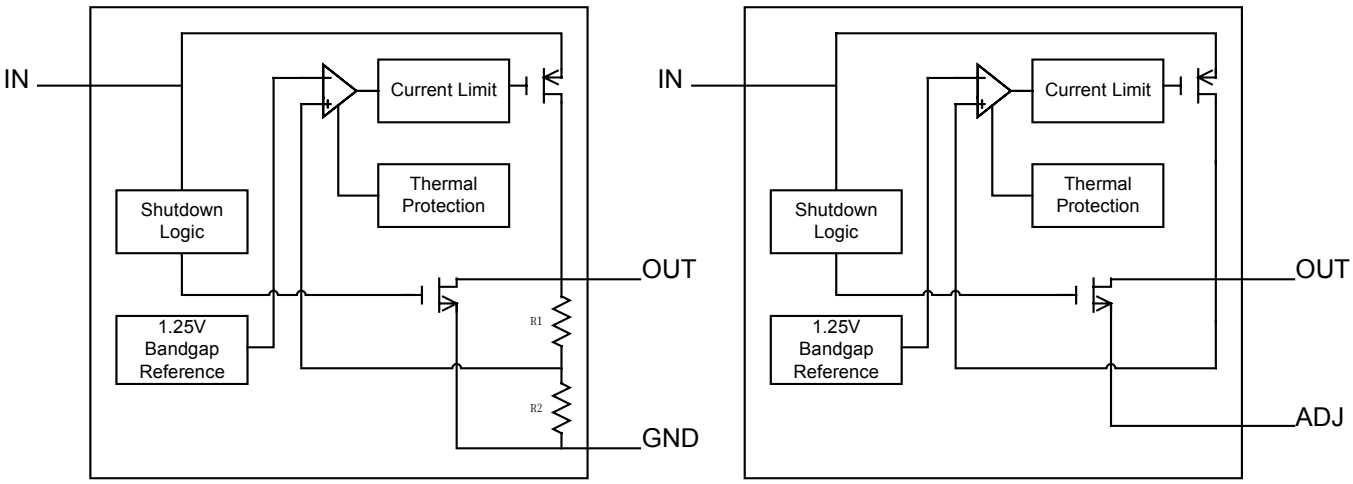
GND provides the reference for all voltages. This pin also functions as a heat sink. Solder to a large pad or the circuit-board ground plane to maximize power dissipation.

ADJ provides V_{REF}=1.25V（Typ.）for adjustable V_{OUT}.

Typical Application Schematic



Function Block Diagram



Fixed Voltage Type

Adjustable Voltage Type

Absolute Maximum Ratings

Input voltage V_{IN} to GND ---------- 9V
Output current limit, $I_{(LIMIT)}$ ---------- 1.3A
Continuous power dissipation, P_D
- SOT-223 ---------- 1.80W
- TO-220 ---------- 2.40W
- TO-252 ---------- 2.00W
- TO-263 ---------- 2.20W

Storage temperature range, T_{STG} ---------- -55℃ to +150℃
Operating ambient temperature range ---------- -40℃ to +85℃
Operating junction temperature range ---------- -40℃ to +125℃
Lead temperature (soldering, 10sec) ---------- 260℃

Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and function operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Electrical Characteristics

