HM3412

6V 6.0A 1.2MHz Synchronous Step-Down Regulator

GENERAL DESCRIPTION

The HM3412 is a high-efficiency, DC-to-DC step-down switching regulators, capable of delivering up to 6A of output current. The HM3412 operates from an input voltage range of 2.75V to 6.0V. It integrates main switch and synchronous switch with very low $R_{DS(ON)}$. This low noise output along with its excellent efficiency achieved by the internal synchronous rectifier, making HM3412 an ideal green replacement for large power consuming linear regulators.

It is equipped with an automatic PSM/PWM mode operation. At light load, the IC operates in the PSM mode to reduce the switching losses. At heavy load, the IC works in PWM mode.

Internal soft-start control circuitry reduces inrush current. Short-circuit and thermal-overload protection improves design reliability.

The HM3412 is available in DFN2x2-8 Package.

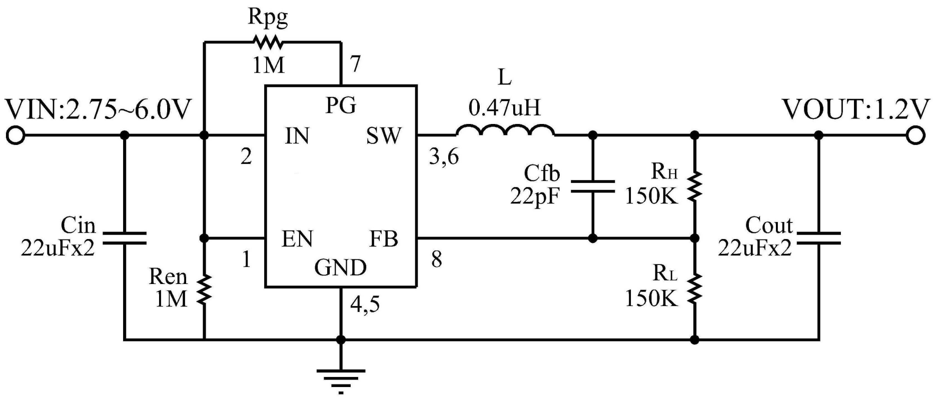
FEATURES

- Low $R_{DS(ON)}$ for internal switches(top/bottom): 35/15mΩ
- 2.75-6.0V input voltage range
- High Efficiency: Up to 95%
- 6A continuous output current capability
- Automatic PSM/PWM mode switch
- 1.2MHz Switching Frequency
- Shutdown current <1μA
- Low dropout 100% Duty operation
- Internal Compensation and Soft-Start
- Power good indicator
- OCP/UVLO/OTP protections
- Available in DFN2x2-8 package

APPLICATIONS

- High definition Set Top Box
- LCD TV
- Notebook PC

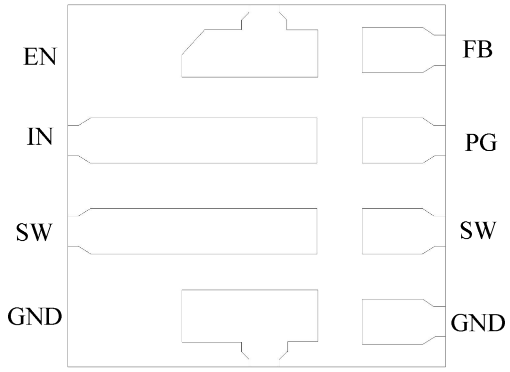
TYPICAL APPLICATION CIRCUIT



ORDER and MARKING INFORMATION

HM3412□□□□ Packing Code Package Code Product Ver	Part No.: HM3412DR Product Ver: A/B/C/D… Package Code: DN: DFN2x2-8 Packing Code: R: Tape and Reel	TOP mark: E6XYZ E6- Product Name, XY- week and year code, Z-Lot number

PIN ASSIGNMENT



DFN2x2-8

PIN DESCRIPTION

PIN No	SYMBOL	DESCRIPTTION
1	EN	Enable pin for the IC. Drive the pin to high to enable the part, and low to disable. Do not float.
4,5	GND	Power Ground
3,6	SW	Inductor connection. Connect an inductor between SW and the regulator output.
2	IN	Power Supply Input Pin.
8	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 To program the output voltage: $V_{OUT}=0.6*(1+R_H/R_L)$
7	PG	Power good indicator. When the output voltage exceeds 90% of regulation point, It becomes open drain low otherwise. Connect this pin to IN by a 1MΩ pull-up resistor.

