1 FEATURES

- 2.5V to 5.5V input voltage
- Up to 2.5A max output current
- Efficiency up to 96%
- Fixed frequency 1MHz
- Low quiescent current:60uA
- PFM mode in light load
- Internal soft start
- Over current protection and Hiccup
- Over temperature protection

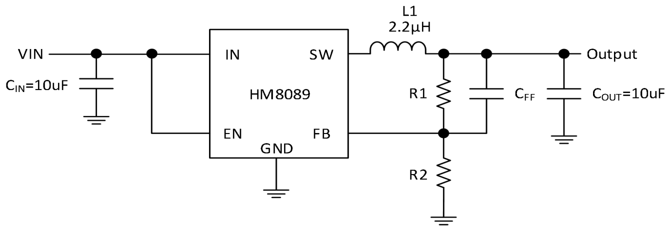
2 APPLICATIONS

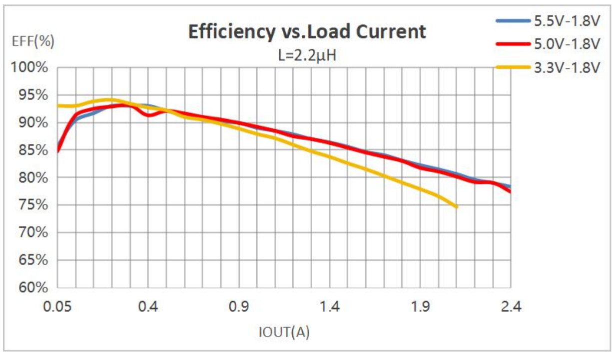
- MIDs, Tablet PC
- Set Top Boxes
- USB ports/Hubs
- Hot Swaps
- Cellphones
- PC Cards

3 DESCRIPTION

The HM8089 is a high-efficiency, DC-to-DC step-down switching regulator, capable of delivering up to 2.5A of output current. The devices operate from an input voltage range of 2.5V to 5.5V and provide output voltages from 0.6V to V_{IN}, making the HM8089 ideal for low voltage power conversions. Running at a fixed frequency of 1MHz allows the use of small inductance value and low DCR inductors, thereby achieving higher efficiencies. Other external components, such as ceramic input and output caps, can also be small due to higher switching frequency, while maintaining exceptional low noise output voltages. PWM/PFM mode operation provides very low output ripple voltage for noise sensitive applications. Internal soft-start control circuitry reduces inrush current. Short-circuit and thermal-overload protection improves design reliability. HM8089 is housed in a tiny SOT23-5L package.

TYPICAL APPLICATION





EFFICIENCY

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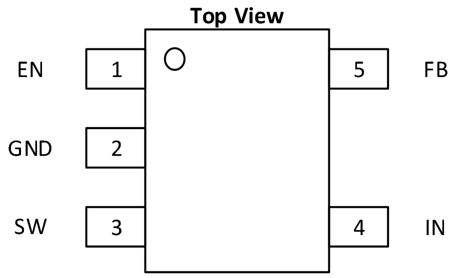
4 PIN CONFIGURATION AND FUNCTIONS



Pin	Symbol	Description
1	EN	Enable pin for the IC. Drive this pin high to enable the part, low to disable.
2	GND	Ground
3	SW	Inductor Connection. Connect an inductor Between SW and the regulator output.
4	IN	Supply Voltage. Bypass with a 10µF ceramic capacitor to GND
5	FB	Feedback Input. Connect an external resistor divider from the output to FB and GND to set the output to a voltage between 0.6V and V_{IN}

5 ABSOLUTE MAXIMUM RATINGS

Parameter	Parameter	Rating	UNIT
V_{IN}	Supply Voltage	-0.3 to 6	V
V_{EN}	Enable Voltage	–0.3 to V_{IN}+0.3V	V
V_{SW}	Switch Node	–0.3 to V_{IN}+0.3V	V
I	Peak SW Sink and Source Current	3	A
T_J	Junction Temperature	+150	°C
T_{STO}	Storage Temperature Range	–65 to +150	°C
θ_{JA}	Thermal Resistance	170	°C/W
θ_{JC}	Thermal Resistance	130	°C/W
T_{OP}	Operating Temperature Range	-40 to 85	°C
T_L	Lead Temperature	260	°C
ESD	HBM	2	KV
ESD	HM	200	V

Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

6 RECOMMENDED OPERATING CONDITIONS

Parameter	Parameter	Rating	UNIT
V_{IN}	Supply Voltage	2.5 to 5.5	V
T_J	Junction Temperature Range	-40 to 125	°C
T_A	Ambient Temperature Range	-40 to 85	°C

7 PACKAGE THERMAL CHARACTERISTICS

Parameter	Parameter	Rating	UNIT
θ_{JA}	Thermal Resistance	130	°C/W
θ_{JC}	Thermal Resistance	60	°C/W

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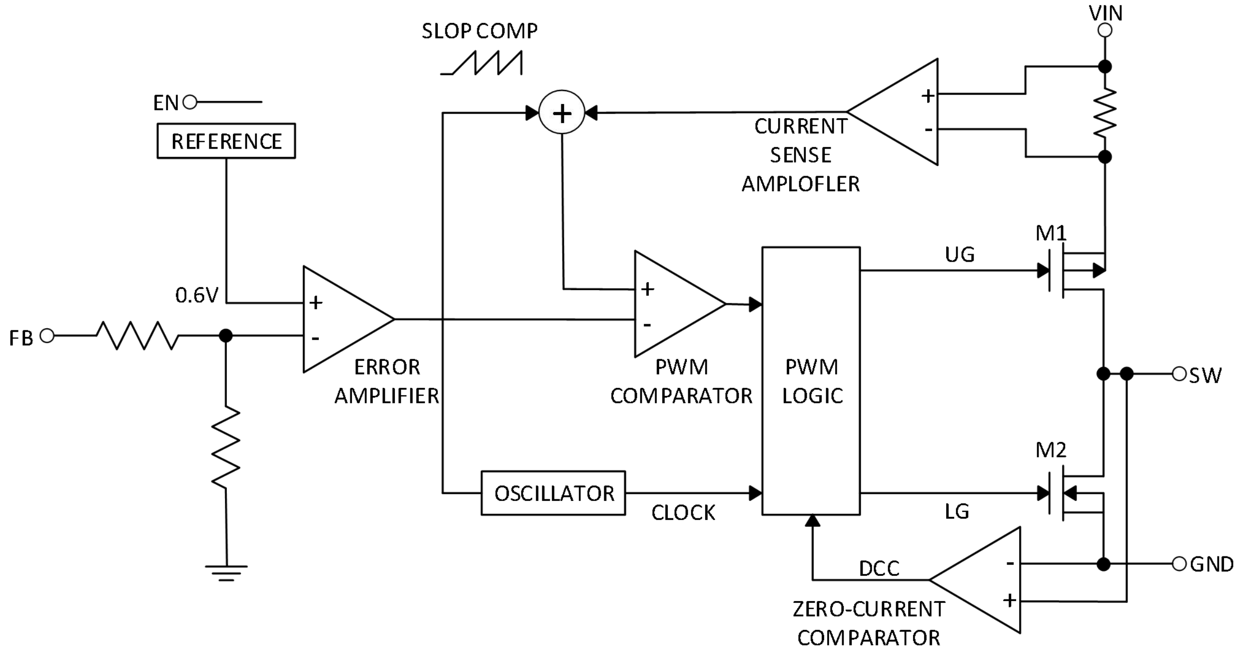
8 BLOCK DIAGRAM



Functional Block Diagram

9 ELECTRICAL CHARACTERISTICS

(V_{IN} = 5V, V_{OUT}= 1.8V, L = 2.2uH, C_{OUT} = 10uF, T_A = 25°C, unless otherwise specified)