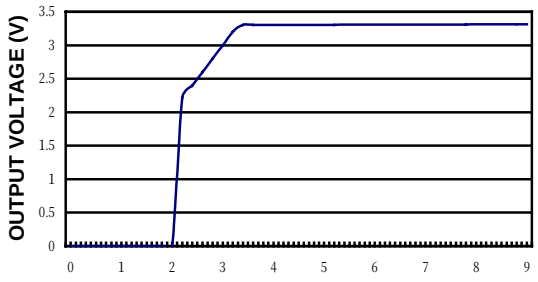
(C_{IN}=10μF, C_{OUT}=10μF, T_A=25℃, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage		2.5		7.0	V
Output Voltage	Fixed Voltage Type V_{IN}=V_{OUT}+1.0V, I_{OUT}=1mA	V_{OUT}-0.035	V_{OUT}	V_{OUT}+0.035	V
	Adjustable Voltage Type V_{IN}=V_{OUT}+1.2V, I_{OUT}=1mA	1.20	1.25	1.30	V
Output Voltage Accuracy	V_{IN}>V_{OUT}+1.0V, V_{IN} ≦ 7V (Fixed Voltage Type)	-35		+35	mV
	V_{IN}>V_{OUT}+1.2V, V_{IN} ≦ 7V (Adjustable Voltage Type)	-50		+50	mV
Maximum Load Current		1			A
Current Limit				1.3	A
Short-Circuit Current	V_{OUT}=0V, V_{IN}>V_{OUT}+1.0V (Fixed Voltage Type)		650	760	mA
	V_{OUT}=0V, V_{IN}>V_{OUT}+1.2V (Adjustable Voltage Type)				
Ground Pin Current	I_{LOAD}=0mA to 1A, V_{IN}=V_{OUT}+1.0V		65	90	μA
ADJ Pin Current	I_{LOAD}=0mA to 1A, V_{IN}=V_{OUT}+1.2V		65	90	uA
Dropout Voltage (Fixed Output Voltage Version)	I_{OUT}=100mA		60	100	mV
	I_{OUT}=500mA		300	500	mV
	I_{OUT}=1.0A		700	1000	mV
Line Regulation	V_{OUT}+1.0V<V_{IN}<7V, I_{LOAD}=1mA (Fixed Voltage Type)		0.2	0.3	%/V
	V_{OUT}+1.2V<V_{IN}<7V, I_{LOAD}=1mA (Adjustable Voltage Type)		0.2	0.3	%/V
Load Regulation	I_{OUT}=0mA to 1.0A (Fixed Voltage Type)		0.02	0.03	%/mA
	I_{OUT}=0mA to 1.0A (Adjustable Voltage Type)		0.1	0.15	%/mA
Output Noise	F=1Hz to 10KHz, C_{OUT}=10μF		80		μV_{RMS}
PSRR	F=10KHz, C_{OUT}=10μF		75		dB
Thermal Shutdown Temperature			170		℃
Thermal Shutdown Hysteresis			20		℃
Thermal Resistance θ_{JA}	SOT-223			80	℃/W
	TO-220			60	℃/W
	TO-252			70	℃/W
	TO-263			65	℃/W

Typical Operating Characteristics

(CIN=10μF, COUT=10μF, TA=+25℃, unless otherwise noted.)

