SY26406SXC

High Efficiency, 0.6A, 100V Input Synchronous Step Down Regulator

General Description

The SY26406 develops a high efficiency synchronous step-down DC/DC converter capable of delivering 0.6A current. The SY26406 operates over a wide input voltage range from 7V to 100V and integrates a main switch and a synchronous switch with very low $R_{DS(ON)}$ to minimize the conduction loss. The SY26406 always operates under continuous condition mode. The SY26406 adopts the instant PWM architecture to achieve fast transient responses for high step down applications.

Applications

- Isolated Telecom Bias Supply
- Secondary High Voltage Post Regulator
- Automotive Systems

Features

- Wide Input Voltage Range: 7-100V
- Internal 500mΩ Main Switch and 285mΩ Synchronous Switch
- 0.6A Output Current Capability
- COT Ripple-Based Control to Achieve Fast Transient Responses
- Programmable Switching Frequency Range: 200kHz~1MHz
- 2ms Internal Soft-start Limits the Inrush Current
- Accurate Feedback Set Point: 1.225V±2%
- Cycle-by-cycle Peak/Valley Current Limit
- Cycle-by-cycle Reverse Current Limit
- Auto Recovery for Over Temperature (OTP)
- RoHS Compliant and Halogen Free
- Compact Package DFN4×4-8

Typical Applications

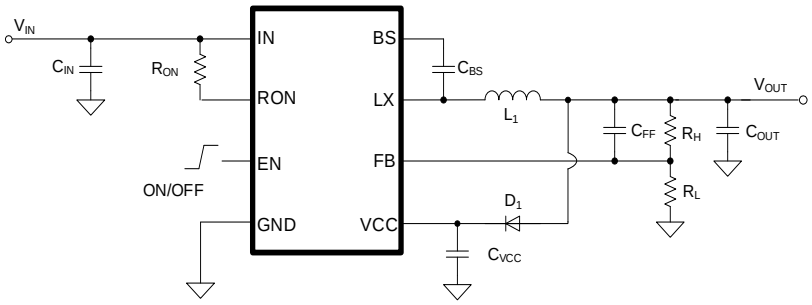


Figure 1. Typical Application Circuit

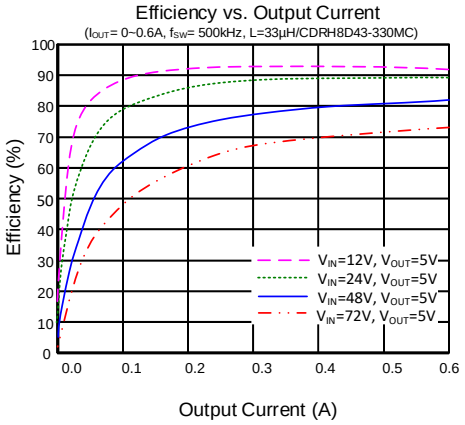


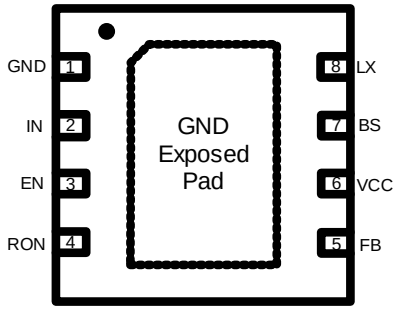
Figure 2. Efficiency vs. Output Current

Ordering Information

Ordering Part Number	Package Type	Top Mark
SY26406SXC	DFN4×4-8 RoHS Compliant and Halogen Free	**CHG*xyz***

x = year code, y = week code, z = lot number code

Pinout (top view)



Pin Description

Pin Name	Pin Number	Pin Description
GND	1, Exposed Pad	Ground pin.
IN	2	Input pin. Decouple this pin to the GND with a low ESR ceramic capacitor.
EN	3	Enable control pin. This pin can also be used for programming V_{IN} turn on voltage with the resistor divider. The device has an accurate 1.225V rising threshold.
RON	4	Connect a resistor from this pin to the IN to set the top switch ON time. The switching frequency can be calculated using the following equation: $f_{sw}(kHz) = \frac{11 \times V_{OUT}(V) + 500}{R_{ON}(M\Omega)}$
FB	5	Output feedback pin. Connect this pin to the center point of the output resistor divider (as shown in Figure 1) to program the output voltage: $V_{OUT}=1.225\times(1+R_H/R_L)$
VCC	6	Supply input of the internal LDO.
BS	7	Boot-strap pin. Supply high side gate driver. Connect a 0.1μF ceramic capacitor between the BS pin and the LX pin.
LX	8	Inductor pin. Connect this pin to the switching node of the inductor.