ABSOLUTE MAXIMUM RATINGS(Note 1)

Parameter		Value
Max Input Voltage		6.5V
Max Operating Junction Temperature(Tj)		125°C
Ambient Temperature(Ta)		-40°C – 85°C
Maximum Power Dissipation	DFN2x2-8	2W
Package Thermal Resistor	θ_{JA}	62°C
	θ_{JC}	10°C/W
Storage Temperature(Ts)		-40°C - 150°C
Lead Temperature & Time		260°C, 10S

Note1: Absolute Maximum Ratings are threshold limit values that must not be exceeded even for an instant under any condition. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

RECOMMANDED OPERATING RANGE

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	VIN Supply Voltage	2.75 to 6.0	V
V_{OUT}	Output voltage	2.75-5.0	V
T_{OPT}	Operating Temperature	-40 to +85	°C

ELECTRICAL CHARACTERISTICS

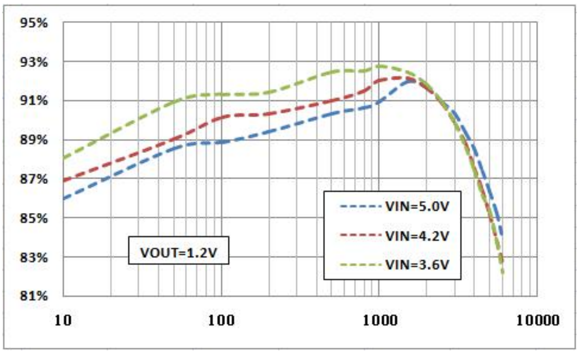
V_{IN}=5V, V_{OUT}=1.2V, L=0.47μH, C_{OUT}=22uFx2, T_A=25°C, I_{OUT}=1A, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage Range		2.75		6.0	V
V_{FB}	Feedback Voltage		0.588	0.6	0.612	V
I_{FB}	Feedback Leakage current			0.1	1	μA
I_Q	Quiescent Current	I_{OUT}=0,EN=1, V_{FB}=105%*V_{REF}		40		μA
I_{SD}	Shutdown Current	Shutdown, EN=0		0.1	1	μA
F_{SW}	Switching Frequency			1.2		MHz
R_{ONP}	PMOSFET R_{DSON}			35		mΩ
R_{ONN}	NMOSFET R_{DSON}			15		mΩ
I_{LIMIT}	Peak Current Limit		7.5			A
T_{SS}	Internal Soft-start Time			0.7		ms
V_{PG}	PGOOD Under-voltage Threshold			0.54		V
V_{SCP}	Short Circuit Protection Threshold			0.25		V
T_{ON}	Min On Time			60		ns
	Max Duty Cycle		100			%
V_{UVLO}	Input UVLO Threshold				2.7	V
V_{HYS}	UVLO Hysteresis			0.3		V
V_{ENH}	EN Input High Voltage		1.2			V
V_{ENL}	EN Input Low Voltage				0.4	V
T_{SD}	Thermal Shutdown Temperature			150		°C
T_{HYS}	Thermal Shutdown Hysteresis			15		°C
$R_{DISCHRG}$	SW Node Discharge Resistance			50		Ω

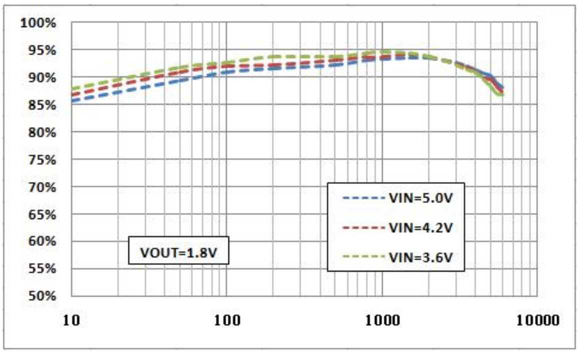
TYPICAL OPERATING CHARACTERISTICS

C_{IN}=22μFx2, C_{OUT}=22μFx2, L=0.47μH, Tested under TA=25°C, unless otherwise specified

