

Features

- Wide input voltage range: 4.5V – 32V
- High efficiency operation
 - Integrated an 80-mΩ LS-MOSFET and an 115-mΩ HS-MOSFET
 - 91% efficiency at 2A load from 12V to 5V conversion
- Automatic PFM mode at light load (LP6462S, LP6462SH) and FPWM mode over all load range (LP6462SF, LP6462SHF)
- ±1% Vref accuracy
- Support 1.0-MHz and 500kHz different switching frequency versions
- COT control scheme with fast load transient response
- Hiccup protection
- Integrated UVLO, OVP, OCP, SCP, and OTP protections
- 600us typical soft-start time
- 1.6mm X 2.9mm SOT23-6 package
- RoHS Compliant and 100% Lead (Pb) Free

Applications

- Industrial PC
- Network/digital video recorder (NVR/DVR)
- TV and TV box
- 12V Industrial bus applications

General Description

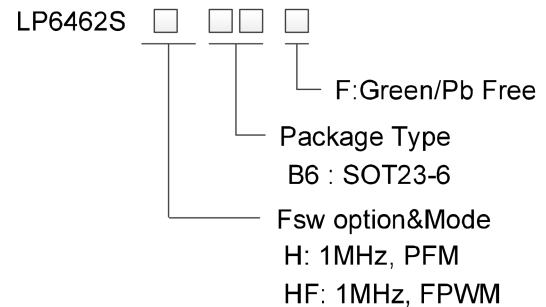
The LP6462S is a synchronous buck converter supporting up to 2A output current. The LP6462S employs an adaptive constant-on-time (COT) control scheme to achieve fast load transient response. The external components are minimized, requiring only one inductor, two resistors, and two capacitors.

The LP6462S supports both aluminum polymer capacitors and ceramic capacitors without extra compensation components.

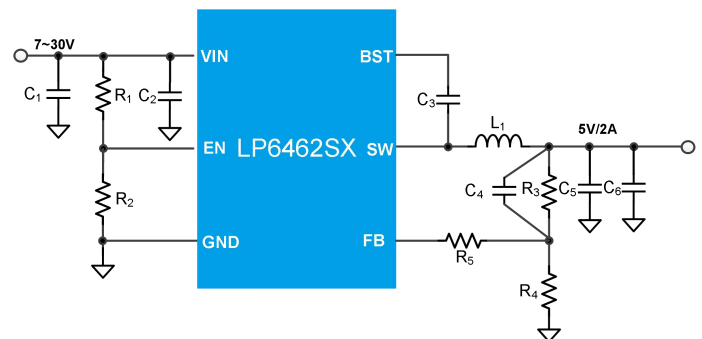
The LP6462S integrates PFM (Pulse Frequency Modulation) operation, which helps maintain the system efficiency at light load. The LP6462S also integrates multiple protection functions, i.e., over-current protection (OCP), over-temperature protection (OTP), under-voltage lockout (UVLO), and short circuit protection (SCP).

The LP6462S is available in a small 6-pin 1.6mmX2.9mm SOT23-6 package.

Order Information



Typical Application Circuit





Device Information

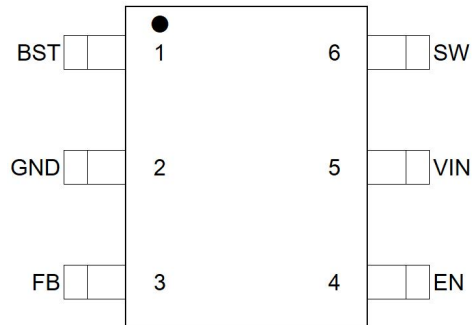
Part Number	Top Marking	Fsw	PFM/FPWM	Shipping	MSL
LP6462SB6F	LPS 5fYWX	500kHz	PFM/PWM	3K/REEL	LEVEL 3
LP6462SFB6F***	TBD	500kHz	FPWM	3K/REEL	LEVEL 3
LP6462SHB6F	LPS 5hYWX	1000kHz	PFM/PWM	3K/REEL	LEVEL 3
LP6462SHFB6F	LPS 5eYWX	1000kHz	FPWM	3K/REEL	LEVEL 3

Marking indication: Y: Year code. W: Week code. X: Batch numbers.
MSL: Moisture Sensitivity Level according to JEDEC Standard.

“***”: Product Preview. Contact LowPowerSemi sales for more information.



Pin Diagram



LP6462S Pinout

Pin Description

Pin #	Name	Description
1	BST	Bootstrap pin. Power supply for high-side MOSFET gate driver. A 0.1- μ F capacitor must be connected between this pin and the SW pin.
2	GND	Power ground of the IC.
3	FB	Feedback pin. Use a resistor divider to set the desired output voltage.
4	EN	Enable input. This pin can be used to control the system power sequence.
5	VIN	IC power supply input.
6	SW	The switching node of the converter.



Absolute Maximum Ratings ^(Note)

VIN, SW to GND	-----	-0.3V to 34V
EN to GND	-----	-0.3V to 34V
FB to GND	-----	-0.3V to 6.5V
BST to SW	-----	-0.3V to 6.5V
SW to GND (5ns transient)	-----	-3.5V to 34V
Operating Ambient Temperature Range (TA)	-----	-40°C to 85°C
Junction Temperature (TJ)	-----	-40°C to 125°C
Maximum Soldering Temperature (at leads, 10 sec)	-----	260°C

Note: Stresses beyond 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 beyond 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.

ESD Ratings

HBM (Human Body Model)	-----	2kV
CDM (Charged-device Model)	-----	500V

Thermal Information

θ_{JA} (Junction-to-Ambient Thermal Resistance)	-----	140°C/W
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Recommended Operating Conditions

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
VIN	Input voltage	4.5		32	V
VOUT	Output voltage	V _{ref}		7	V
L	Inductor	0.7		13	μH
TA	Ambient temperature range	-40		85	°C
CIN	Input decoupling capacitor	4.7		100	μF
COUT	Output capacitor	10		100	μF

Electrical Characteristics

(The specifications are measured under conditions V_{IN} = 12V, T_A = 25°C, unless otherwise specified.)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT SECTION						
V _{ULVO_R}	Input voltage under lockout threshold	V _{IN} rising threshold		4.2	4.5	V
V _{ULVO_H}	UVLO hysteresis	V _{IN} falling threshold		0.2		V
I _{q_VIN}	Input quiescent current	No switching, EN=3V, FB=1.0V		300		μA
BUCK CONVERTER						



SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{LIM}	Low-side valley current limit	$T_A=25^{\circ}C$	2.0	3.0	4.0	A
V_{ref}	Reference voltage	$T_A=25^{\circ}C$,	0.594	0.6	0.606	V
R_{dson_HS}	High-side FET on resistance	$V_{IN}=12V$		115		m Ω
R_{dson_LS}	Low-side FET on resistance	$V_{IN}=12V$		80		m Ω
F_{sw}	Switching frequency	LP6462S		500		kHz
		LP6462SH		1000		kHz
t_{on-min}	Minimum on-time ^[1]			50		ns
$t_{off-min}$	Minimum off-time ^[1]	$V_{FB}=V_{ref} - 0.2V$		100		ns
$t_{on-hiccup}$	Hiccup on time ^[1]			1		ms
$t_{off-hiccup}$	Hiccup waiting time ^[1]			10		ms
t_d	EN delay time ^[1]	From EN high to first switching		250		us
t_{ss}	Soft-start time ^[1]	From first switching to 95%Vref		600		us
T_{jSD}	Thermal shutdown threshold	Rising threshold		160		$^{\circ}C$
	Thermal shutdown threshold	Falling threshold		135		$^{\circ}C$
I_{leak_FB}	FB pin leakage current			0.01		μA
EN Logic						
V_H	EN pin logic high threshold	EN Rising threshold	1.14	1.2	1.26	V
V_{hys}	EN pin threshold hysteresis			0.1		V
	EN pin internal pull-down resistance			1000		k Ω
Output OVP						
V_{OVP_rise}	OVP threshold	VOUT rising edge, reference to Vref	108	110	112	%
V_{OVP_fall}	OVP hysteresis	VOUT falling edge, reference to Vref		105		%

[1]: Not production tested. Guaranteed by design.