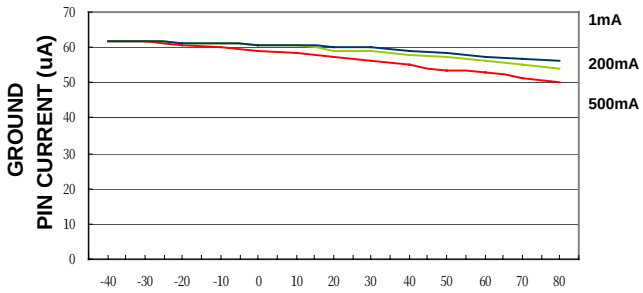
OUTPUT VOLTAGE vs. INPUT VOLTAGE



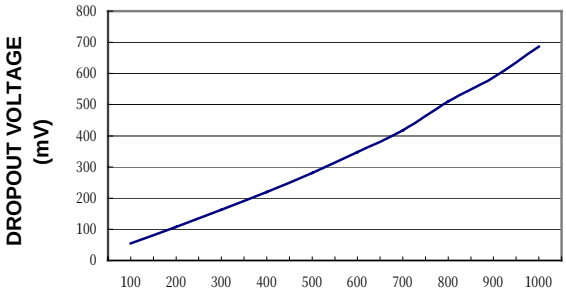
*EX：Model FS8860-33Cx

I_{LOAD} = 0mA

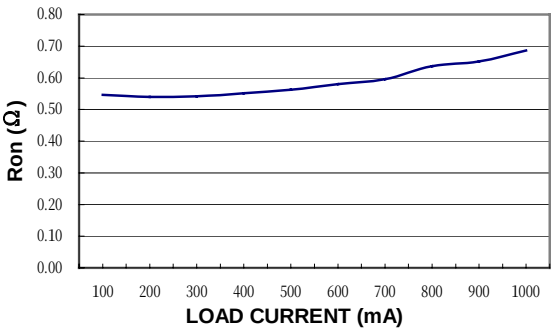
GROUND PIN CURRENT vs. TEMPERATURE



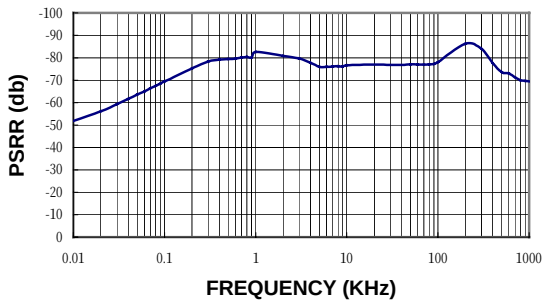
DROPOUT VOLTAGE vs. LOAD CURRENT



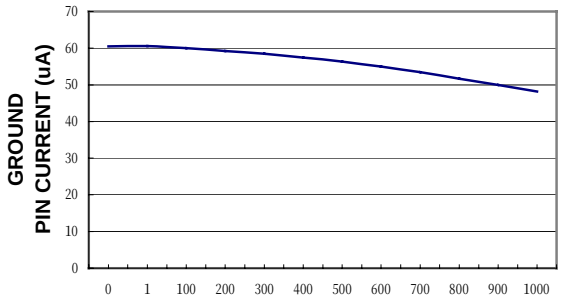
LOAD CURRENT vs. Ron



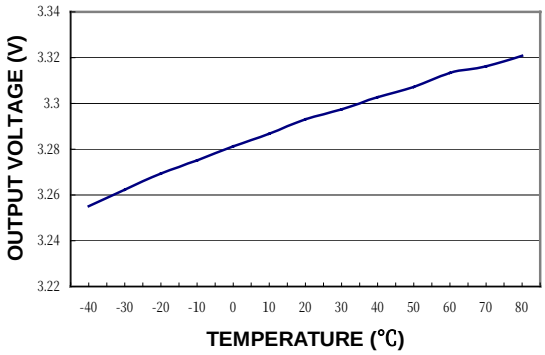
POWER SUPPLY REJECTION RATIO vs. FREQUENCY