Block Diagram

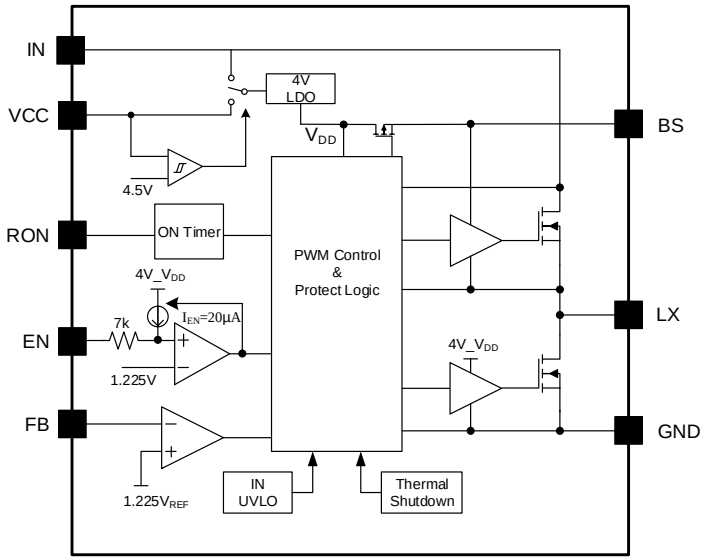


Figure 3. Block Diagram

Absolute Maximum Ratings

Parameter (Note 1)	Min	Max	Unit
IN	-0.3	100	V
EN, LX, RON	-0.3	IN + 0.3	
BS-LX	-0.3	6	
FB	-0.3	6	
VCC	-0.3	30	
LX, 50ns duration	IN+3	GND-5	
Junction Temperature, Operating	-40	150	°C
Lead Temperature (Soldering,10s)		260	
Storage Temperature	-65	150	

Thermal Information

Parameter (Note 2)	Typ	Unit
θ_{JA} Junction-to-Ambient Thermal Resistance	44.5	°C/W
θ_{JC} Junction-to-Case Thermal Resistance	22.1	
P_D Power Dissipation T_A = 25°C	2.8	W

Recommended Operating Conditions

Parameter (Note 3)	Min	Max	Unit
IN	7	100	V
Ambient Temperature	-40	85	°C
Junction Temperature	-40	125	

Electrical Characteristics

(V_{IN} = 48V, V_{OUT} = 5V, L = 33μH, C_{OUT} = 10μF, I_{OUT} = 0.6A, unless otherwise specified. Typical value corresponds to T_J = 25°C. Minimum and maximum limits apply over -40°C to 125°C junction temperature range.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		7		100	V
Input UVLO Rising Threshold	$V_{IN,UVLO}$		5.8	6.3	6.8	V
Input UVLO Hysteresis	V_{HYS}		0.15	0.25	0.35	V
Shutdown Current	I_{SHDN}	EN=0		8	30	μA
Feedback Reference Voltage	V_{REF}		1.2	1.225	1.25	V
FB Input Current	I_{FB}	V_{FB}=3.3V	-100		100	nA
Top FET RON	$R_{DS(ON)1}$			500		mΩ
Bottom FET RON	$R_{DS(ON)2}$			285		mΩ
Top FET peak Current Limit	$I_{LIM,TOP}$		0.9	1.2	1.5	A
Bottom FET Valley Current Limit	$I_{LIM,BOTTOM}$		0.6	0.8	1	A
Negative Current Limit	$I_{LIM,NEG}$		-480	-650	-820	mA
VCC Input Rising UVLO Threshold	$V_{VCC,UVLO}$			4.5		V
VCC Input UVLO Hysteresis	$V_{VCC,HYS}$			0.3		V
EN Rising Threshold	V_{EN}		1.185	1.225	1.265	V
EN Hysteresis Input Current	$I_{EN, HYS}$		-10	-20	-29	μA
Switching Frequency	f_{SW}	V_{IN}=48V, R_{ON}=1.1MΩ	350	500	650	kHz
Min ON Time	t_{ON}			90		ns
Min OFF Time	t_{OFF}			200		ns
Thermal Shutdown Temperature	T_{SD}			150		°C
Thermal Shutdown Hysteresis	T_{HYS}			15		°C