Typical Characteristics

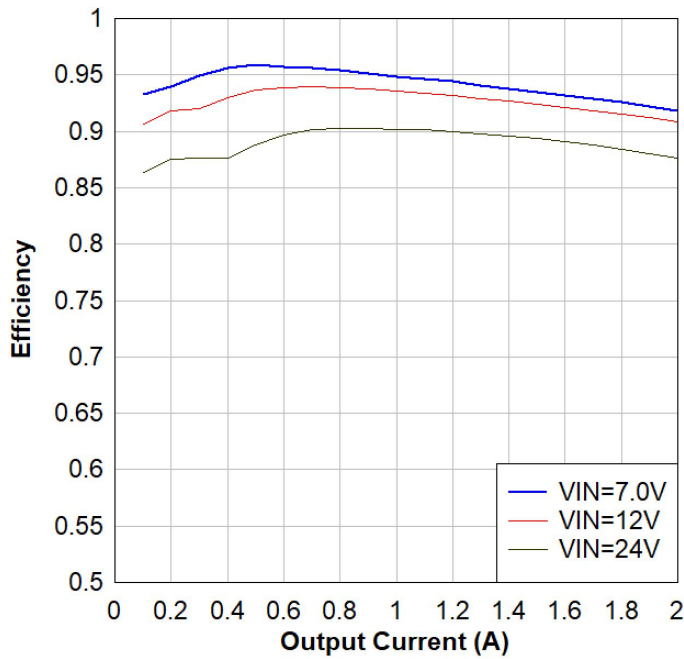


Figure 1. $V_{OUT}=5V$, Efficiency, $L=4.7\mu H$, LP6462SH

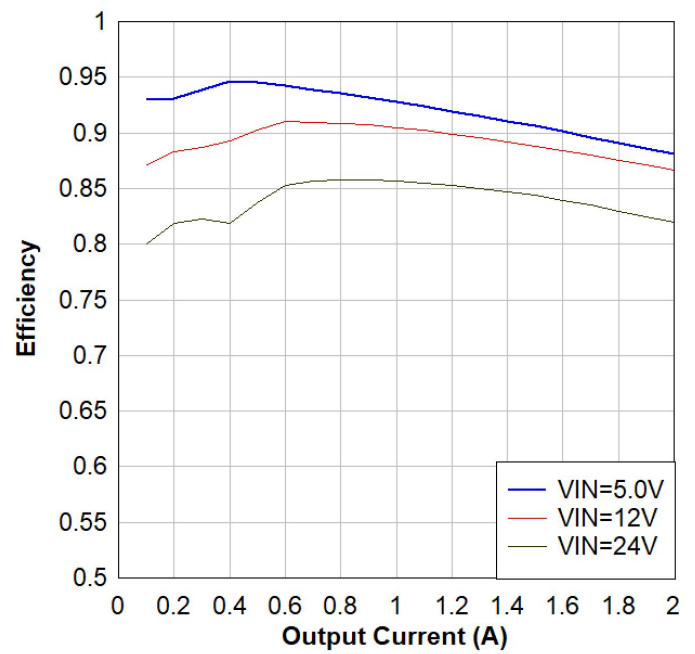


Figure 2. $V_{OUT}=3.3V$, Efficiency, $L=3.3\mu H$, LP6462SH

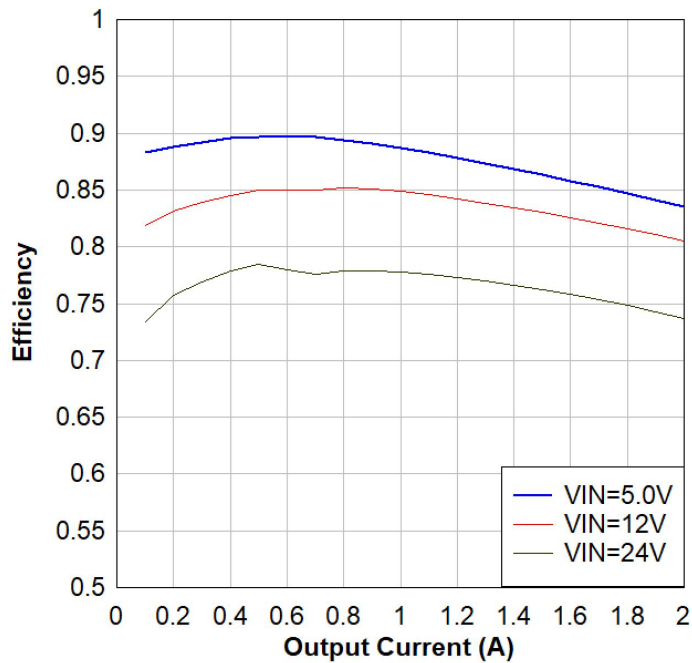


Figure 3. $V_{OUT}=1.8V$, Efficiency, $L=1\mu H$, LP6462SH

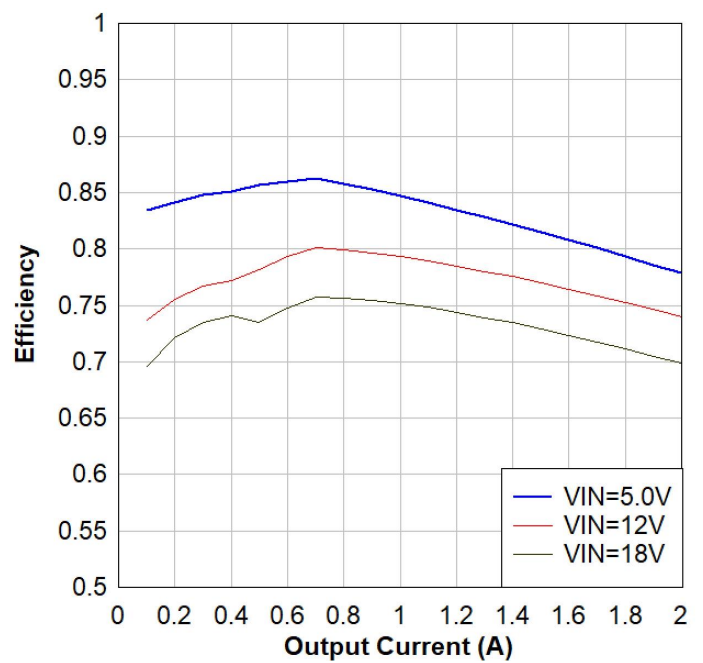


Figure 4. $V_{OUT}=1.2V$, Efficiency, $L=1\mu H$, LP6462SH

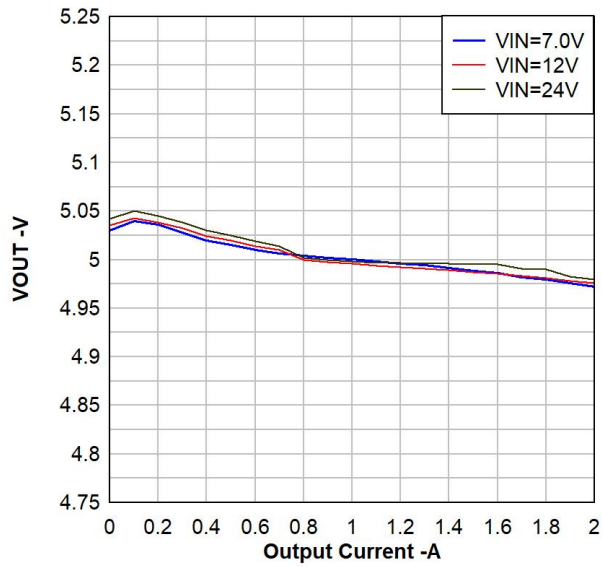


Figure 5. VOUT=5V, Regulation, L=4.7uH, LP6462SH

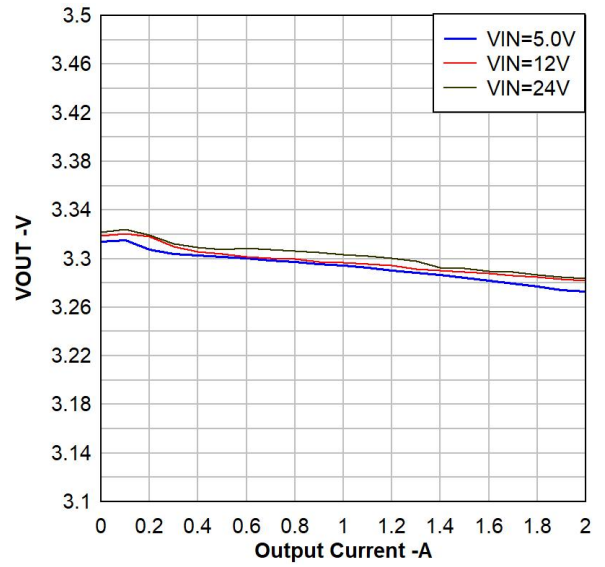


Figure 6. VOUT=3.3V, Regulation, L=3.3uH, LP6462SH

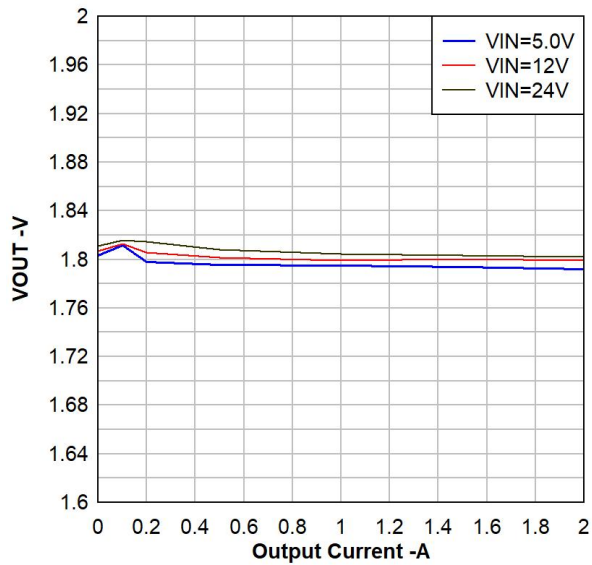


Figure 7. VOUT=1.8V, Regulation, L=1uH, LP6462SH

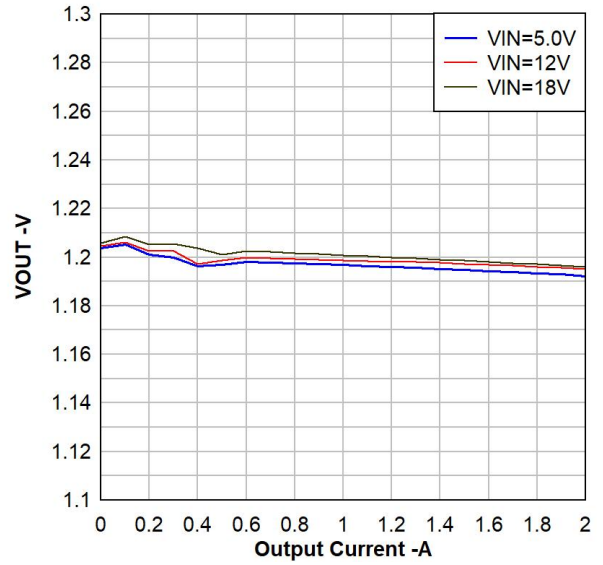


Figure 8. VOUT=1.2V, Regulation, L=1uH, LP6462SH

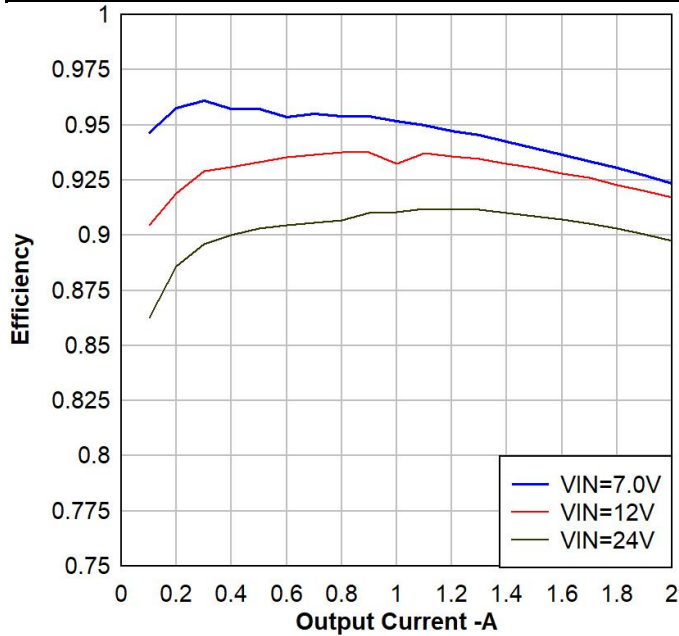


Figure 9. $V_{OUT}=5.0V$, Efficiency, $L=4.7\mu H$, LP6462S

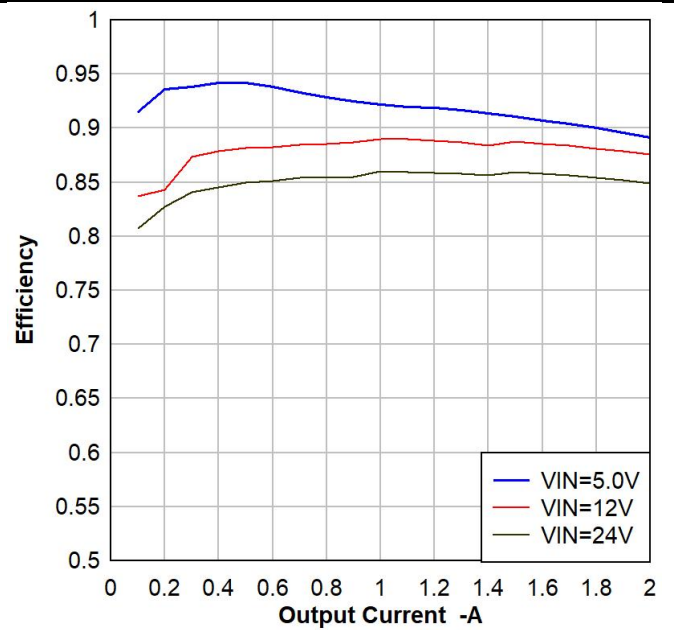


Figure 10. $V_{OUT}=3.3V$, Efficiency, $L=4.7\mu H$, LP6462S

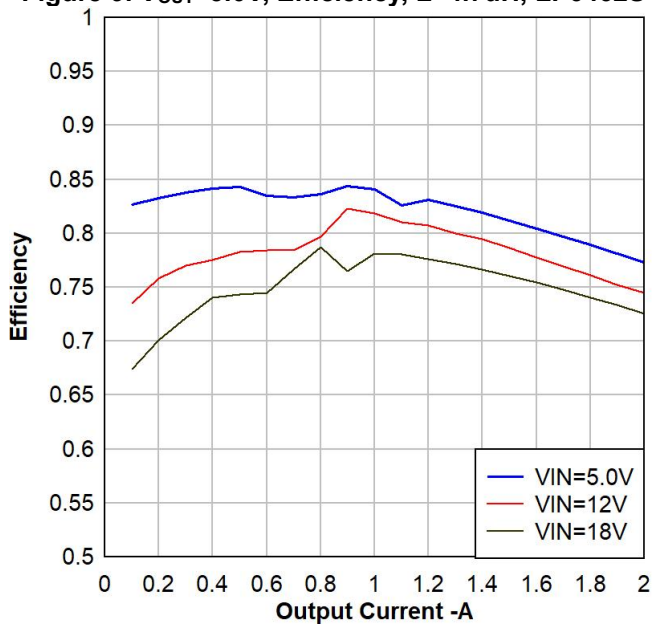


Figure 11. $V_{OUT}=1.2V$, Efficiency, $L=2.2\mu H$, LP6462S

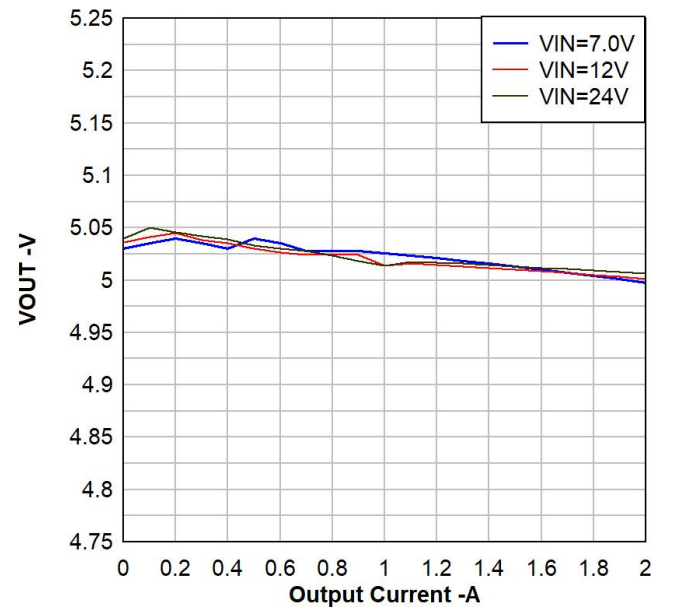


Figure 12. $V_{OUT}=5V$, Regulation, $L=4.7\mu H$, LP6462S

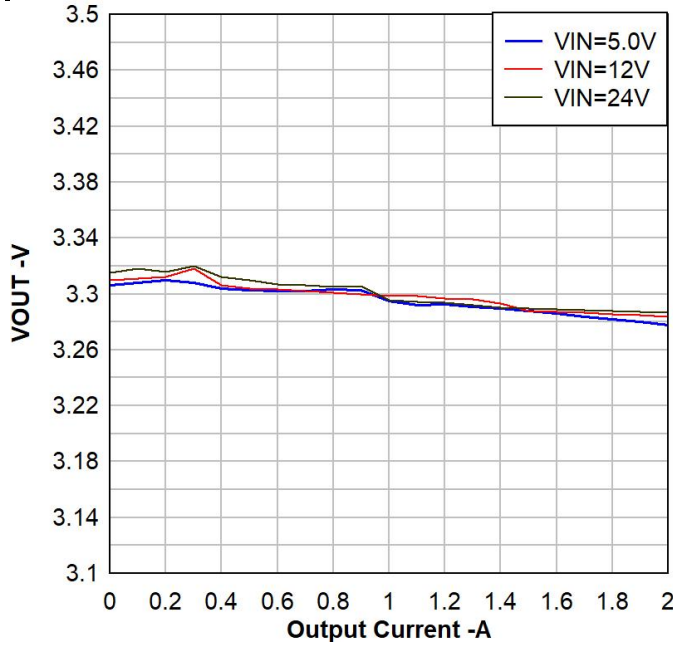


Figure 13. V_{OUT}=3.3V, Regulation, L=4.7uH, LP6462S

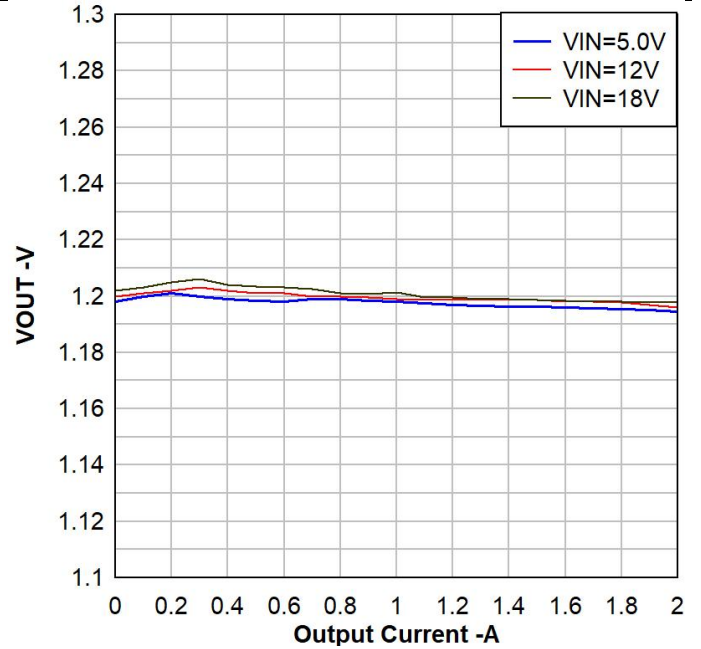
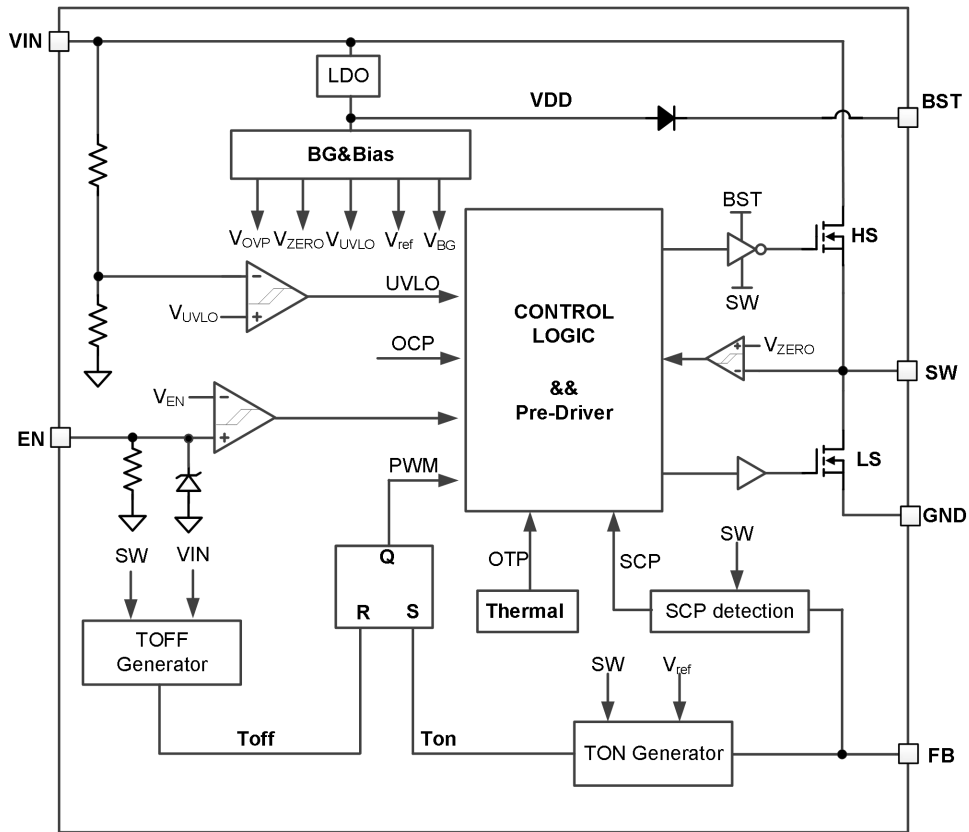


Figure 14. V_{OUT}=1.2V, Regulation, L=2.2uH, LP6462S



Functional Block Diagram





Detailed Description

Overview

The LP6462SX is a 2A synchronous buck converter series, supporting 4.2-32V input voltage range. The adaptive COT control scheme enables fast transient respond and minimizes the output capacitance. The LP6462S supports both aluminum polymer capacitors and low-ESR ceramic capacitors without external compensation circuit. The LP6462S automatically transfers between PFM and PWM according to the output current to achieve high light load efficiency while the LP6462SF is in FPWM mode to minimize the output ripple across the whole load range.

Under Voltage Lockout (UVLO)