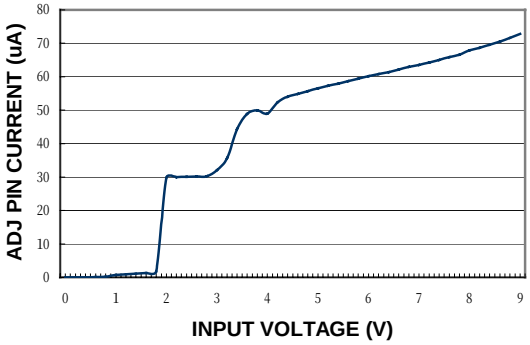
GROUND PIN CURRENT vs. LOAD CURRENT



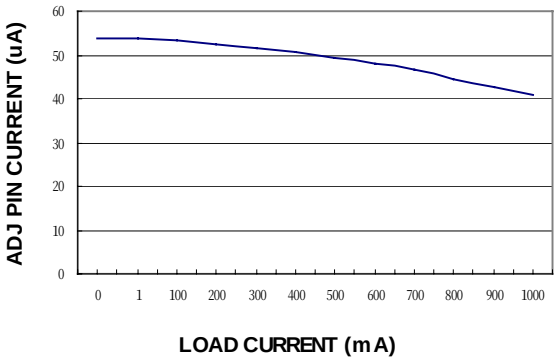
OUTPUT VOLTAGE vs. TEMPERATURE



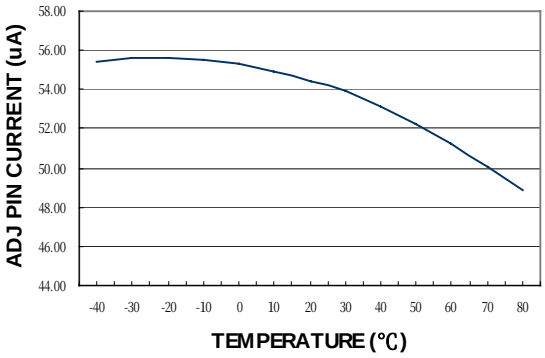
ADJ PIN CURRENT vs. INPUT VOLTAGE



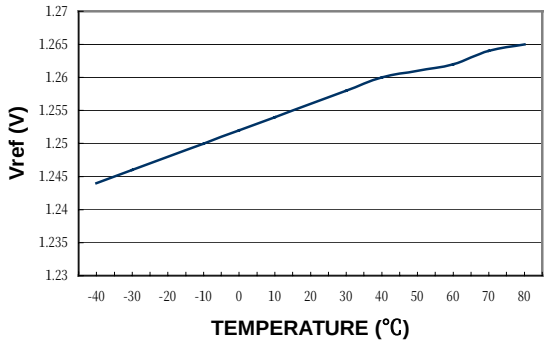
ADJ PIN CURRENT vs. LOAD CURRENT



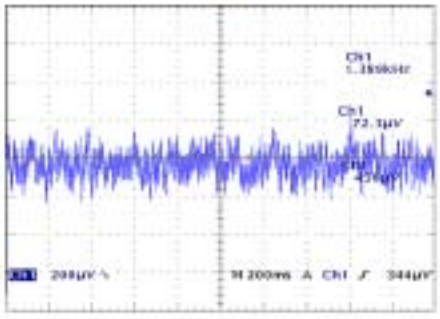
ADJ PIN CURRENT vs. TEMPERATURE



Vref vs. TEMPERATURE

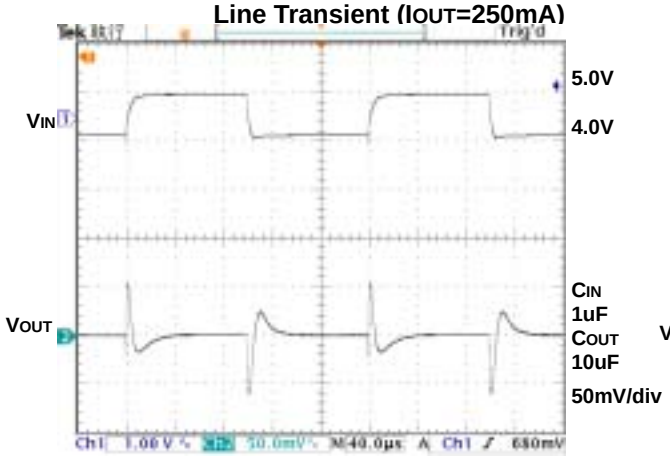


Output Noise DC to 1MHz

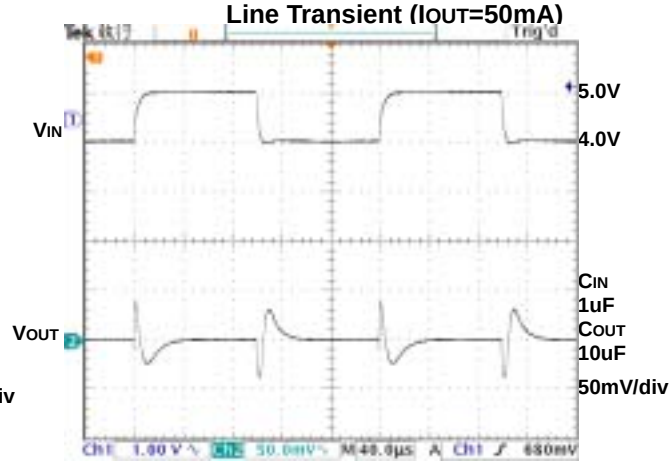


ILoad=0

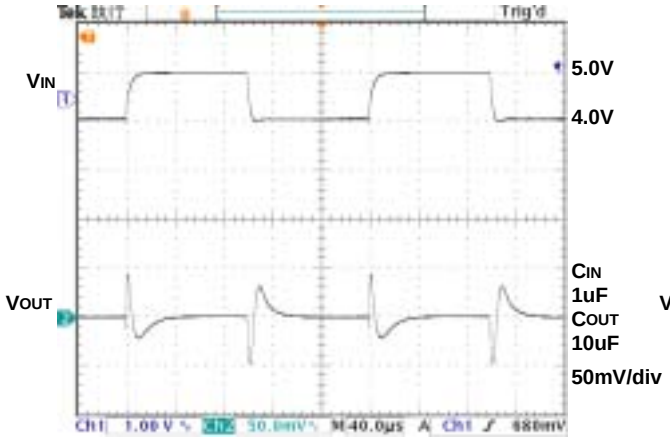
Line Transient (I_{OUT}=250mA)