Note 1: Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: θ_{JA} is measured in accordance with JESD51-2 at T_A = 25°C on a high effective 4-layer PCB built according to JESD51-7 with thermal via.

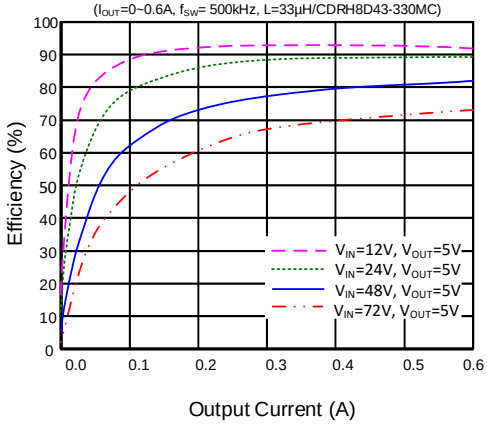
Note 3: The device is not guaranteed to function outside its operating conditions.

Typical Performance Characteristics

(T_A = 25℃, V_{IN} = 48V, V_{OUT} = 5V, L = 33μH, C_{OUT} = 10μF, f_{SW} = 500kHz, unless otherwise noted)

Efficiency vs. Output Current

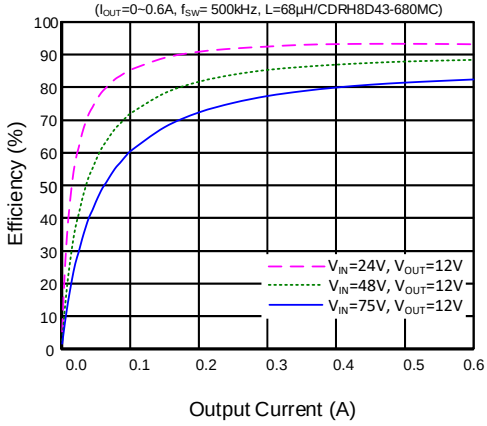
(I_{OUT}=0~0.6A, f_{SW}= 500kHz, L=33μH/CDRH8D43-330MC)



Output Current (A)

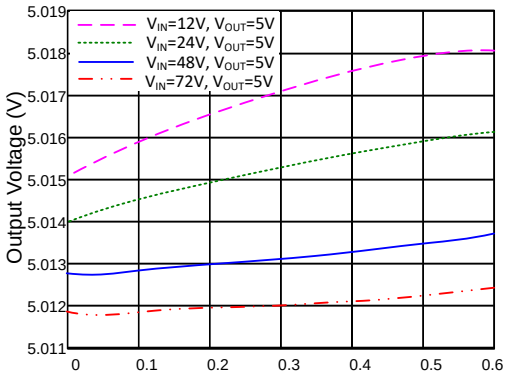
Efficiency vs Output Current

(I_{OUT}=0~0.6A, f_{SW}= 500kHz, L=68μH/CDRH8D43-680MC)



Output Current (A)

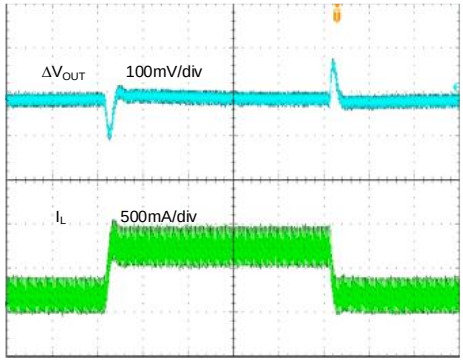
Output Voltage vs Output Current



Output Current (A)