When the input voltage V_{IN} is lower than the UVLO threshold, all functions are shut down. When the input voltage is higher than the UVLO rising threshold, the LP6462S can be enabled by the EN pin.

EN Control

The EN pin can be used to control the system power-up sequence. A precise voltage reference is used as the threshold. When the V_{IN} is above the UVLO threshold and EN voltage rises above the EN pin logic high threshold (1.2V typically), the LP6462S enables all the internal circuits, delays for 250us, and begins the soft-start (refer to Soft-start section for more details).

The EN pin has an internal 1000k Ω pull-down resistor to ground.

Soft-start

The LP6462S integrates soft-start function with a typical time of 600us (t_{ss}). After passing the UVLO threshold and enabled by the EN pin with the 250us delay(t_d), the internal reference voltage ramps from zero to the V_{ref} in 600us and the output voltage ramps up accordingly.

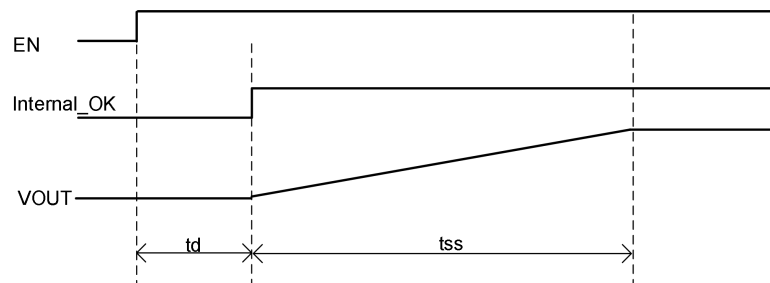


Figure 15. Soft Start Sequence

Constant-ON Time (COT) Control Scheme

The LP6462S integrates the COT control scheme for pseudo-fixed- frequency operation when operating in continuous conduction mode (CCM). Refer to the Functional Block Diagram for better understanding of the operation. The internal on-time (TON) generator block monitors the FB-pin voltage and turns on the high-side MOSFET to start a switching cycle, when the FB-pin voltage drops to an internal reference voltage V_{ref} . Then the internal circuits start to calculate the on-time of the high-side MOSFET, which is proportional to the input voltage and inversely proportional to the output voltage. Once the on-time is finished, the TOFF generator turns off the high-side MOSFET and turns on the low-side MOSFET.

PFM Operation

The LP6462S is designed to maintain high efficiency at light load by adopting pulse-frequency modulation (PFM). In the PFM, the switching cycle is still initiated by the TON generator monitoring the FB-pin voltage. The high-side MOSFET is turned on for TON time and then turned off, followed by turning on the low-side MOSFET. The inductor current falls when