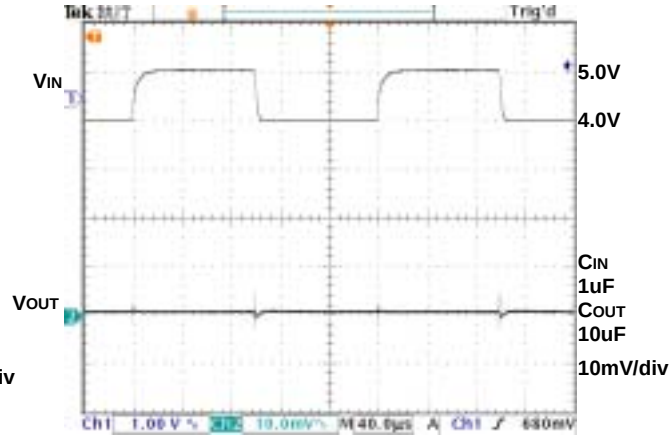
Line Transient (I_{OUT}=50mA)



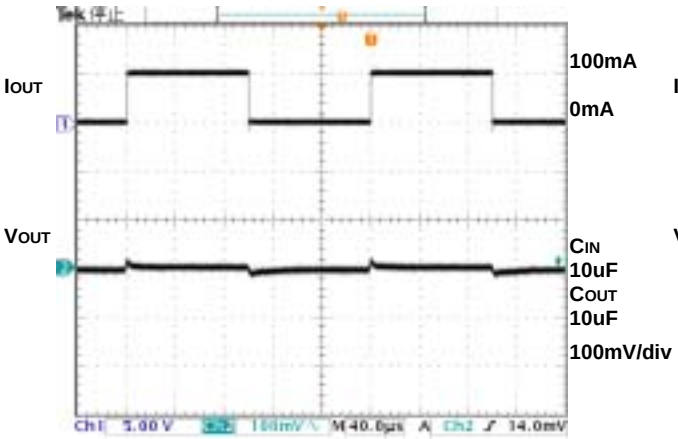
Line Transient (I_{OUT}=100mA)



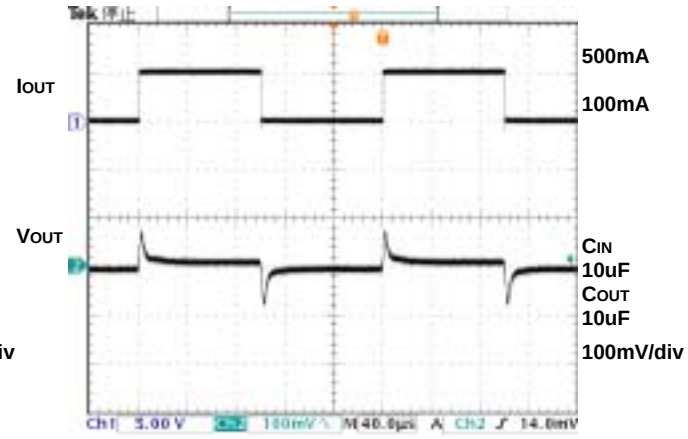
Line Transient (I_{OUT}=0mA)