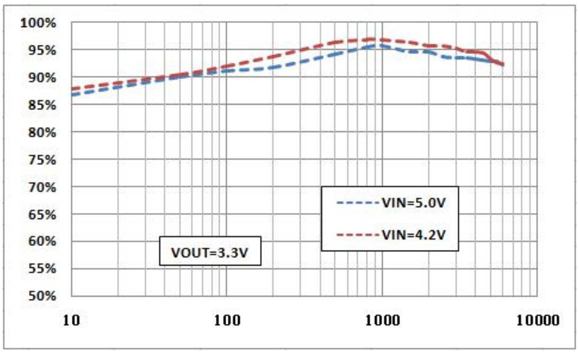
Efficiency vs. Load Current



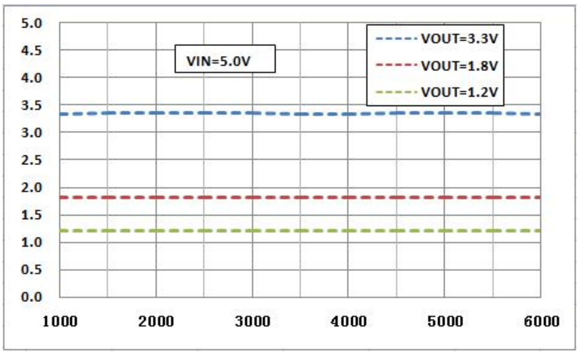
Efficiency vs. Load Current



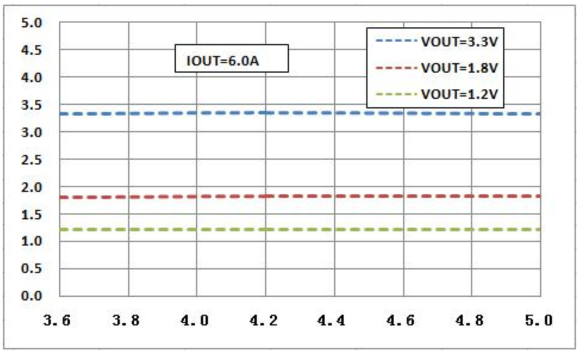
Efficiency vs. Load Current



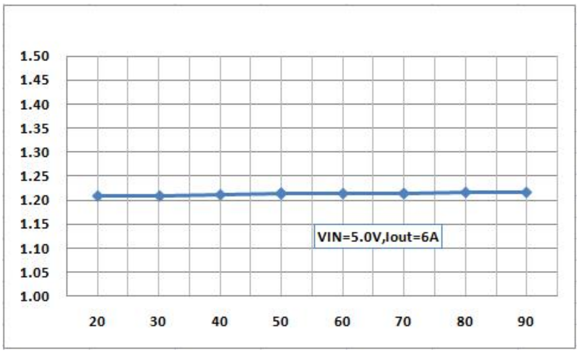
Output Voltage vs. Output Current



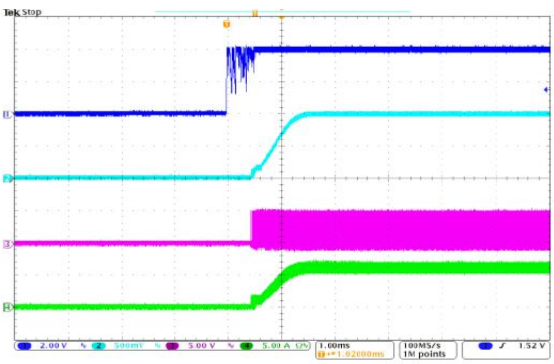
Output Voltage vs. Input Voltage



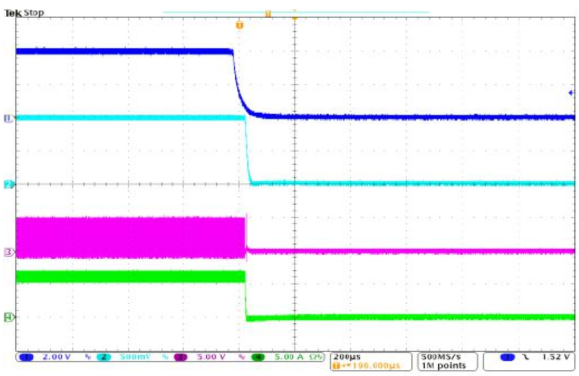