the low-side MOSFET is on. When the inductor current reaches zero, detected by the zero-current detection (ZCD) comparator, the low-side MOSFET is turned off, together with the high-side MOSFET. Both MOSFETs remains off until a new switching cycle begins, determined by TON generator. As the load current decreases, the duration for both MOSFETs to remain off increases, leading to a lower switching frequency and higher power efficiency.



FPWM Operation

The LP6462SF/LP6462SHF is designed to work at FPWM to maintain the good load regulation and transient performance. When the output decreases, the inductor is allowed to flow from the output to the ground plane. In this way, the switching frequency is kept the same even without load.

The FPWM operation mode reduced the output ripple under light load at the cost of lower light load efficiency.

Bootstrap Capacitor

The LP6462S integrates two N-MOSFET to achieve high efficiency. The high-side MOSFET is powered by the bootstrap capacitor C_{BST} , which is between the BST pin and SW pin.

Over Current Protection and Short Circuit Protection

The LP6462S protects an over current situation by limiting the inductor valley current. The current of low-side MOSFET is monitored all the time to sense the inductor valley current when the LP6462S is enabled. The high-side MOSFET cannot be turned on if the valley current is higher than the low-side valley current limit, protecting the inductor current from further increasing. The inductor current is limited to the valley current limit plus a half of the inductor ripple current.

The SCP is realized by monitoring the FB-pin voltage when the inductor current is limited. Once the output load draws more current than the current limit, the output voltage drops. When the FB voltage drops to 50% of the V_{ref} for 1-ms, the LP6462S shuts down. The LP6462S will restart after a typical 10-ms hiccup waiting time. If the SCP condition still holds after soft-start, the LP6462S shutdown again, repeating the hiccup operation.

When the over current condition is removed, the output voltage returns to normal operation.

