Preliminary Specifications Subject to Change without Notice

DESCRIPTION

The HM8113C and HM8113CM are monolithic buck switching regulator based on I2 architecture for fast transient response. Operating with an input range of 4.5V~18V, HM8113C and HM8113CM deliver 3A of continuous output current with two integrated N-Channel MOSFETs. The internal synchronous power switches provide high efficiency without the use of an external Schottky diode. At light loads, HM8113C and HM8113CM operate in low frequency to maintain high efficiency.

HM8113C and HM8113CM guarantee robustness with output short protection, thermal protection, current run-away protection and input under voltage lockout.

HM8113C and HM8113CM are available in SOT23-6 package, which provide a compact solution with minimal external components.

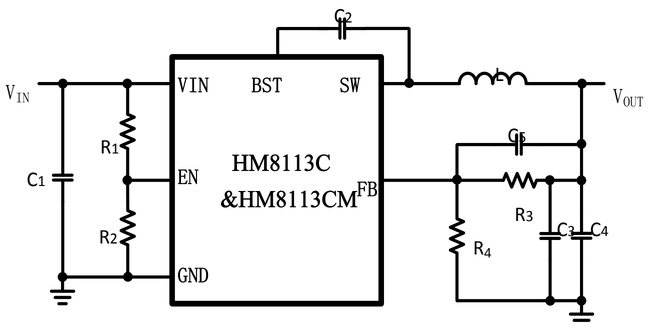
FEATURES

- 4.5V to 18V operating input range
  3A output current
- Up to 95% efficiency
- PFM at light load
- 600kHz switching frequency
- Internal soft-start
- Input under-voltage lockout
- Current run-away protection
- Output short protection
- Thermal protection
- Available in SOT23-6 package

APPLICATIONS

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics/ Appliances
- Notebook Computers

TYPICAL APPLICATION



ORDER INFORMATION

DEVICE[1)]	PACKAGE	TOP MARKING[2)]	ENVIRONMENTAL[3)]
HM8113CSOTB#TR	SOT23-6	JWPB□ YW□□□	Green
HM8113CMSOTB#TR	SOT23-6	JWPE□ YW□□□	Green

Notes:

1) HM□□#TR
- Tape and Reel (If TR is not shown, it means Tube)
- Package Code
- Part No.

2) Line1: JW □□□
- Product code
- H&M Semi LOGO

Line2: YW□□□
- Lot number
- Week code
- Year code

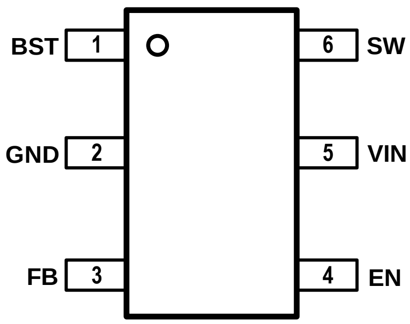
3) All Joulwatt products are packaged with Pb-free and Halogen-free materials and compliant to RoHS standards.

DEVICE INFORMATION

DEVICE	Operation Mode at light load	Function	Package	MSL
HM8113CSOTB#TR	PFM	-	SOT23-6	MSL1
HM8113CMMSOTB#TR	PFM	-	SOT23-6	MSL3

PIN CONFIGURATION

TOP VIEW



SOT23-6

ABSOLUTE MAXIMUM RATING[1)]

VIN, EN Pin……….. -0.3V to 20V
SW Pin…………………………..………………………………….-0.3V(-5V for 10ns) to 20V(22V for 10ns)
BST Pin.. SW-0.3V to SW+4V
All other Pins .... -0.3V to 4V
Junction Temperature[2)] 150ºC
Lead Temperature 260ºC
Storage Temperature ....-65ºC to +150ºC

RECOMMENDED OPERATING CONDITIONS

Input Voltage V_{IN} ....4.5V to 18V
Output Voltage V_{OUT} ....0.6V to V_{IN}*D_{max}
Operation Junction Temperature Tj .... -40°C to 125°C

THERMAL PERFORMANCE

	θ_{JA}	θ_{Jc}
SOT23-6[3)]	220	130ºC/W
SOT23-6[4)]	100	25ºC/W

Note:

1) Exceeding these ratings may damage the device. These stress ratings do not imply function operation of the device at any other conditions beyond those indicated under RECOMMENDED OPERATING CONDITIONS.
2) The HM8113C and HM8113CM include thermal protection that is intended to protect the device in overload conditions. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.
3) Measured on JESD51-7, 4-layer PCB.
4) Measured on a 2OZ two-layer HM8113C/HM8113CM Evaluation Board at T_A=25℃.