PARAMETER	Symbol	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Voltage	V_{IN}		2.5		5.5	V
UVLO Thershold	V_{uvlo}			2.1		V
FB Feedback Voltage	V_{ref}	V_{IN} =5V	0.586	0.6	0.614	V
Feedback Leakage current	I_{FB}			0.1		μA
Shutdown Supply Current	I_S	V_{EN} = 0V			1	μA
Quiescent Current	I_Q	V_{EN} = V_{IN}, V_{FB} = 0.7V		60		μA
Line Regulation	LnReg	V_{IN} =2.5 to 5.5V,I_{load}=1A		0.1	0.2	%/V
Load Regulation	LdReg	I_{OUT}= 0.01A to 2.5A		0.1	0.2	%/A
Switching Frequency	F_{OSC}			1		MHz
PMOS Rdson	RdsonP	I_{SW} = 100mA		120		mΩ
NMOS Rdson	RdsonN	I_{SW} = −100mA		90		mΩ
SW Leakage Current	I_{swlk}	V_{EN} = 0V, V_{SW} = 0V or V_{IN}			1	μA
EN Leakage Current	I_{enlk}				1	μA
EN Input High Voltage	V_{h_en}	−40°C ≤ T_A ≤ 85°C		1.1		V
EN Input Low Voltage	V_{l_en}	−40°C ≤ T_A ≤ 85°C		0.8		V
Soft-Start Period	t_s			120		μs
Thermal Shutdown *	T_S			160		°C
Thermal Hysteresis	T_H			20		°C

* Guaranteed by design, not tested.

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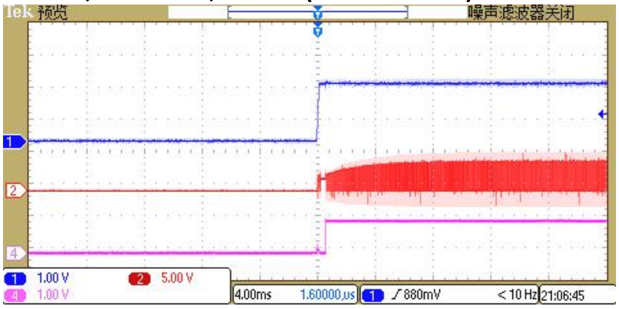
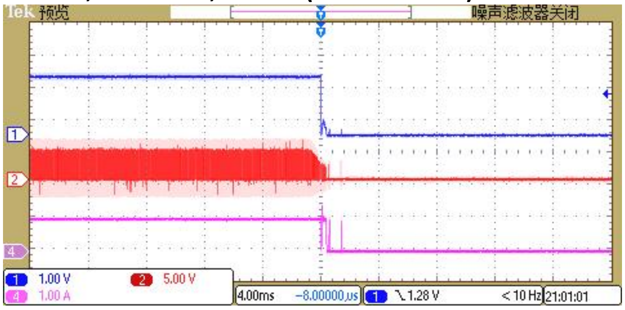
10 TYPICAL CHARACTERISTICS

V_{IN} = 5V, V_O = 1.8V, L1 = 2.2µH, C_{ff}=51pF,T_A = +25°C, unless otherwise noted.

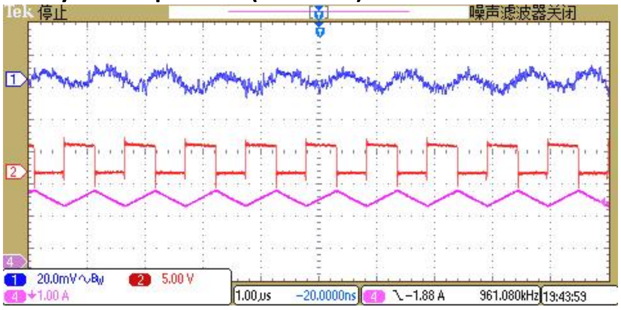
Startup through Enable
VIN=5V,Vout=1.8V,Iout=1A(Resistive load)



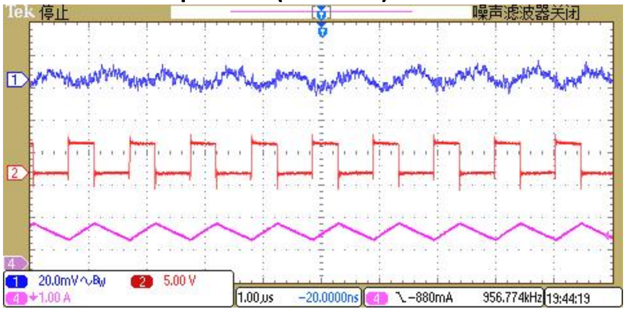
Shutdown through Enable
VIN=5V,Vout=1.8V,Iout=1A(Resistive load)