Thermal Protection

The LP6462S has a thermal protection function. The device will shut down when the internal temperature is higher than 160°C and will restart after the temperature drops below 135°C.



Application Information

Design Requirements

The table 1 shows the design parameters for a typical 5V output voltage in the IPC application.

Table 1 Design Parameters

Parameter	Target
Input voltage range	9~30V
Output voltage	5V
Transient ripple	±200mV
Operating frequency	1000kHz

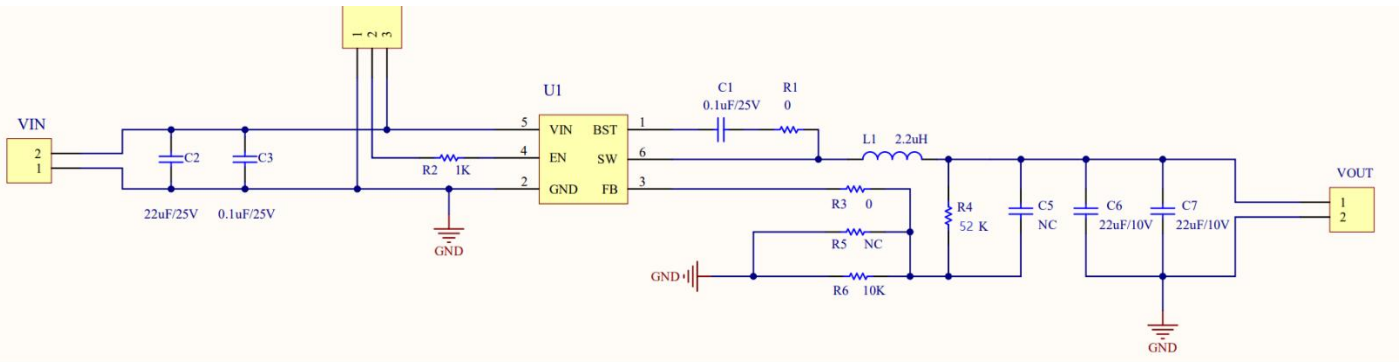


Figure 16. Typical schematic

Output Voltage Setting

The output voltage can be programmed by adjusting the external resistor divider R_{UP} and R_{DOWN} according to the equation below:

$$V_{OUT} = \left(\frac{R_{UP}}{R_{DOWN}} + 1 \right) * V_{ref}$$

When the output voltage is in regulation, the typical voltage at FB pin is 0.6V.

For better accuracy, the R_{DOWN} is recommended to be lower than 100kΩ to ensure the current flowing through R_{DOWN} is at least 100 times larger than the FB pin leakage current.

For a 5V-output application, a 10kΩ R_{DOWN} is selected and the R_{UP} is 73kΩ.

A resistor with higher than 1kΩ but lower than 100kΩ should be placed between the resistor divider and FB pin if a C_{ff} capacitor is soldered.

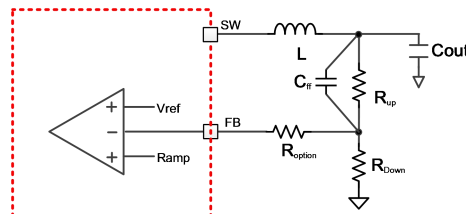


Figure 17. FB connection

EN Design



The LP6462S allows the user to design a precise VIN voltage to enable the converter during power on. The startup sequence can be designed by adjusting the resistor divider of R_{UP_EN} and R_{DOWN_EN} with the equation below,

$$V_{EN} = \frac{1000k\Omega // R_{DOWN_EN}}{R_{UP_EN} + 1000k\Omega // R_{DOWN_EN}} * V_{IN}$$

where V_{EN} is the EN rising threshold voltage at which the converter is enabled, which is 1.2V typically. A 47pF-1nF capacitor is recommend to be soldered in parallel with the R_{EN_DOWN} to avoid the high-frequency noise influence from the switching node.

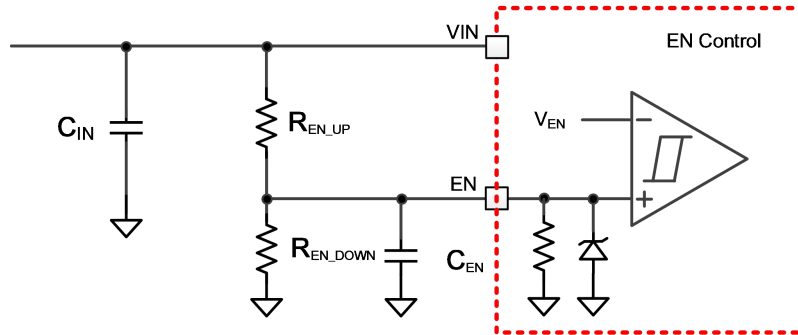


Figure 18. EN connection

Inductor and Output Capacitor Setting

The inductor ripple is calculated by the equation below:

$$I_{PP} = \left(\frac{V_{OUT}}{L * F_{SW}} * \frac{V_{IN} - V_{OUT}}{V_{IN}} \right)$$

To get a better efficiency, the inductor ripple is recommended to be controlled under 40% of the output current to minimize the AC loss of the inductor and power MOSFETs.

For a typical 12V input voltage and 5V output voltage, a low DCR value, 2.2-μH inductor is recommended.

The output capacitor not only impacts the output ripple but also the loop stability. Please follow the design rules in the table below. A feedforward capacitor C_{FF} can be selected to improve the transient behavior. The typical capacitance can be 10-100pF. For this design, 10V, X5R, 22μF capacitors (GRM21BR61A226ME51) from Murata are soldered at the VOUT to GND. Multiple capacitors should be soldered to keep the system stable because of the voltage rating effect.

Table 2 Recommend R/L/C values (1MHz)

Vout	Inductor-L	Cout	R _{UP}	R _{DOWN}	R _{option}	C _{ff}
1.2V	1μH/1.2μH	22μF*1	10 kΩ	10 kΩ	0 Ω	NA
3.3V	1.5μH~3.3μH	22μF*2	45 kΩ	10 kΩ	1~10 kΩ	10-100pF
5.0V	2.2μH ~6.8μH	22μF*2	73 kΩ	10 kΩ	1~10 kΩ	47-100pF

Table 3 Recommend R/L/C values (500kHz)

Vout	Inductor-L	Cout	R _{UP}	R _{DOWN}	R _{option}	C _{ff}
1.2V	1.5μH/2.2μH	22μF*1	10 kΩ	10 kΩ	0 Ω	NA
3.3V	2.2μH~4.7μH	22μF*2	45 kΩ	10 kΩ	1~10 kΩ	10-100pF
5.0V	4.7μH ~10μH	22μF*2	73 kΩ	10 kΩ	1~10 kΩ	47-100pF

Bootstrap capacitor

A 0.1-μF ceramic capacitor is needed to supply power for the high-side N-MOSFET driver. The capacitor should be at least 10V.

Input capacitor



A typical 22- μ F ceramic capacitor is needed to serve as the bulk capacitor at the VIN pin. An additional 0.1 μ F is strongly recommended to provide additional high frequency filtering and should be placed to the VIN pin and GND as close as possible.

Application Waveforms (Vin=12V, L=4.7 μ H, Cout=22 μ F*2, LP6462SH)