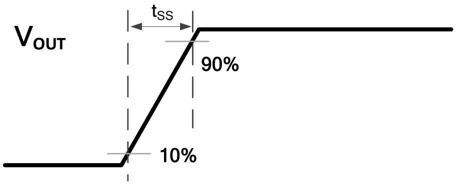
ELECTRICAL CHARACTERISTICS

V_{IN}=12V, T_A=25℃，Unless otherwise stated。

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
V_{IN} Under Voltage Lockout Threshold	V_{IN_MIN}	V_{IN} rising	4.0	4.2	4.5	V
V_{IN} Under voltage Lockout Hysteresis	$V_{IN\_MIN\_HYST}$			300		mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V		0.2	1	μA
Supply Current	I_Q	V_{EN}=5V, V_{FB}=1V		150	220	μA
Feedback Voltage	V_{FB}	T_j=25 ºC	594	600	606	mV
		T_j=-40 ºC~125 ºC	588	600	612	mV
FB Leakage Current	I_{FB}	V_{FB}=0.85V			100	nA
Top Switch Resistance	$R_{DS(ON)T}$			80		mΩ
Bottom Switch Resistance	$R_{DS(ON)B}$			55		mΩ
Top Switch Leakage Current	I_{LEAK_TOP}	V_{IN}=18V, V_{EN}=0V, V_{SW}=0V			1	μA
Bottom Switch Leakage Current	I_{LEAK_BOT}	V_{IN}=18, V_{EN}=0V, V_{SW}=18V			1	μA
Bottom Switch Current Limit	I_{LIM_BOT}		3	3.5	5.2	A
Minimum On Time[5)]	T_{ON_MIN}			120		ns
Minimum Off Time	T_{OFF_MIN}	V_{FB}=0.4V		150		ns
Maximum On Time	T_{ON_Max}			4		us
EN Rising Threshold	V_{EN_H}	V_{EN} rising	1.1	1.2	1.3	V
EN Falling Threshold	V_{EN_L}	V_{EN} falling	0.98	1.05	1.12	V
Soft-Start Period[5)6)]	t_{SS}		0.7	1	1.4	ms
Frequency	f_{SW}		480	600	720	kHz
Thermal Shutdown[5)]	T_{TSD}			160		°C
Thermal Shutdown Hysteresis[5)]	T_{TSD_HYST}			20		°C

Note:

5) Guaranteed by design.
6) Soft-Start Period is tested from 10% to 90% of the steady state output voltage.