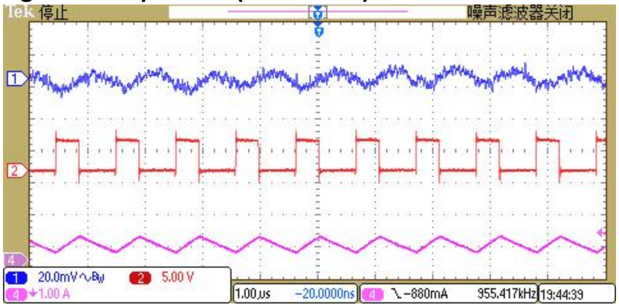
Heavy Load Operation(2A LOAD)



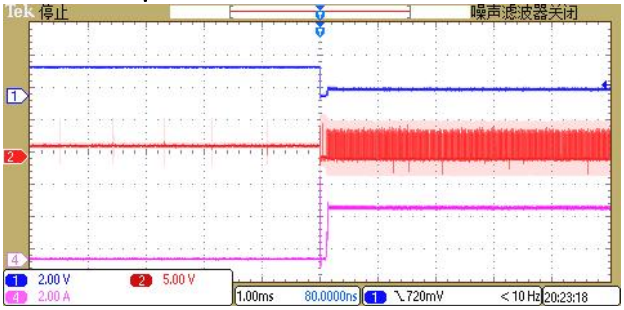
Medium Load Operation(1A LOAD)



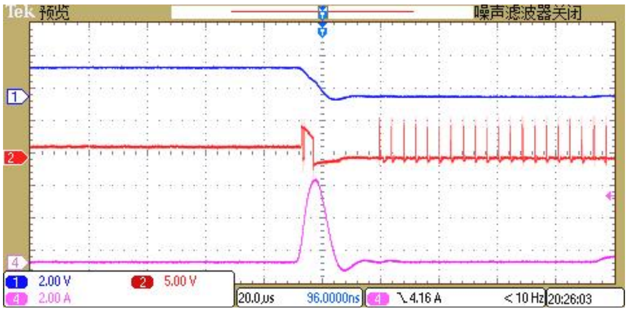
Light Load Operation(0.5A LOAD)



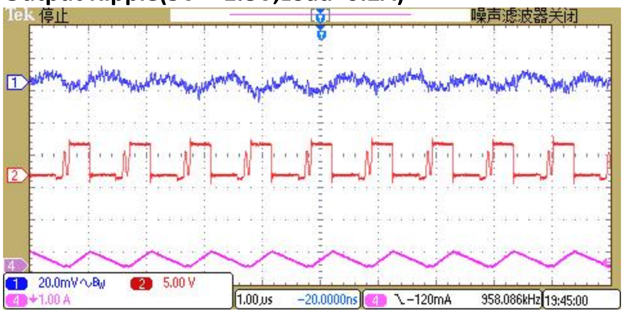
Short&Hiccup Protection



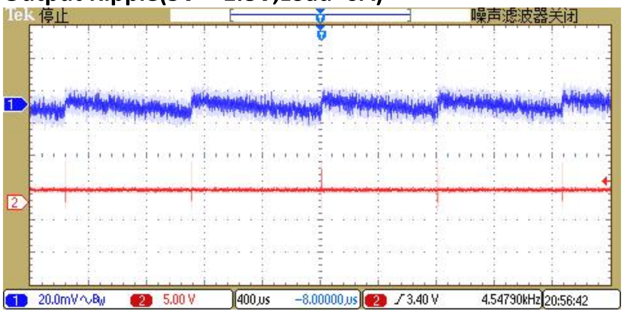
Short Circuit Protection



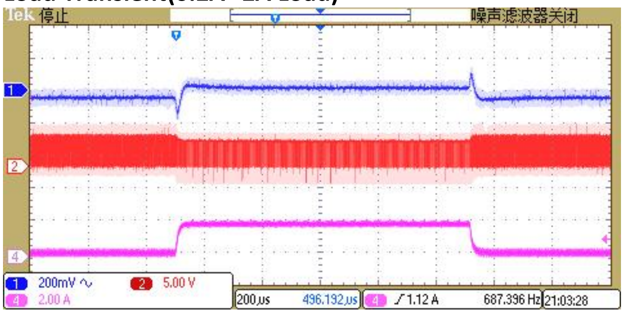
Output Ripple(5V=>1.8V,Load=0.2A)