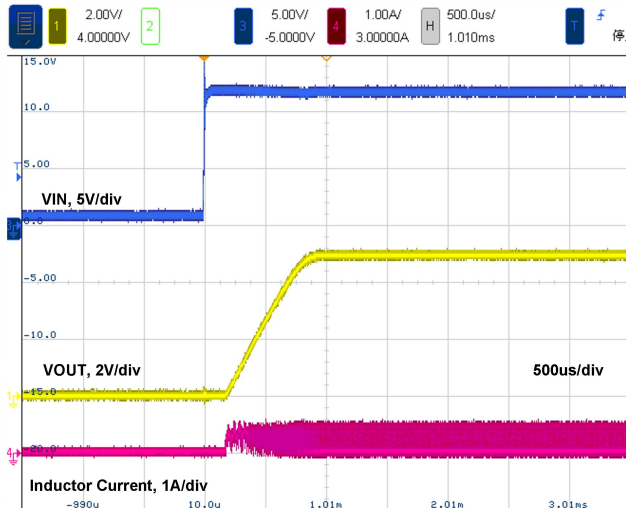


Figure 19. Startup by VIN, 50 Ω load

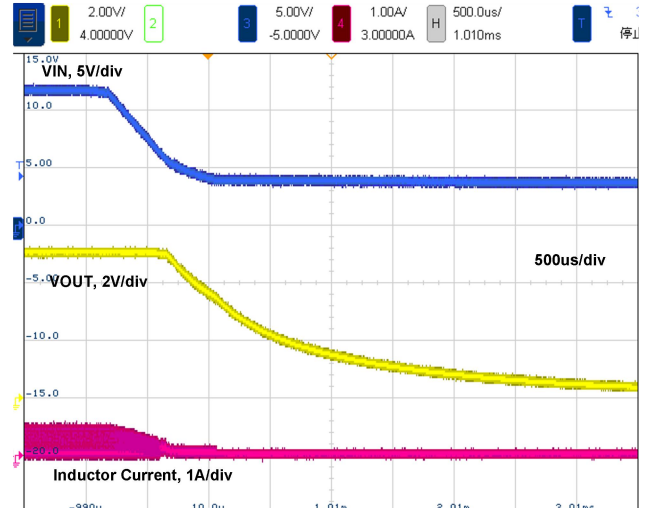


Figure 20. Shutdown by VIN, 50 Ω load

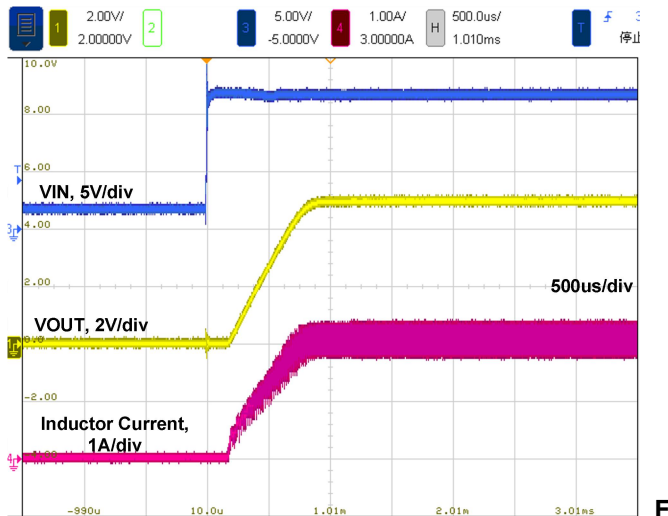


Figure 21. Startup by VIN, 2.5 Ω load

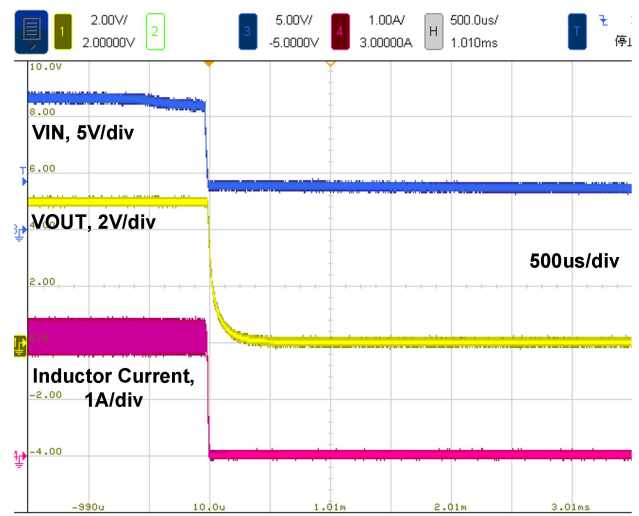


Figure 22. Shutdown by VIN, 2.5 Ω load

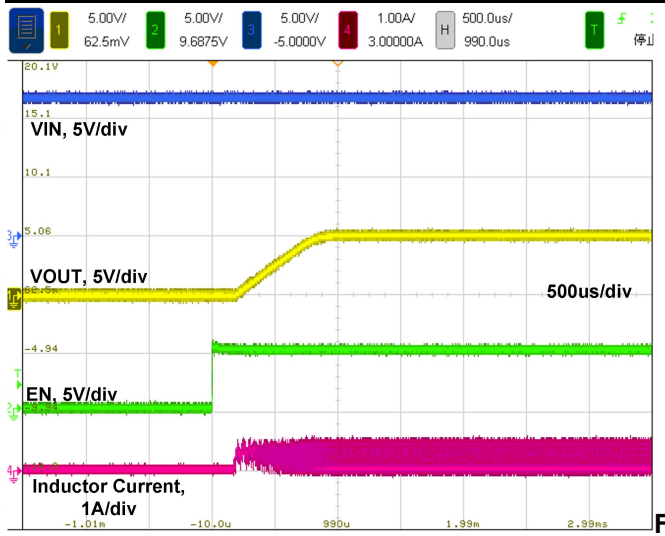


Figure 23. Startup by EN, 50Ω load

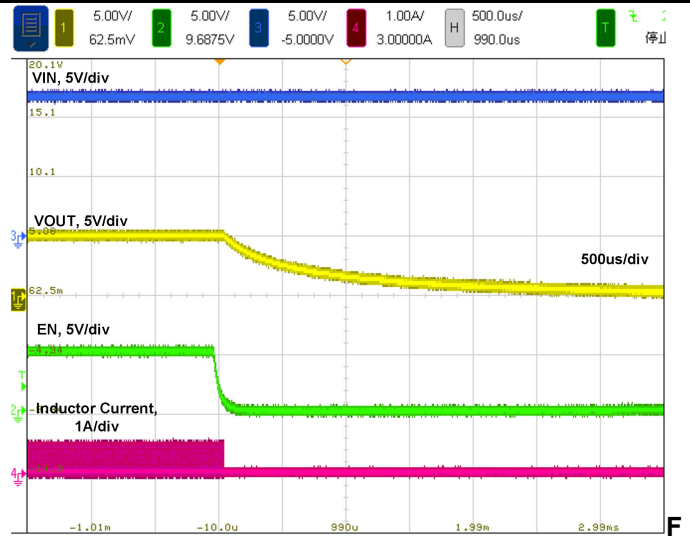


Figure 24. Shutdown by EN, 50Ω load

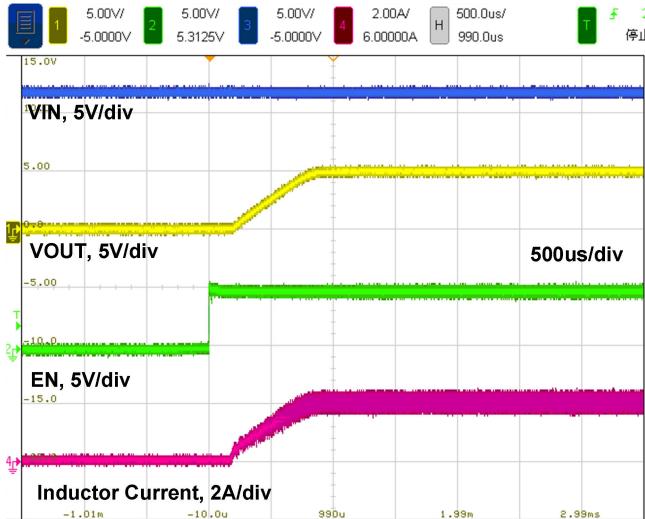


Figure 25. Startup by EN, 2.5Ω load

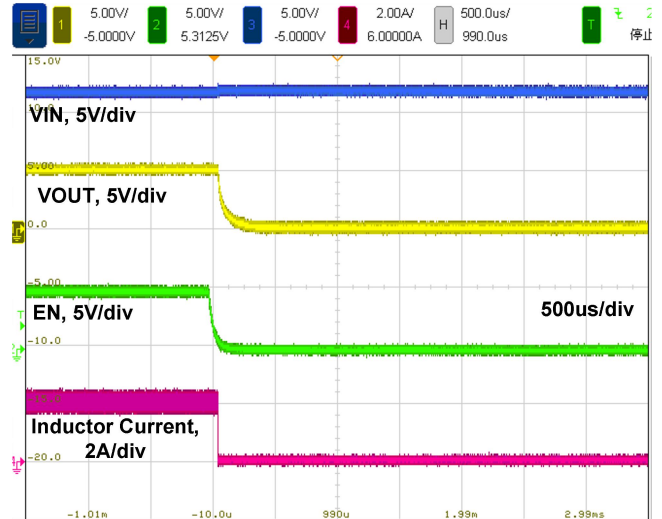


Figure 26. Shutdown by EN, 2.5Ω load

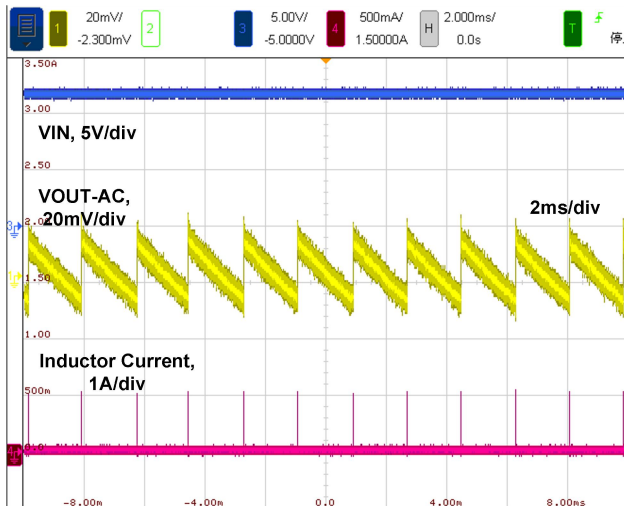


Figure 27. Switching Waveform, 0A load

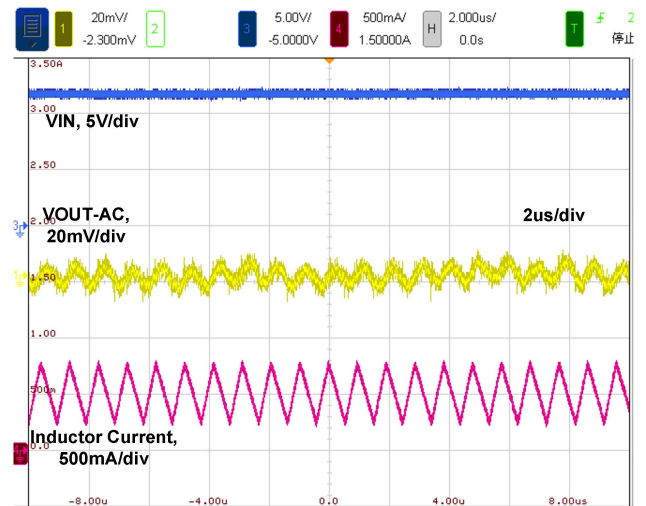


Figure 28. Switching Waveform, 500mA load

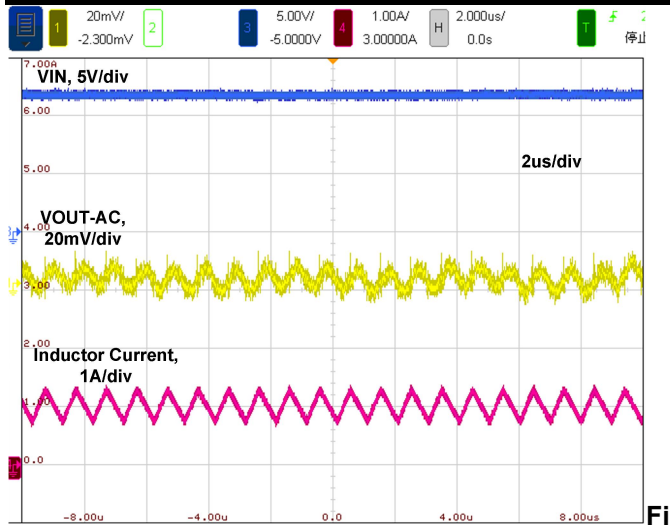


Figure 29. Switching Waveform, 1A load

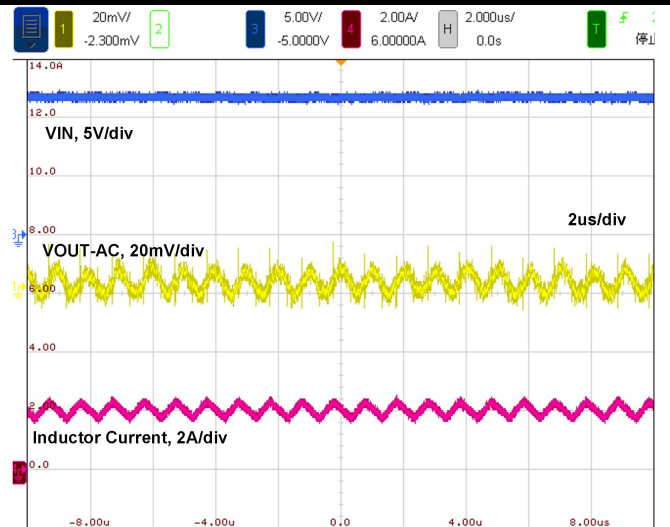


Figure 30. Switching Waveform, 2A load

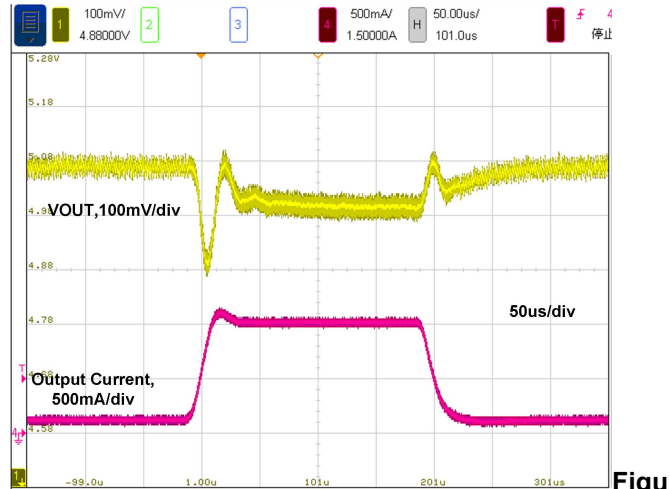


Figure 31. Load Transient, 0.1A-1A-0.1A

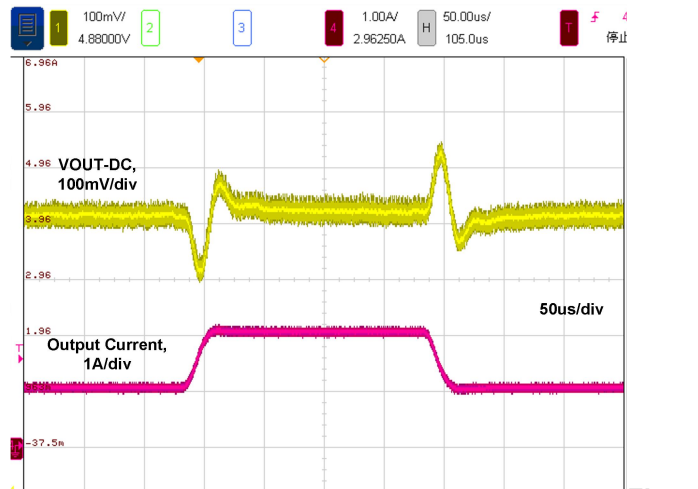


Figure 32. Load Transient, 1A-2A-1A

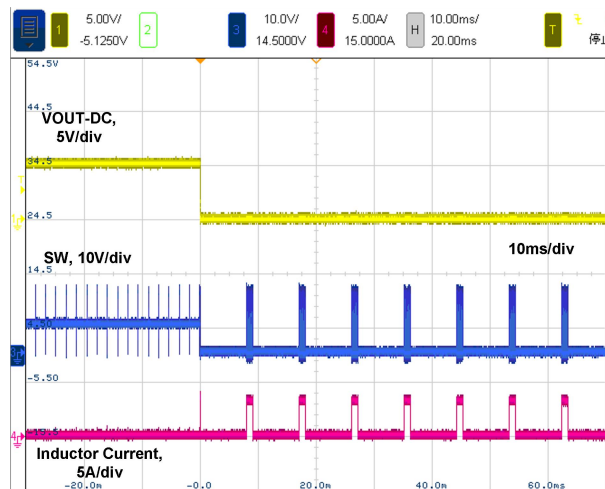