Temperature vs. Output Voltage



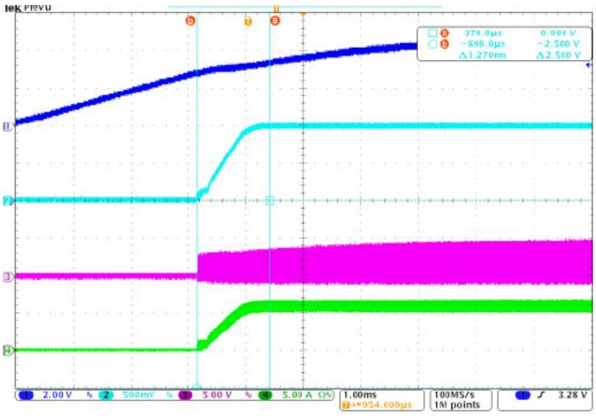
VEN Control Power On



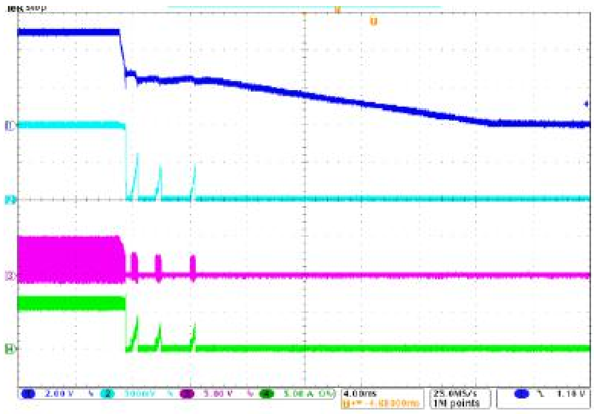
VEN Control Power Off



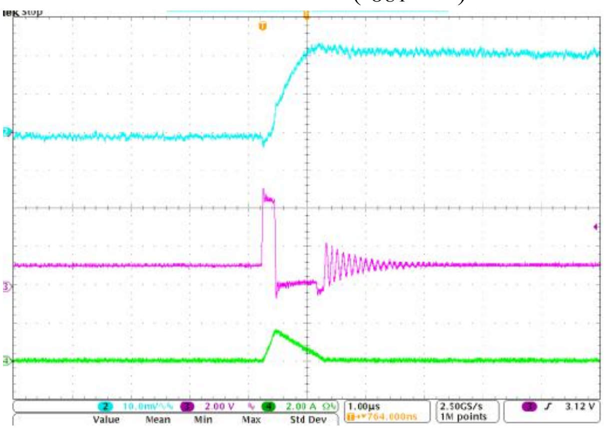
VIN Power On



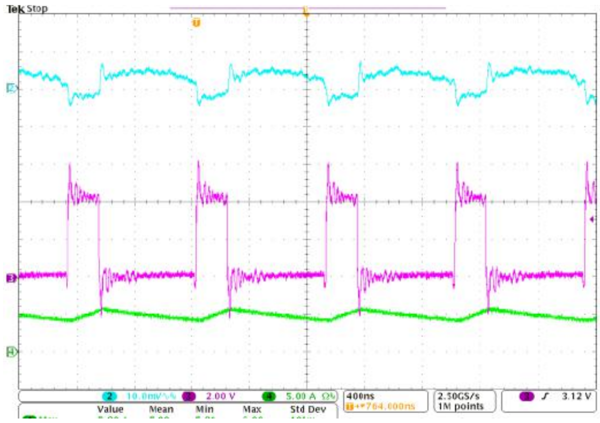
VIN Power Off



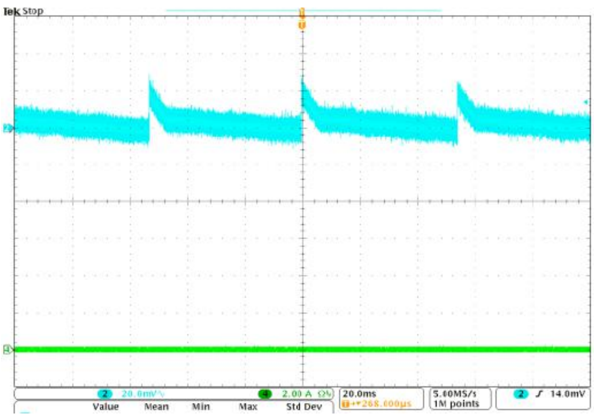
Switch Waveform (I_{OUT}=0A)



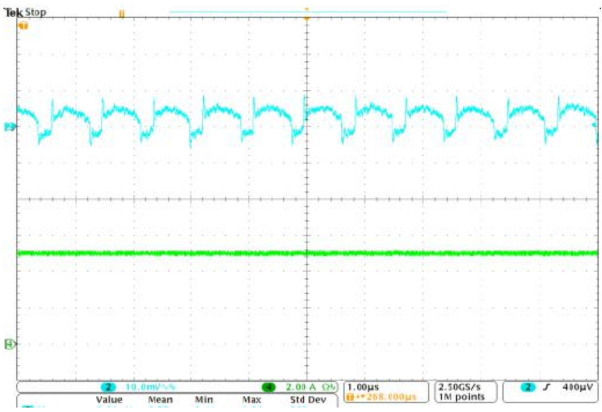
Switch Waveform (I_{OUT}=6A)