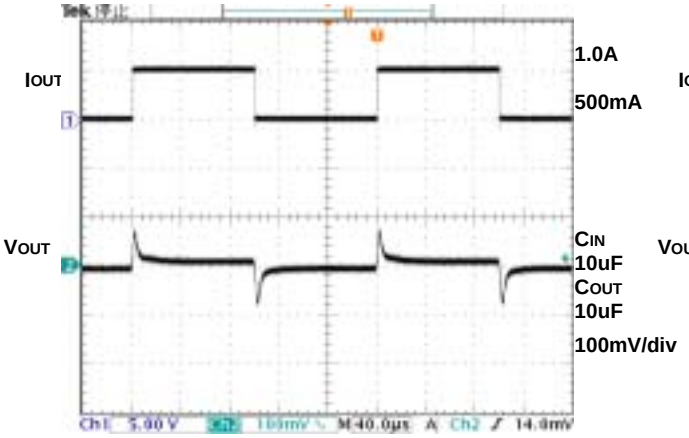
Load Transient



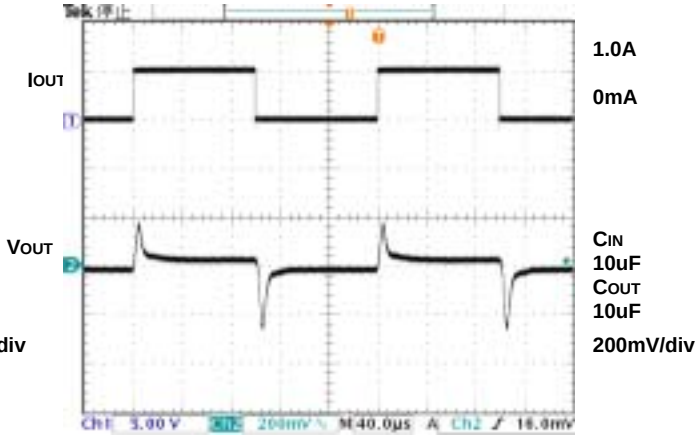
Load Transient



Load Transient



Load Transient



Detail Description

The FS8860 is a low-dropout linear regulator. It supplies a pre-selected 1.8V, 2.5V and 3.3V output or can be made with options of the output range from 1.3V to 4.5V in 100mV increments for load currents up to 1.0A. As illustrated in function block diagram, it consists of a 1.25V reference, an error amplifier, a p-channel pass transistor and an internal feedback voltage divider (fixed voltage types).

The 1.25V bandgap reference is connected to the error amplifier, which 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 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 is feed back through an internal resistive divider (or external resistive divider for adjustable output voltage version) connected to OUT. Additional blocks include an output current limiter, thermal sensor, and shutdown logic.

Internal P-channel Pass Transistor

The FS8860 features a P-channel MOSFET pass transistor. Unlike similar designs using PNP pass transistors, P-channel MOSFETs require no base drive, which reduces ground pin 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 FS8860 does not suffer from these problems and consumes only 65μA (Typ.) of ground pin current under heavy loads as well as in dropout.

Output Voltage Selection

The fixed voltage version of FS8860, output voltage is preset at an internally trimmed voltage, or can be mask option from 1.3V to 4.5V. The first two-digit part number suffix identifies the output voltage (see ***Ordering Information***). For example, the FS8860-33CJ has a preset 3.3V output voltage.
The adjustable voltage version of FS8860, the output by comparing the output voltage to an internally generated reference voltage. V_{REF} is available externally as 1.25V between V_{OUT} and ADJ. The output voltage is given by the equation: $V_{OUT}=V_{REF}*(1+R2/R1)+I_{ADJ}*R2$ (see ***Typical Application Schematic***)

Current Limit

The FS8860 also includes a fold back current limiter. It monitors and controls the pass transistor's gate voltage, estimating the output current and limiting it to 1.3A.

Thermal Overload Protection

Thermal overload protection limits total power dissipation in the FS8860. When the junction temperature exceeds T_J = +170℃, a thermal sensor turns off the pass transistor, allowing the IC to cool. The thermal sensor turns the pass transistor on again after the junction temperature cools by 20℃, resulting in a pulsed output during continuous thermal overload conditions.

Thermal overload protection is designed to protect the FS8860 in the event of fault conditions. For continual operation, the absolute maximum junction temperature rating of T_J = +170℃ should not be exceeded.

Operating Region and Power Dissipation

Maximum power dissipation of the FS8860 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 airflow. The power dissipation across the devices is P = I_{OUT} x (V_{IN}-V_{OUT}). The resulting maximum power dissipation is:

$$P_{MAX} = \frac{(T_J - T_A)}{\theta_{JC} + \theta_{CA}} = \frac{(T_J - T_A)}{\theta_{JA}}$$

Where (T_J-T_A) is the temperature difference between the FS8860 die junction and the surrounding air, θ_{JC} is the thermal resistance of the package chosen, and θ_{CA} is the thermal resistance through the printed circuit board, copper traces and other materials to the surrounding air. The best heatsinking, the copper area should be equally shared between the IN, OUT, and GND pins.