Output Ripple(5V=>1.8V,Load=0A)



Load Transient(0.2A--2A Load)



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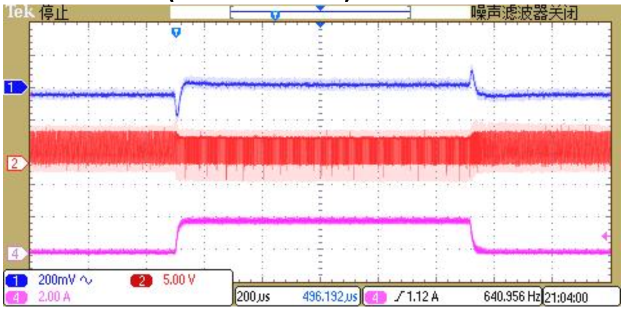
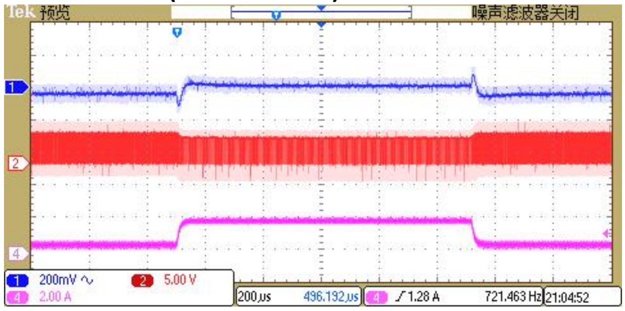
Load Transient(0.05A--2A Load)



Load Transient(0.5A--2A Load)



11 OPERATION

The HM8089 high efficiency switching regulator is a small, simple, DC-to-DC step-down converter capable of delivering up to 2.5A of output current. The device operates in pulse-width modulation (PWM) at 1MHz from a 2.5V to 5.5V input voltage and provides an output voltage from 0.6V to VIN, making the HM8089 ideal for on-board post-regulation applications. An internal synchronous rectifier improves efficiency and eliminates the typical Schottky free-wheeling diode. Using the on resistance of the internal high-side MOSFET to sense switching currents eliminates current-sense resistors, further improving efficiency and cost.

CURRENT MODE PWM CONTROL

Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for superior load and line response and protection of the internal main switch and synchronous rectifier. HM8089 switches at a constant frequency 1MHz and regulates the output voltage. During each cycle the PWM comparator modulates the power transferred to the load by changing the inductor peak current based on the feedback error voltage. During normal operation, the main switch is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until either the next cycle starts or the inductor current drops to zero. The device skips pulses to improve efficiency at light load.The HM8089 has power save mode for light load. During this time, the internal clock is blocked, thus the HM8089 skips some pulses for PFM(Pulse Frequency Modulation) mode and achieves the light load power save.

DROPOUT OPERATION

HM8089 allows the main switch to remain on for more than one switching cycle and increases the duty cycle while the input voltage is dropping close to the output voltage. When the duty cycle reaches 100%, the main switch is held on continuously to deliver current to the output up to the PMOSFET current limit. The output voltage then is the input voltage minus the voltage drop across the main switch and the inductor.

SHORT CIRCUIT PROTECTION

The HM8089 has short circuit protection. When the output is shorted to ground, the oscillator frequency is reduced to prevent the inductor current from increasing beyond the PMOSFET current limit. The frequency will return to the normal values once the short circuit condition is removed and the Vout reaches regulated voltage.

MAXIMUM LOAD CURRENT

The HM8089 can up to 2.5A output current; however the maximum load current decreases at lower input due to large IR drop on the main switch and synchronous rectifier. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%.Conversely the current limit increases as the duty cycle decreases.