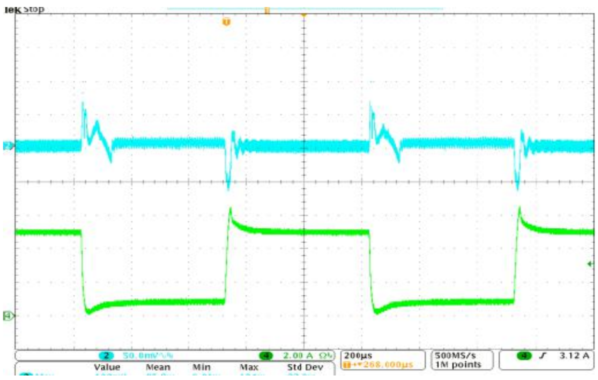
VOUT Ripple (I_{OUT}=0mA)



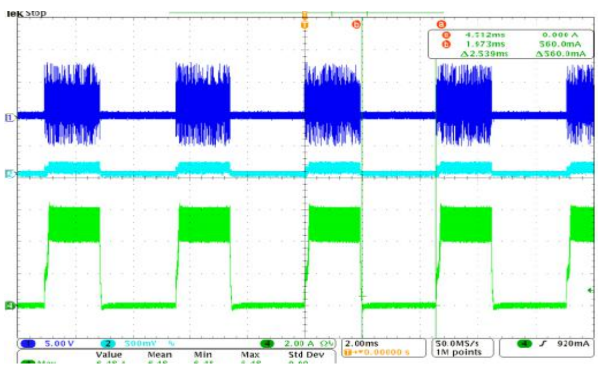
VOUT Ripple (I_{OUT}=6A)



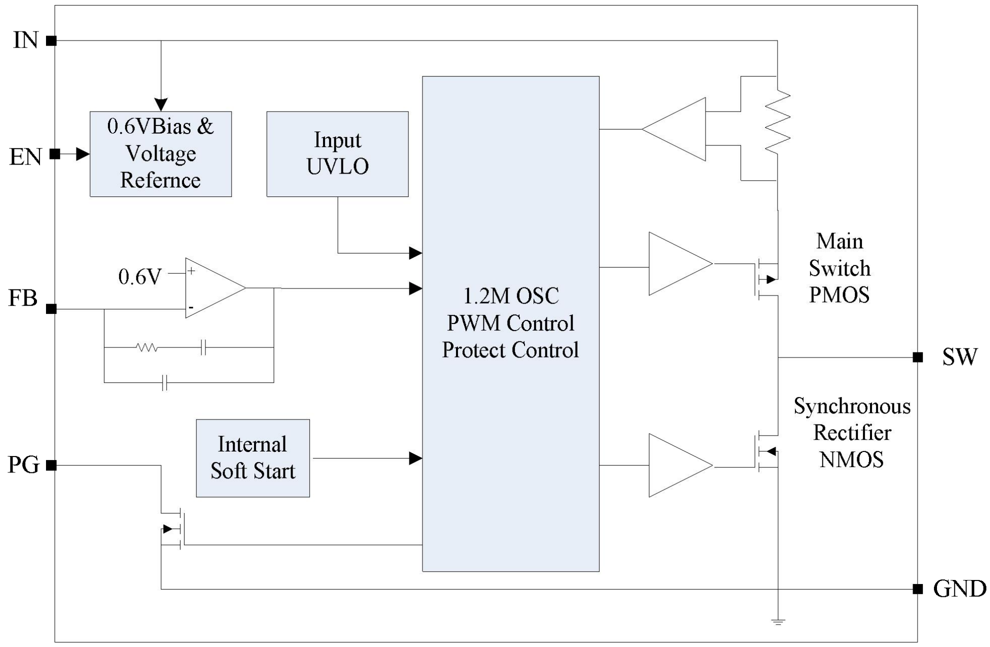
Load Transient Response (1A-6A)



Short Protection Waveform



SIMPLIFIED BLOCK DIAGRAM



OPERATION DESCRIPTION

The HM3412 high-efficiency switching regulator is a small, simple, DC-to-DC step-down converter capable of delivering up to 6A of output current. The device operates in pulse-width modulation (PWM) at 1.2MHz from a 2.75V to 6.0V input voltage and provides an output voltage from 0.6V to VIN-0.3V, making the HM3412 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.