The FS8860 uses a SOT-223 package, When this package is mounted on a double sided printed circuit board with two square inches of copper allocated for “heat spreading”, if the resulting θ_{JA} is 80 ℃/W.

Based on a maximum junction temperature 170 ℃ with an ambient of 25℃, the maximum power dissipation will be:

$$P_{MAX} = \frac{(T_J - T_A)}{\theta_{JC} + \theta_{CA}} = \frac{(170 - 25)}{80} = 1.8125W$$

Thermal characteristics were measured using a double-sided board with 1” x 2” square inches of copper area connected to the GND pins for “heat spreading”.

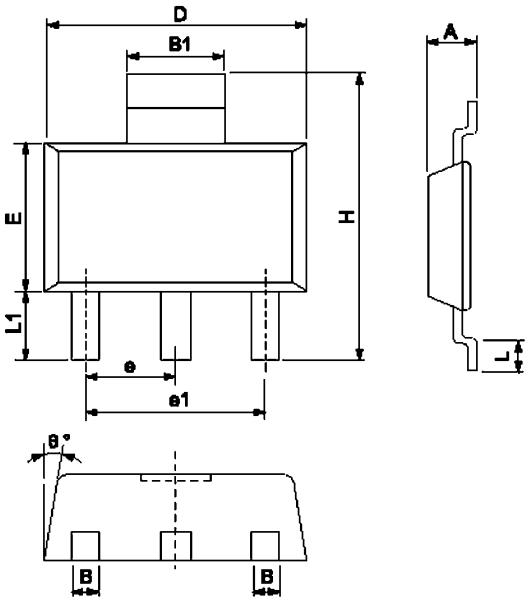
Input-Output Voltage

A 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. The FS8860 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.

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

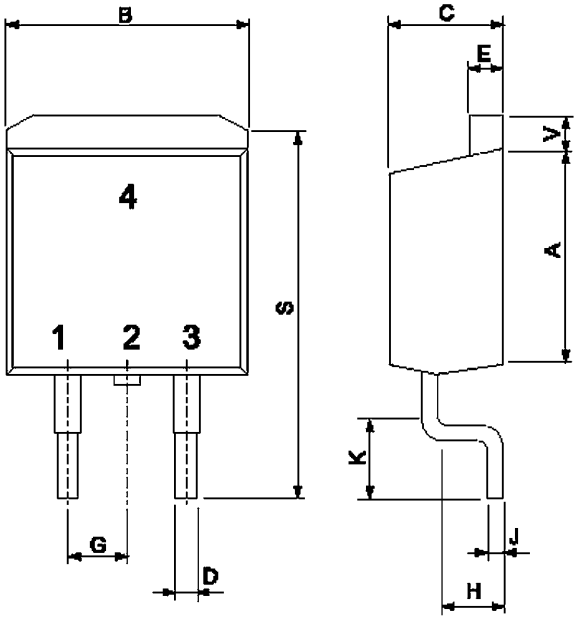
Package Information

SOT-223



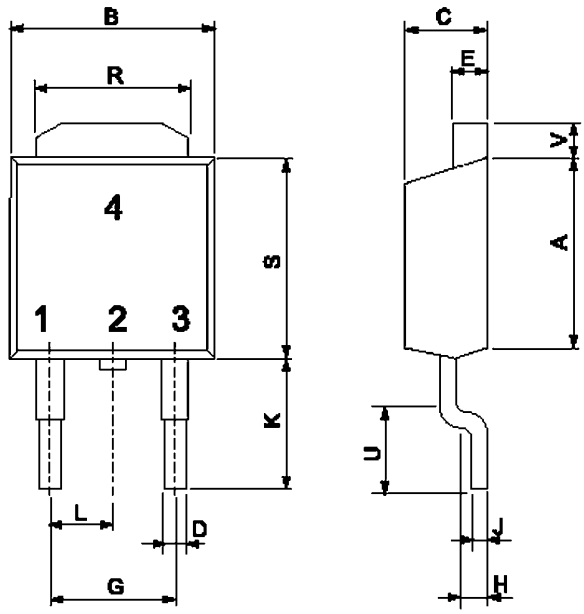
Symbols	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.50	--	1.800	0.0591	--	0.0709
B	0.60	--	0.838	0.0236	--	0.0330
B1	2.895	--	3.150	0.1140	--	0.1240
D	6.299	--	6.706	0.2480	--	0.2640
E	3.30	--	3.708	0.1299	--	0.1460
e	--	2.30BSC	--	--	0.090BSC	--
e1	--	4.60BSC	--	--	0.181BSC	--
H	6.70	--	7.300	0.2638	--	0.2874
L	--	0.91Min.	--	--	0.036Min.	--
L1	--	2.00Max.	--	--	0.0787Max.	--
θ	--	--	13°	--	--	13