Figure 33. SCP Happen, Hiccup Operation

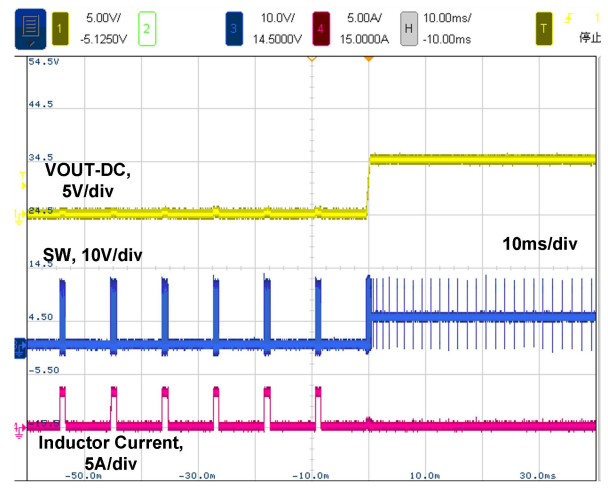


Figure 34. SCP Recovery



PCB Layout Guidelines

Proper layout of the components to minimize high frequency current path loop is important to prevent electrical and magnetic field radiation and high frequency resonant problems. Follow this specific order carefully to achieve the proper layout.

- Place input capacitor (C_2 and C_4) as close as possible to VIN pin and GND pin and use shortest copper trace connection or GND plane.
- Put output capacitor near to the inductor output terminal and the device. Ground connections need to be tied to the IC ground with a short copper trace or GND plane
- Place inductor input terminal to SW pin as close as possible and limit SW node copper area to lower electrical and magnetic field radiation. Do not use multiple layers in parallel for this connection. Minimize parasitic capacitance from this area to any other trace or plane.
- R_1 is reserved to slow down the switching speed for noise sensitive applications and R_3 with higher than $1k\Omega$ resistor should be soldered if the feedforward capacitor is soldered at the same time.