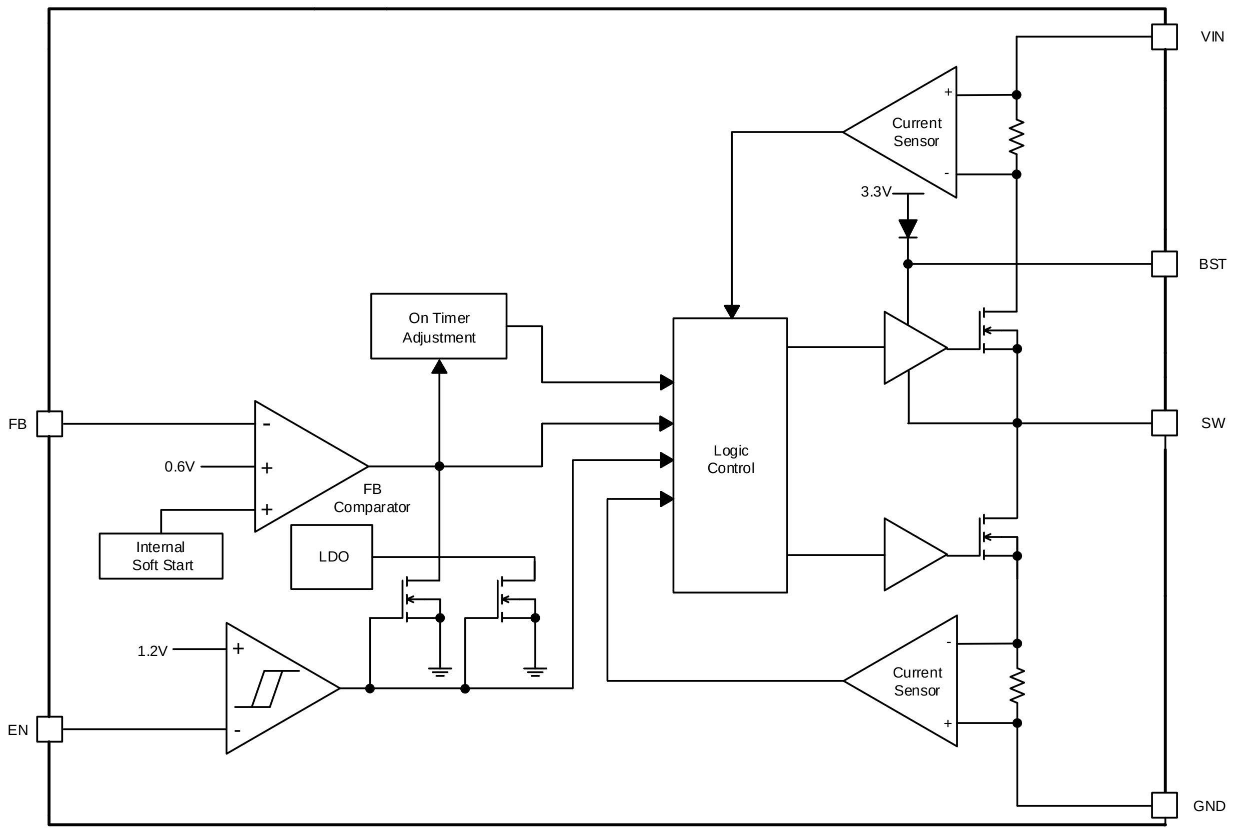


t_{SS} Waveform

PIN DESCRIPTION

SOT23-6	Name	Description
1	BST	Connect a 0.1μF capacitor between BST and SW pin to supply voltage for the top switch driver.
2	GND	Ground pin.
3	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 0.6V. Connect a resistive divider at FB.
4	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
5	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 4.5V to 18V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
6	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.

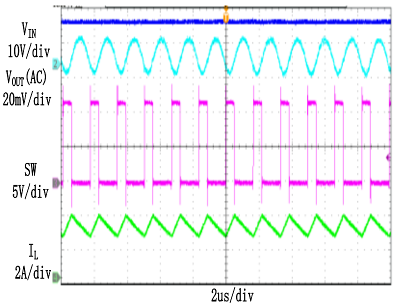
BLOCK DIAGRAM



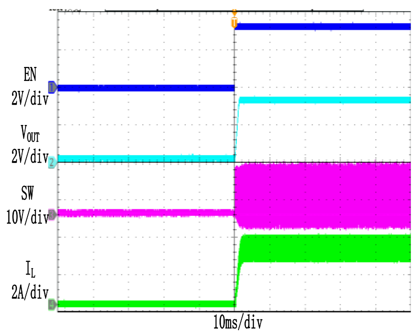
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} =12V, V_{OUT} = 3.3V, L = 3.3μH, C_{OUT} = 22μF*2, TA = +25°C, unless otherwise noted

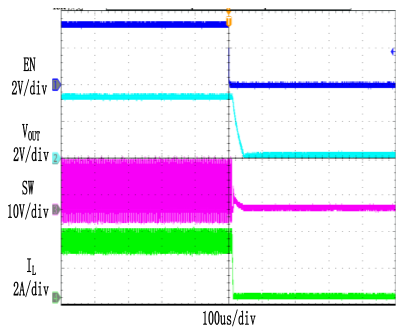
Steady State Test
V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=3A