Load Transient

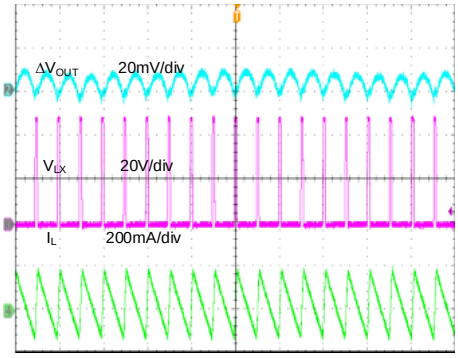
(V_{IN}=48V, V_{OUT}=5V,I_{OUT}=0.06A~0.6A)



Time (100μs/div)

Output Ripple

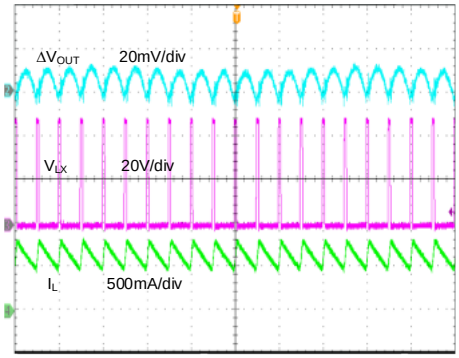
(V_{IN}=48V,V_{OUT}=5V,I_{OUT}=0A)



Time (4μs/div)

Output Ripple

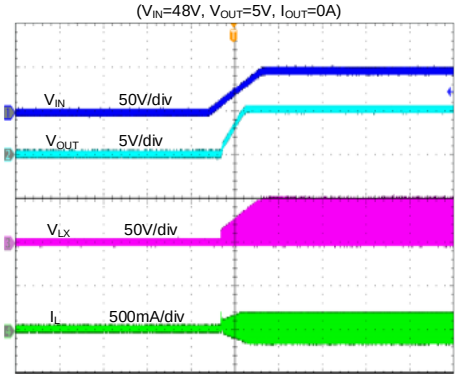
(V_{IN}=48V,V_{OUT}=5V,I_{OUT}=0.6A)



Time (4μs/div)

V_{IN} ON

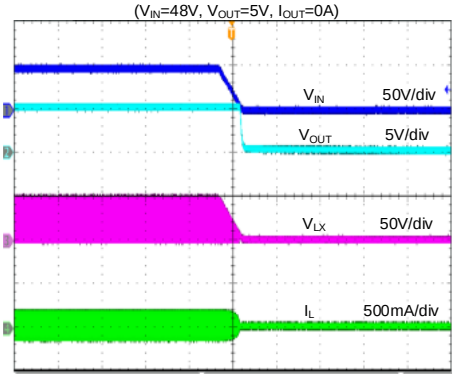
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0A)



Time (4ms/div)

V_{IN} OFF

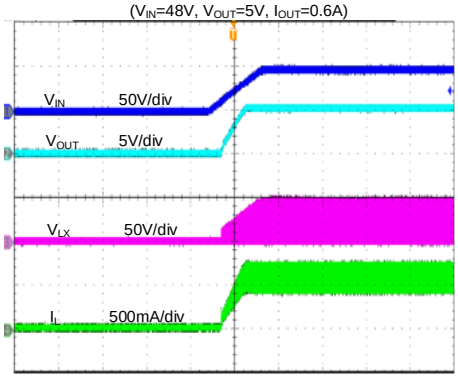
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0A)



Time (200ms/div)

V_{IN} ON

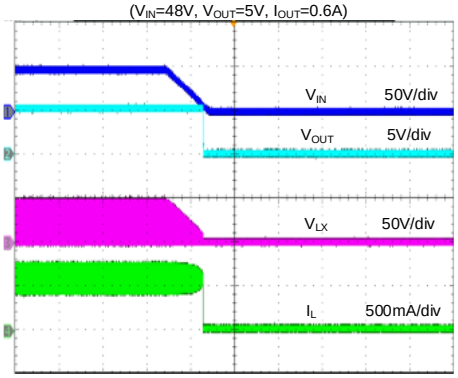
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0.6A)