UVLO AND THERMAL SHUTDOWN

If IN drops below 2.2V, the UVLO circuit inhibits switching. Once IN rises above 2.4V, the UVLO clears, and the soft-start sequence activates. Thermal-overload protection limits total power dissipation in the device. When the junction temperature exceeds T_J= +160°C, a thermal sensor forces the device into shutdown, allowing the die to cool. The thermal sensor turns the device on again after the junction temperature cools by 15°C, resulting in a pulsed output during continuous overload conditions. Following a thermal-shutdown condition, the soft-start sequence begins.

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SOFT-START

HM8089 has an internal soft-start circuitry to reduce supply inrush current during startup conditions. When the device exits under-voltage lockout (UVLO), shutdown mode, or restarts following a thermal-overload event, the soft-start circuitry slowly ramps up current available at SW.

12 APPLICATION INFORMATION

SETTING THE OUTPUT VOLTAGE

The external resistor divider sets the output voltage. The feedback resistor R1 also sets the feedback-loop bandwidth through the internal compensation capacitor (see the Typical Application circuit). Choose R2 around 10kΩ, and R1 by:

$$R2 = R1 / (V_{OUT}/0.6V – 1)$$

Use a network below for when V_{OUT} is low.

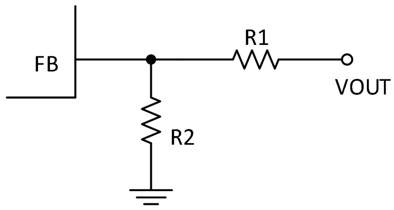

Figure 1: Network.

INDUCTOR SELECTION

A 2.2µH to 4.7µH is recommended for general used. The value of inductor depends on the operating frequency. Higher frequency allows smaller inductor and capacitor but increases internal switching loss. Two inductor parameters should be considered, current rating and DCR. The inductor with the lowest DCR is chosen for the highest efficiency.
The inductor value can be calculated as:

$$L \geq [V_{OUT}/(f \times \Delta I_L)](1 – V_{OUT}/V_{IN})$$

ΔI_L: inductor ripple current, which is defined as:

$$\Delta I_L = V_{OUT}[(1 – V_{OUT}/V_{IN})/(L \times f)] \text{ (General Setting)}$$
$$\approx \alpha \times I_{O\text{-}MAX} \ (\alpha = 0.2\text{~}0.4)$$

The inductor should be rated for the maximum output current (I_O-MAX) plus the inductor ripple current (ΔI_L) to avoid saturation. The maximum inductor current ($I_{L\text{-}MAX}$) is given by:

$$I_{L\text{-}MAX} = I_{O\text{-}MAX} + \Delta I_L/2$$

CAPACITOR SELECTION

The small size of ceramic capacitors are ideal for HM8089 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types. A 4.7µF input capacitor and a 10µF output capacitor are sufficient for most HM8089 applications.
When selecting an output capacitor, consider the output ripple voltage and the ripple current. The ESR of capacitor is a major factor to the output ripple. For the best performance, a low ESR output capacitor is required. The ripple voltage is given by:

$$\Delta V_O = \Delta I_L [ESR + 1/(8 \times f \times C_O)].$$

CHECKING TRANSIENT RESPONSE

The regulator loop response can be checked by looking at the load transient response. Switching regulators take several cycles to respond to a step in load current. When a load step occurs, V_{OUT} will be shifted immediately by an amount equal to ($\Delta I_{LOAD} \times$ ESR), where ESR is the effective series resistance of C_{OUT}. ΔI_{LOAD} will also begin to charge or discharge C_{OUT}, which generates a feedback error signal. Then the regulator loop will act to return V_{OUT} to its steady state value. During this recovery time, V_{OUT} can be monitored for overshoot or ringing that will indicate the stability problem.
The discharged bypass capacitors are effectively put in parallel with C_{OUT}, causing a rapidly drop in V_{OUT}. No regulator can deliver enough current to prevent this problem if the load switch resistance is low and it is driven quickly. The only solution is to limit the rise time of the switch drive, so that the load rise time will be limited to approximately (25 × C_{LOAD}).