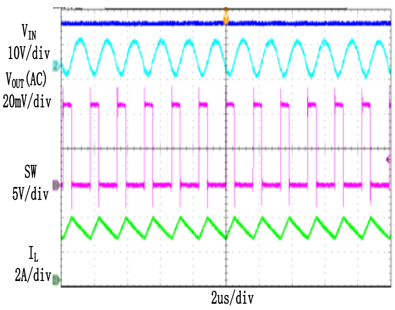
Startup through Enable
V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=3A (Resistive load)



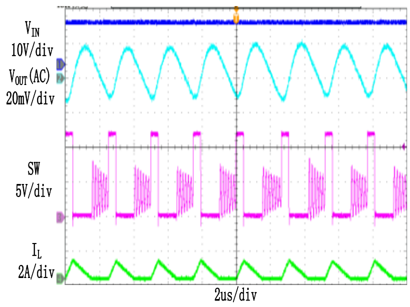
Shutdown through Enable
V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=3A (Resistive load)



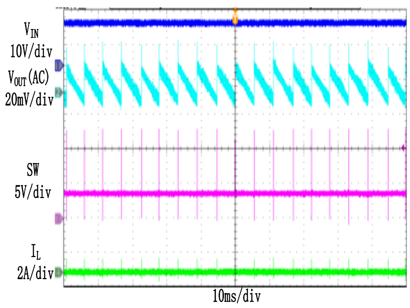
Heavy Load Operation
3A LOAD



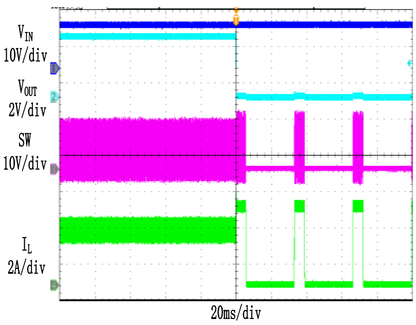
Medium Load Operation
0.3A LOAD



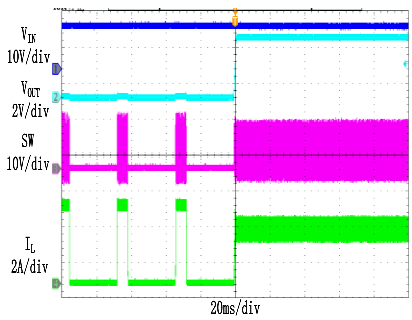
Light Load Operation
0 A LOAD



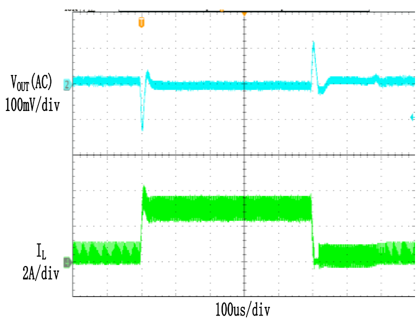
Short Circuit Protection
V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}=3A- Short



Short Circuit Recovery
V_{IN}=12V, V_{OUT}=3.3V
I_{OUT}= Short-3A



Load Transient
C5=51pF
0.3A LOAD → 3A LOAD → 0.3A LOAD



TYPICAL PERFORMANCE CHARACTERISTICS

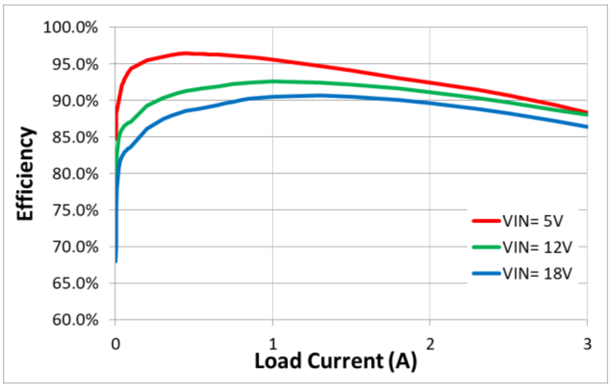


Figure 1. Efficiency vs. Load Current

(V_{OUT}=3.3V, L=3.3μH)