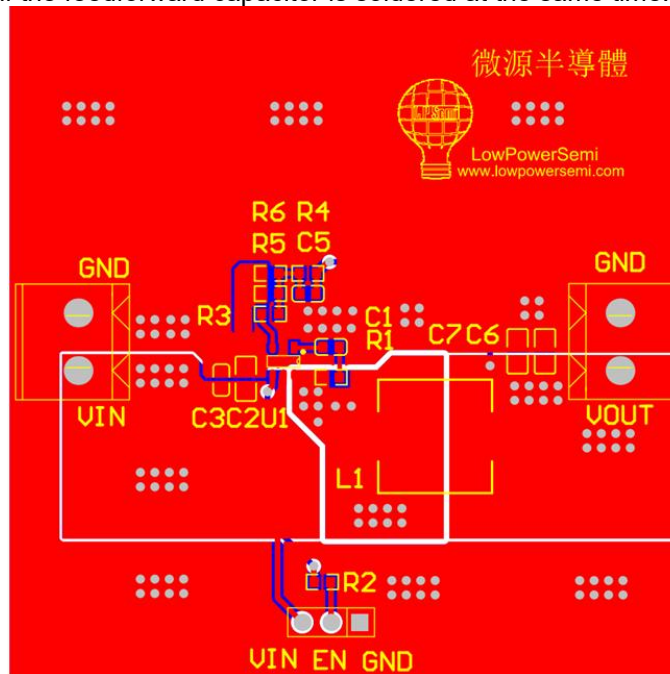
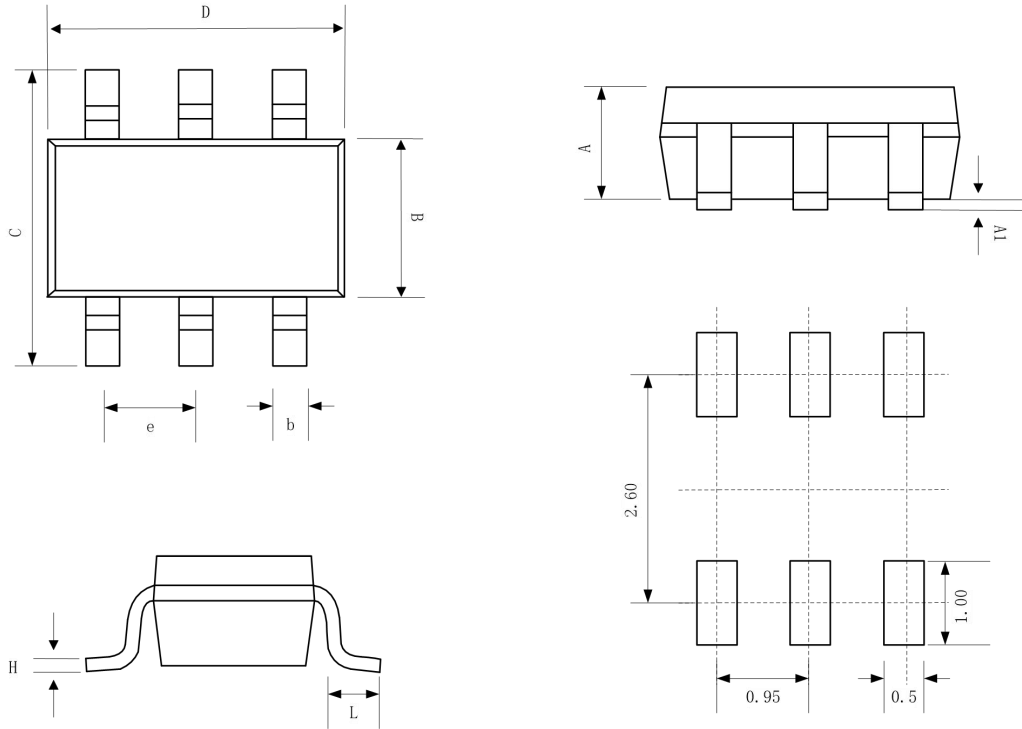


Figure 35 Layout example



Packaging Information

1.6x2.9 SOT23-6 package



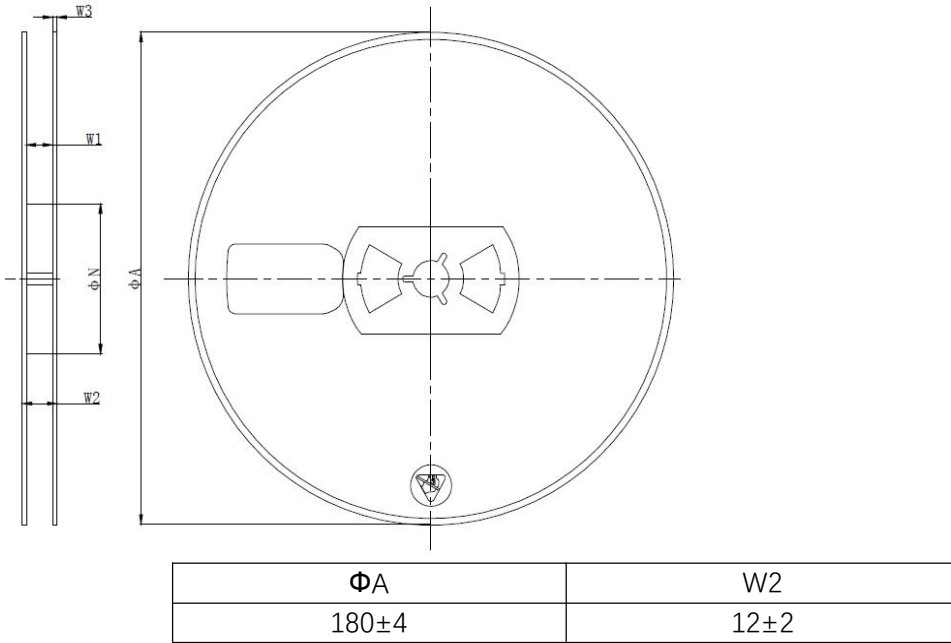
Recommended Land Pattern

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.889	1.100	1.295
A1	0.000	0.050	0.152
B	1.397	1.600	1.803
b	0.28	0.35	0.559
C	2.591	2.800	3.000
D	2.692	2.920	3.120
e	0.95BSC		
H	0.080	0.152	0.254
L	0.300	0.450	0.610

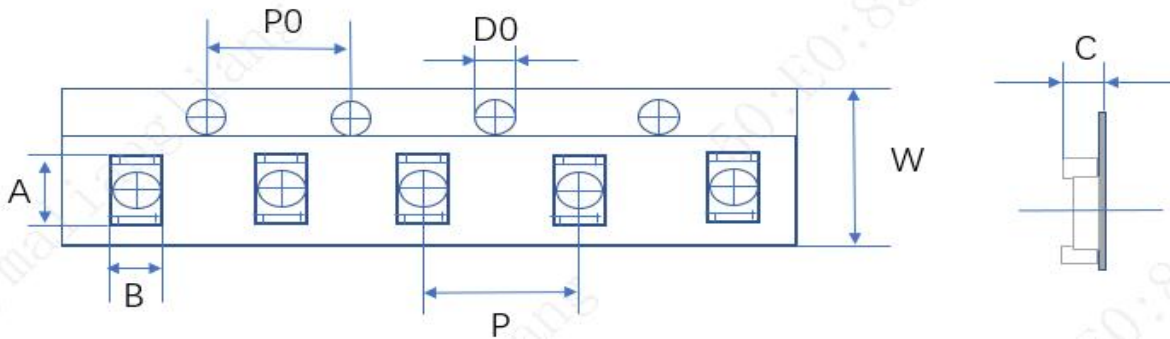


Tape and Reel information

REEL DIMENSIONS (Unit:mm)

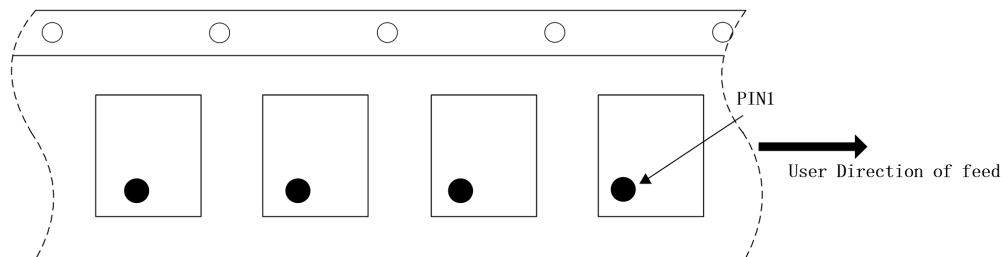


TAPE DIMENSIONS (Unit:mm)



口袋宽度A		口袋长度B		编带孔中心间距P0		IC中心间距P		孔径D0		编带宽度W		编带厚度C	
尺寸(mm)	公差	尺寸(mm)	公差	尺寸(mm)	公差	尺寸(mm)	公差	尺寸(mm)	公差	尺寸(mm)	公差	尺寸(mm)	公差
3.2	±0.2	3.26	±0.2	4	±0.1	4	±0.1	1.5	±0.15	8	±0.3	1.4	±0.2

PIN1 AND TAPE FEEDING DIRECTION





Revision History

Revision	Date	Change Description
Rev 1p0	10/5/2022	First release version
Rev 1p1	12/18/2023	1: VIN, SW, BST voltage range update 2: Add tape and reel information
Rev 1p2	12/29/2023	1 : V_{ref} update 2: "Output voltage setting" section update
Rev 1p3	2/10/2025	1 : Add MSL information 2 : Add LP6462S part number and Top Marking