Loop Operation

HM3412 uses a PWM current-mode control scheme. An open-loop comparator compares the integrated voltage-feedback signal against the sum of the amplified current-sense signal and the slope compensation ramp. At each rising edge of the internal clock, the internal high-side MOSFET turns on until the PWM comparator terminates the on cycle. During this on-time, current ramps up through the inductor, sourcing current to the output and storing energy in the inductor. The current mode feedback system regulates the peak inductor current as a function of the output voltage error signal. During the off cycle, the internal high-side P-channel MOSFET turns off, and the internal low-side N-channel MOSFET turns on. The inductor releases the stored energy as its current ramps down while still providing current to the output.

PSM

In order to increase light load efficiency, save switching loss is used in HM3412. During in light load, the device only switching when output voltage is below the pre-set threshold. This function can skip some switching cycle that save unnecessary loss.

Current Sense

An internal current-sense amplifier senses the current through the high-side MOSFET during on time and produces a proportional current signal, which is used to sum with the slope compensation signal. The summed signal then is compared with the error amplifier output by the PWM comparator to terminate the on cycle.

Current Limit

There is a cycle-by-cycle current limit on the high-side MOSFET of 7.5A. When the current flowing out of SW exceeds this limit, the high-side MOSFET turns off and the synchronous rectifier turns on. HM3412 utilizes a frequency fold-back mode to prevent overheating during short-circuit output conditions. The device enters frequency fold-back mode when the FB voltage drops below 200mV, limiting the current to 7.5A and reducing power dissipation. Normal operation resumes upon removal of the short-circuit condition.

Soft-start

HM3412 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.

Short-Circuit Protection

When HM3412 output node is shorted to GND, chip will enter soft-start to protect itself, when short circuit is removed,HM3412 enter normal operation again. If HM3412 reach OCP threshold while short circuit, HM3412 will enter soft-start cycle until the current under OCP threshold.

UVLO and Thermal Shutdown

If IN drops below 2.7V, the UVLO circuit inhibits switching. Once IN rises above 2.7V, 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= +150°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.

Power Good

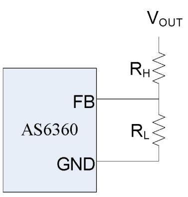
Power good flag is pulled down when HM3412 start-up and the FB pin voltage is still outside pre-set voltage window. During normal operation phase, when FB pin voltage drop under 90% or increase over 110%, power good flag is also pulled down.

APPLICATION INFORMATION

Setting Output Voltages

Output voltages are set by external resistors. The FB threshold voltage (V_{FB}) is 0.6V. The output voltage can be calculated as below:

$$V_{OUT}=V_{FB}*(1+R_H/R_L)$$



Using large feedback resistor can increase efficiency, but too large value affects the device's output accuracy because of leakage current going into device's FB pin.

Input Capacitor Selection

Because buck converters have a pulsating input current, a low ESR input capacitor is required. This results in the best input voltage filtering, minimizing the interference with other circuits caused by high input voltage spikes. Also, the input capacitor must be sufficiently large to stabilize the input voltage during heavy load transients. For good input voltage filtering, usually two 22µF input capacitors are sufficient. It can be increased without any limit for better input-voltage filtering. Ceramic capacitors show better performance because of the low ESR value, and they are less sensitive against voltage transients and spikes compared to tantalum capacitors. Place the input capacitor as close as possible to the input and GND pin of the device for better performance.

Output Capacitor

The output capacitor is required to maintain the DC output voltage. Low ESR capacitors are preferred to keep the output voltage ripple low. In a buck converter circuit, output ripple voltage is determined by inductor value, switching frequency, output capacitor value and ESR. The output ripple is determined by:

$$\Delta V_{OUT} = \Delta I_L \times (ESR_{COUT} + \frac{1}{8 \times F_{OSC} \times C_{OUT}})$$

Where F_{OSC} = operating frequency, C_{OUT}= output capacitance and ΔI_L = ripple current in the inductor. For a fixed output voltage, the output ripple is highest at maximum input voltage since ΔI_L increases with input voltage. Two 22μF ceramic capacitors are recommended value in typical application.