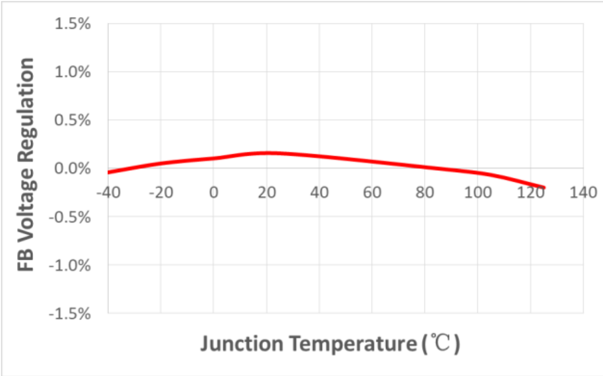


Figure 2. FB Voltage Regulaion vs Junction Temperature

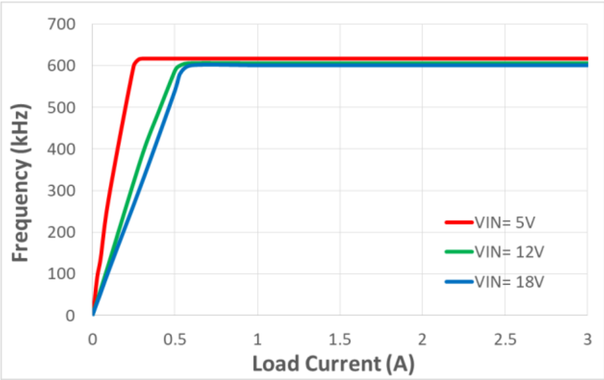


Figure 3. Frequency vs Load Current

(V_{OUT}=3.3V, L=3.3μH)

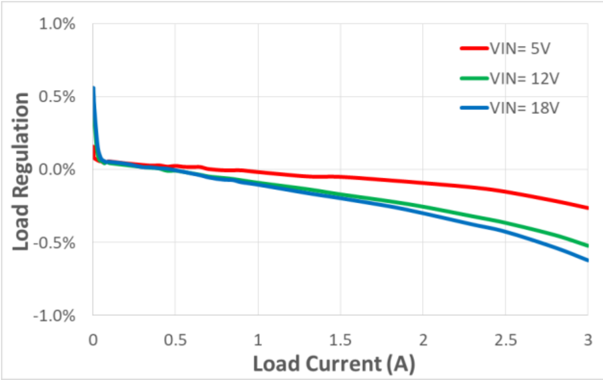


Figure 4. Load Regulation vs Load Current

(V_{OUT}=3.3V, L=3.3μH)