TO-263



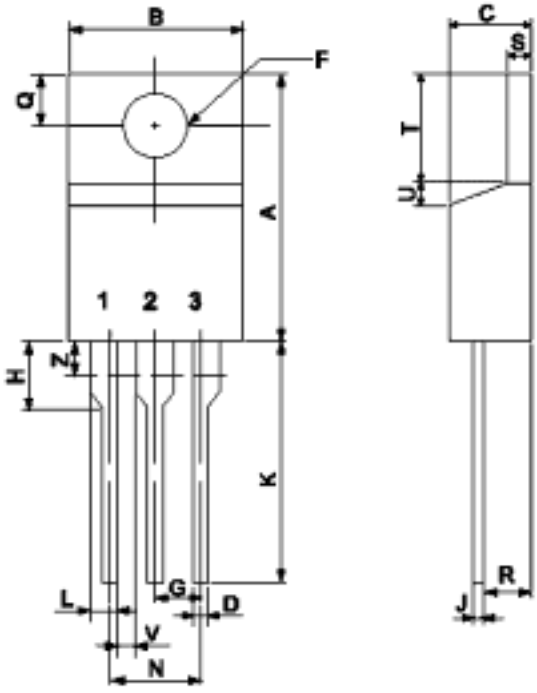
Symbols	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	8.64	--	9.65	0.340	--	0.380
B	9.65	--	10.29	0.380	--	0.405
C	4.06	--	4.83	0.160	--	0.190
D	0.51	--	0.89	0.020	--	0.035
E	1.14	--	1.40	0.045	--	0.055
G	2.54BSC			0.100BSC		
H	2.03	--	2.79	0.080	--	0.110
J	0.46	--	0.64	0.018	--	0.025
K	2.29	--	2.79	0.090	--	0.110
S	14.60	--	15.88	0.575	--	0.625
V	1.14	--	1.40	0.045	--	0.055

TO-252



Symbols	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	5.97	--	6.35	0.235	--	0.250
B	6.35	--	6.73	0.250	--	0.265
C	2.19	--	2.38	0.086	--	0.094
D	0.69	--	0.88	0.027	--	0.035
E	0.84	--	1.01	0.033	--	0.047
G	4.58BSC			0.180BSC		
H	0.87	--	1.01	0.034	--	0.040
J	0.46	--	0.58	0.018	--	0.023
K	2.60	--	2.89	0.102	--	0.114
L	2.29BSC			0.090BSC		
R	4.45	--	5.46	0.175	--	0.215
S	0.51	--	1.27	0.020	--	0.050
U	0.51	--	--	0.020	--	--
V	0.77	--	1.27	0.030	--	0.050

TO-220



Symbols	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	14.48	--	15.75	0.570	--	0.620
B	9.66	--	10.28	0.380	--	0.405
C	4.07	--	4.82	0.160	--	0.190
D	0.64	--	0.88	0.025	--	0.035
F	3.61	--	3.73	0.142	--	0.147
G	2.42	--	2.66	0.095	--	0.105
H	2.80	--	3.93	0.110	--	0.155
J	0.46	--	0.64	0.018	--	0.025
K	12.70	--	14.27	0.500	--	0.562
L	1.15	--	1.52	0.045	--	0.060
N	4.83	--	5.33	0.190	--	0.210
Q	2.54	--	3.04	0.100	--	0.120
R	2.04	--	2.79	0.080	--	0.110
S	1.15	--	1.39	0.045	--	0.055
T	5.97	--	6.47	0.235	--	0.255
U	0.00	--	1.27	0.000	--	0.050
V	1.15	--	--	0.045	--	--
Z	--	--	2.04	--	--	0.080