Inductor Selection

For high efficiencies, the inductor should have a low DC resistance to minimize conduction losses. Especially at high-switching frequencies, the core material has a higher impact on efficiency. When using small chip inductor, the efficiency is reduced mainly due to higher inductor core losses. This needs to be considered when selecting the appropriate inductor. The inductor value determines the inductor ripple current. The larger the inductor value, the smaller the inductor ripple current and the lower the conduction losses of the converter. Conversely, larger inductor values cause a slower load transient response. A reasonable starting point for setting ripple current, ΔL, is 40% of maximum output current. The recommended inductor value can be calculated as below:

$$L \geq V_{OUT} \times \frac{1 - V_{OUT} / V_{IN, MAX}}{F_{SW} \times \Delta I_L}$$

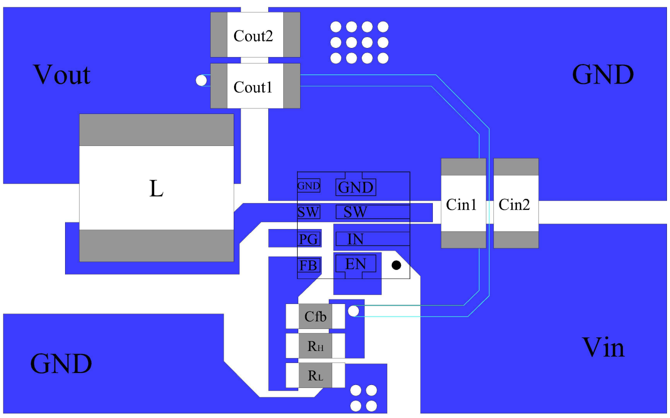
$$I_{L, MAX} = I_{OUT, MAX} + 1/2 \times \Delta I_L$$

To avoid the saturation of the inductor, the inductor should be rated at least for the maximum output current of the converter plus the inductor ripple current.

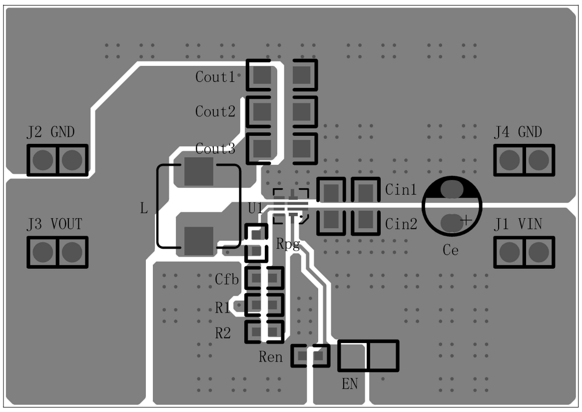
Layout Consideration

The layout design of HM3412 regulator is relatively simple. For the best efficiency and minimum noise problems, we should place the following components close to the IC: C_{IN}, L, R_H and R_L:

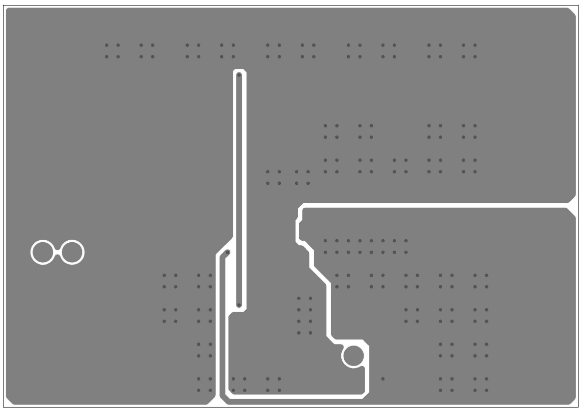
1) Multi-layer board is suggested for HM3412 output current application. It is desirable to maximize the PCB copper area connecting to GND pin to achieve the best thermal and noise performance. Reasonable vias are suggested to be placed around GND pins to enhance the soldering quality and thermal performance.
2) C_{IN} must be close to Pins IN and GND. The loop area formed by C_{IN} and GND must be minimized.
3) The PCB copper area associated with SW pin must be minimized to avoid the potential noise problem.
4) The components R_H and R_L, and the trace connecting to the FB pin must not be adjacent to the SW net on the PCB layout to avoid the noise problem.