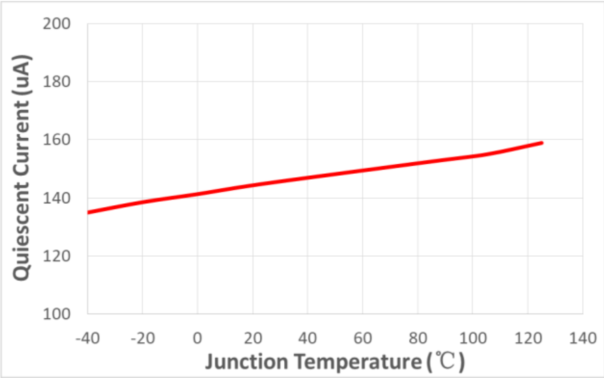


Figure 5. Supply Current vs Junction Temperature

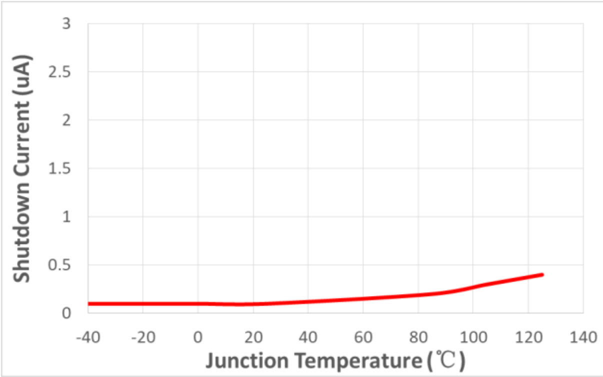


Figure 6. Shutdown Current vs Junction Temperature

FUNCTIONAL DESCRIPTION

HM8113C and HM8113CM are synchronous step-down regulator based on I2 control architecture. It regulates input voltages from 4.5V to 18V down to an output voltage as low as 0.6V, and is capable of supplying up to 3A of load current.

Shut-Down Mode

The regulator shuts down when voltage at EN pin is driven below 0.4V. The entire regulator is off and the supply current consumed by the regulator drops below 1μA.

Power Switch

N-Channel MOSFET switches are integrated on the HM8113C and HM8113CM to down convert the input voltage to the regulated output voltage. Since the top MOSFET needs a gate voltage great than the input voltage, a boost capacitor connected between BST and SW pins is required to drive the gate of the top switch. The boost capacitor is charged by the internal 3.3V rail when SW is low.

CCM Operation

Continuous conduction mode (CCM) occurs when the output current is high, and the inductor current is always above zero amps.

In CCM operation, the switching frequency is fairly constant; hence the output ripple keeps almost the same.

PFM Operation

At light load condition, HM8113C and HM8113CM are configured to work in PFM mode to optimize the efficiency. When the load decreases, the inductor current will decrease as well. Once the inductor current reaches zero, the part transitions from CCM to PFM mode.

In PFM operation, the high side MOSFET is turned off by the peak current reference and the low side MOSFET turns on until the inductor current reaches zero. At this time, the output voltage is still higher than the target value which causes the internal COMP voltage lower than a clamp value, and the high side MOSFET is not allowed to turn on until the COMP voltage rises above its clamp voltage.

V_{IN} Under-Voltage Protection

A resistive divider can be connected between V_{IN} and ground, with the central tap connected to EN, so that when V_{IN} drops to the pre-set value, EN drops below 1.05V to trigger input under voltage lockout protection.

Output Current Run-Away Protection

At start-up, due to the high voltage at input and low voltage at output, current inertia of the output inductor can be easily built up, resulting in a large start-up output current. A valley current limit is designed in HM8113C and HM8113CM so that only when output current drops below the valley current limit can the top power switch be turned on. By such control mechanism, the output current at start-up is well controlled.

Output Short Protection

When the output is shorted to ground, the regulator is allowed to switch for 2048 cycles. If the short condition is cleared within this period, then the regulator resumes normal operation. If the short condition is still present after 2048 switching cycles, then no switching is allowed and the regulator enters hiccup mode for 6144 cycles. After the 6144 hiccup cycles, the regulator will try to start-up again. If the short condition still exists after 2048 cycles of switching, the regulator enters hiccup mode. This process of start-up and hiccup iterate itself until the short condition is removed.

Thermal Protection

When the temperature of the regulator rises above 160°C, it is forced into thermal shut-down. Only when core temperature drops below 140°C can the regulator become active again.

APPLICATION INFORMATION

Output Voltage Set

The output voltage is determined by the resistor divider connected at the FB pin, and the voltage ratio is:

$$V_{FB} = V_{OUT} \cdot \frac{R_4}{R_4 + R_3}$$

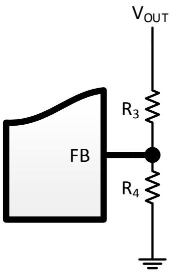
where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.

Choose R_4 around 11kΩ, and then R_3 can be calculated by:

$$R_3 = R_4 \cdot \left(\frac{V_{OUT}}{0.6} - 1 \right)$$

The following table lists the recommended values.

V_{OUT}(V)	R_4(kΩ)	R_3(kΩ)
0.8	11	3.6
1	11	7.3
1.2	11	11
1.8	11	22
2.5	11	34.8
3.3	11	49.9
5	11	80.6



Feedforward Capacitor

In order to improve dynamic performance, a feedforward capacitor (C_5) can be considered to be in parallel with R_3.