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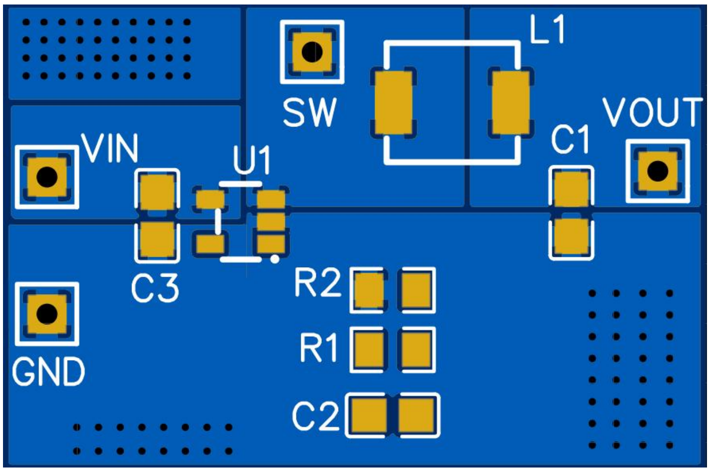
13 LAYOUT

PCB layout is very important to achieve stable operation. Please follow the guidelines below.

1) Keep the path of switching current short and minimize the loop area formed by Input capacitor, high-side MOSFET and low-side MOSFET.
2) Bypass ceramic capacitors are suggested to be put close to the VIN Pin.
3) Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
4) Rout SW away from sensitive analog areas such as FB.
5) Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.
6) It is recommended to reserve a place for CFF in layout.



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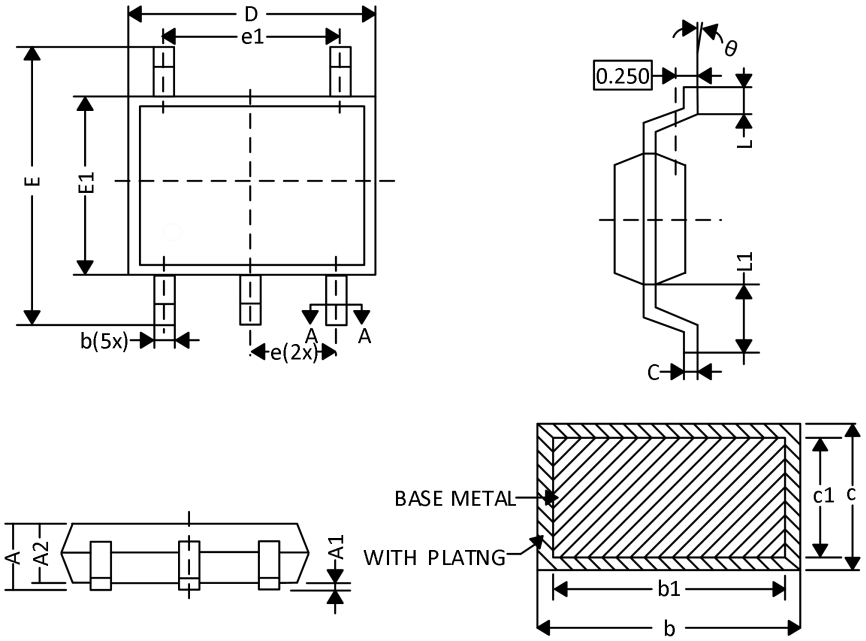
PACKAGE DIMENSIONS
SOT23-5



SYMBOLS	MIN	NOM	MAX
A	-	-	1.25
A1	0.03	0.08	0.15
A2	1.05	1.10	1.15
b	0.27	-	0.35
b1	0.26	0.285	0.31
c	0.135	-	0.23
c1	0.127	0.152	0.178
D	2.82	2.92	3.02
E	2.60	2.90	3.00
E1	1.50	1.62	1.70
e	0.95 BSC		
e1	1.90 BSC		
L	0.35	0.45	0.55
L1	0.49	0.64	0.79
θ	0°	-	8°

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ORDER INFORMATION

Order number	Package	Marking information	Operation Temperature Range	MSL Grade	Ship, Quantity	Green
HM8089T	SOT23-5	80XXX(1)	-40 to 85°C	3	T&R,3000	Rohs

(1)XXX stands for datecode.

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