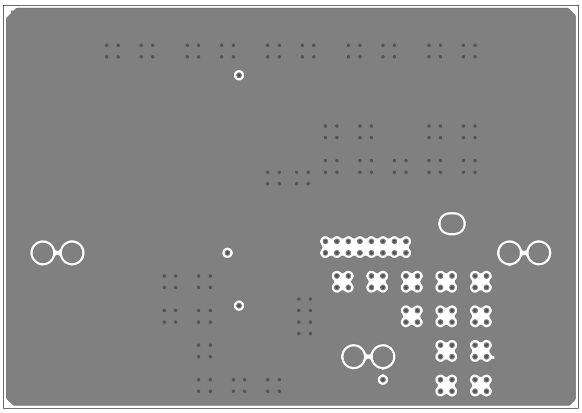
Evaluation Board PCB_Layout



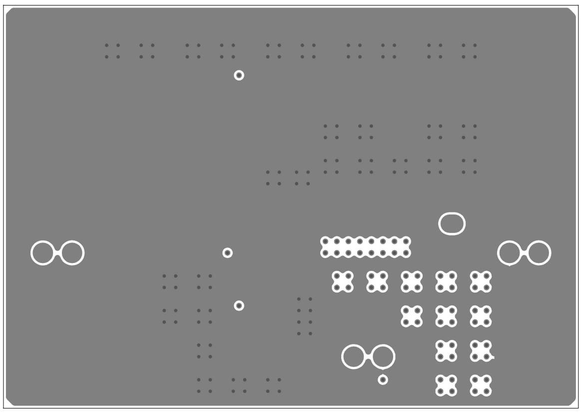
(1) Top Layer



(2) Middle Layer1



(3) Middle Layer2



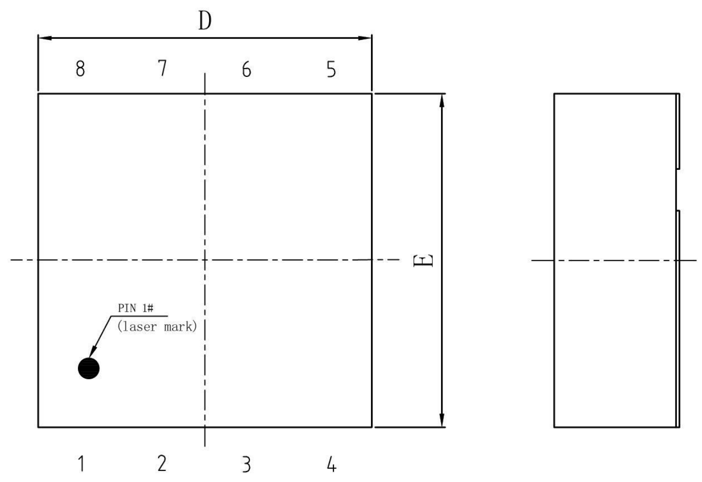
(4) Bottom Layer

BOM LIST

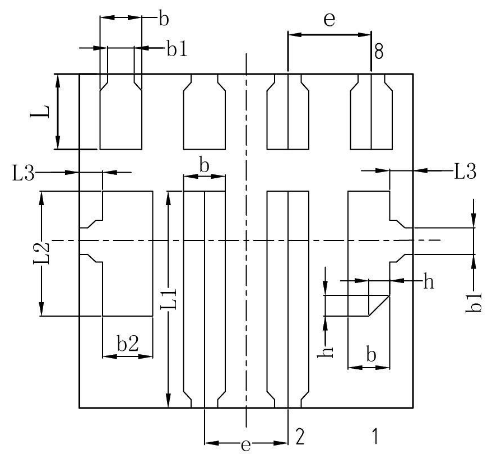
Reference Designator	Description	Part Number	Manufacturer
Ce	470uF/16V Electrolytic Cap		
Cin1,2	22uF/6.3V/X5R, 0805	C2012X5R0J226M	TKD
Cout1,2	22uF/6.3V/X5R, 0805	C2012X5R0J226M	TKD
Cfb	22pF/50V/X5R, 0603	C1608C0G1H22D	TKD
L	0.47uH/17A inductor	SPM6530T-R47M	TKD
R1	150kΩ, 0603, 1%		
R2	150kΩ, 0603, 1%		
Ren	1MΩ, 0603		
R_{pg}	1MΩ,0603		

PACKAGE OUTLINE

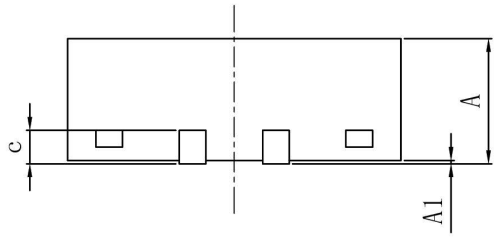
DFN2x2-8



TOP VIEW



BOTTOM VIEW



SIDE VIEW

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.20	0.25	0.30
b1	0.16REF		
b2	0.25	0.30	0.35
c	0.18	0.203	0.25
D	1.90	2.00	2.10
E	1.90	2.00	2.10
e	0.50BSC		
L	0.40	0.45	0.50
L1	1.25	1.30	1.35
L2	0.70	0.75	0.80
L3	0.09	0.14	0.19
h	0.075	0.125	0.175