Input Capacitor

The input capacitor is used to supply the AC input current to the step-down converter and maintain the DC input voltage. Estimate the RMS current in the input capacitor with:

$$I_{C1} = I_{LOAD} \cdot \sqrt{\frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

where I_{LOAD} is the load current, V_{OUT} is the output voltage, V_{IN} is the input voltage.

The input capacitor can be calculated by the following equation when the input ripple voltage is determined.

$$C_1 = \frac{I_{LOAD}}{f_S \cdot \Delta V_{IN}} \cdot \frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

where C_1 is the input capacitance value, f_S is the switching frequency, $\triangle V_{IN}$ is the input ripple voltage.

The input capacitor can be electrolytic, tantalum or ceramic. To minimize the potential noise, a small X5R or X7R ceramic capacitor, e.g. 0.1μF, should be placed as close to the IC as possible when using electrolytic capacitors.

A 22μF/25V ceramic capacitor is recommended in typical application.

Output Capacitor

The output capacitor is required to maintain the DC output voltage, and the capacitance value determines the output ripple voltage. The output voltage ripple can be calculated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \cdot L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \cdot \left(R_{ESR} + \frac{1}{8 \cdot f_S \cdot C_{OUT}}\right)$$

where C_{OUT} is the output capacitance value and R_{ESR} is the equivalent series resistance value of the output capacitor.

The output capacitor can be low ESR electrolytic, tantalum or ceramic, and lower ESR capacitors get lower output ripple voltage.

The output capacitors also affect the system stability and transient response, and a 44μF~66μF ceramic capacitor is recommended in typical application.

Inductor

The inductor is used to supply constant current to the output load, and the value determines the ripple current which affect the efficiency and the output voltage ripple. The ripple current is typically allowed to be 40% of the maximum switch current limit, thus the inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_S \cdot \Delta I_L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

where V_{IN} is the input voltage, V_{OUT} is the output voltage, f_S is the switching frequency, and $\triangle I_L$ is the peak-to-peak inductor ripple current.

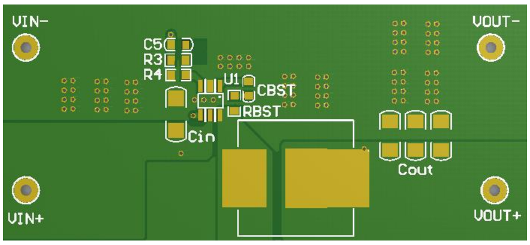
External Bootstrap Capacitor

A bootstrap capacitor is required to supply voltage to the top switch driver. A 0.1μF low ESR ceramic capacitor is recommended to be connected between the BST pin and SW pin.

PCB Layout Note

For minimum noise problem and best operating performance, the PCB is preferred to follow the guidelines as below.

1. Place the input decoupling capacitor as close to HM8113C or HM8113CM(VIN pin and PGND) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.
2. Put the feedback trace as far away from the inductor and noisy power traces as possible.
3. The ground plane on the PCB should be as large as possible for better heat dissipation.
4. Keep the swiching node SW short to prevent excessive capacitive coupling.
5. Make VIN, VOUT and ground bus connections as wide as possible. This reduces any voltage drops on the input or output paths of the converter and maximizes efficiency.



PCB Layout Recommendation

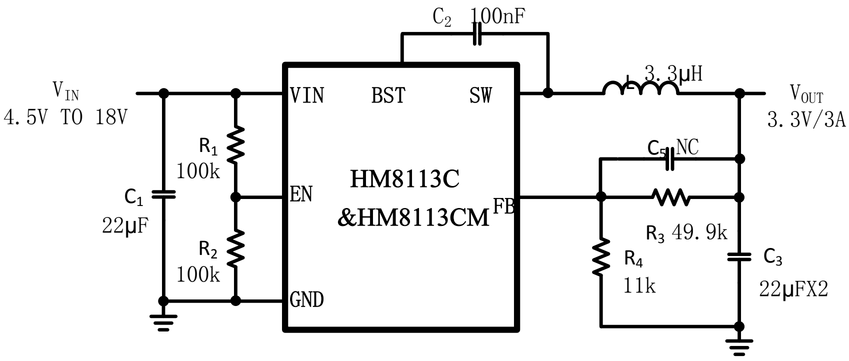
REFERENCE DESIGN

Reference 1:

V_{IN}: 4.5V~18V

V_{OUT}: 3.3V

I_{LOAD}: 0~3A



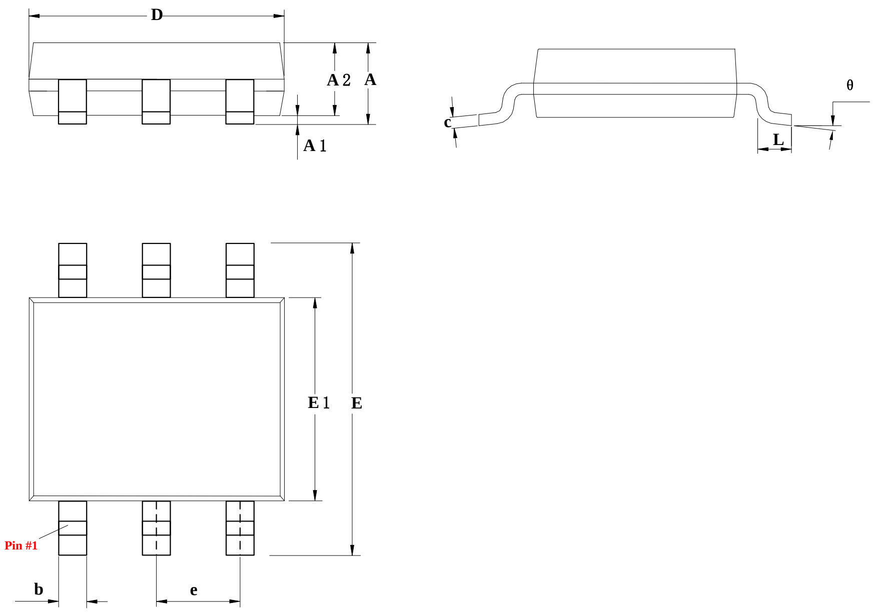
External Components Suggestion (V_{IN}=12V):

V_{OUT}(V)	R_4 (kΩ)	R_3 (kΩ)	C_5 (pF)	L (μH)	C_3 (μF)
0.8	11	3.6	NC	1	66
1	11	7.3	NC	1.5	66
1.2	11	11	NC	1.5	66
1.8	11	22	NC	2.2	44
2.5	11	34.8	NC	2.2	44
3.3	11	49.9	NC	3.3	44
5	11	80.6	NC	4.7	44

Note: In order to improve dynamic performance, a feedforward capacitor (C_5) can be considered to be in parallel with R_3.

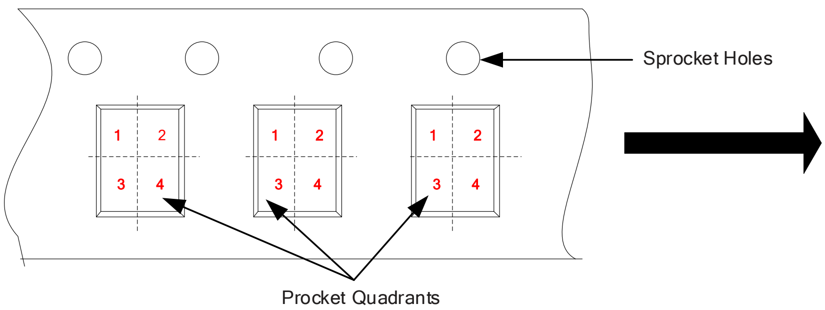
PACKAGE OUTLINE

SOT23-6 UNIT: mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	1.05	--	1.30
A1	0	0.05	0.15
A2	0.95	1.10	1.20
b	0.30	0.40	0.50
c	0.05	--	0.23
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95（BSC)		
L	0.30	0.45	0.60
θ	0°	—	8°

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Package Type	Pin1 Quadrant
SOT23-6	3