Time (4ms/div)

V_{IN} OFF

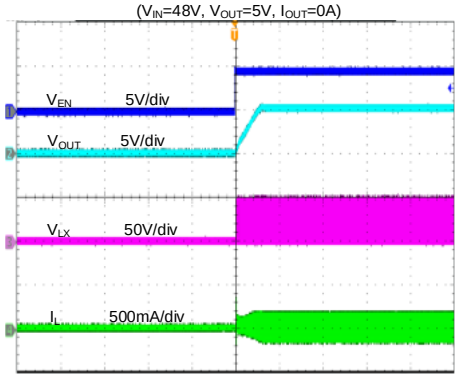
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0.6A)



Time (100ms/div)

EN ON

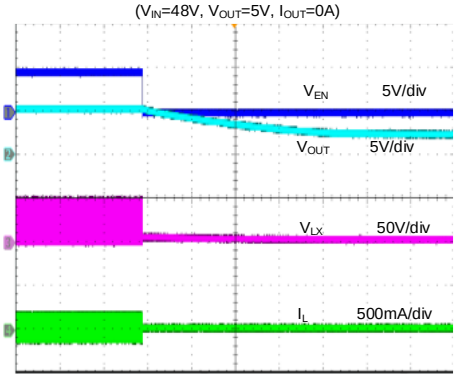
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0A)



Time (4ms/div)

EN OFF

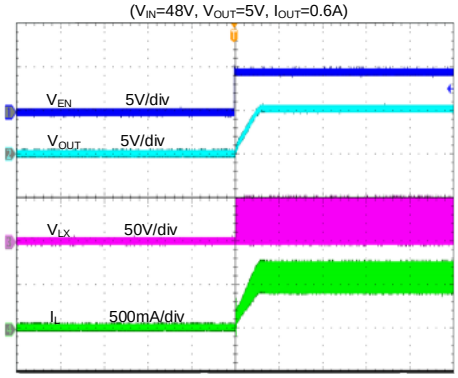
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0A)



Time (200ms/div)

EN ON

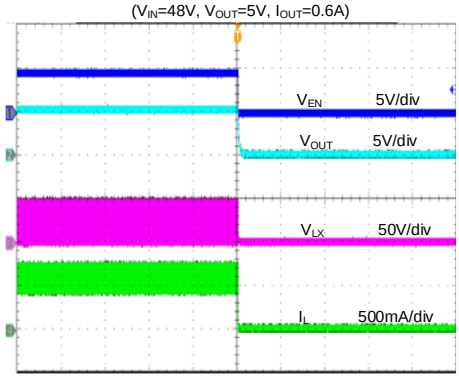
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0.6A)



Time (4ms/div)

EN OFF

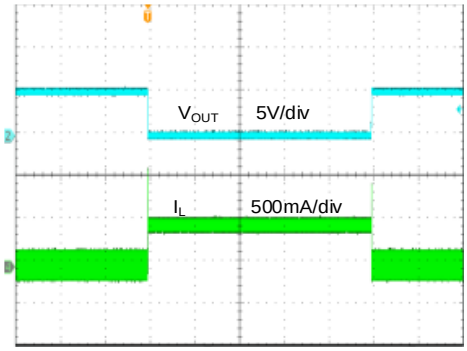
(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0.6A)



Time (4ms/div)

Short Circuit Protection

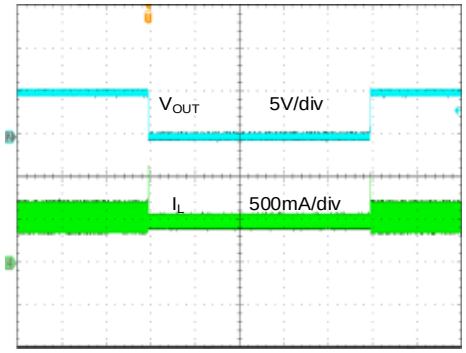
(V_{IN}=48V, V_{OUT}=5V,I_{OUT}=0A~Short)



Time (10ms/div)

Short Circuit Protection

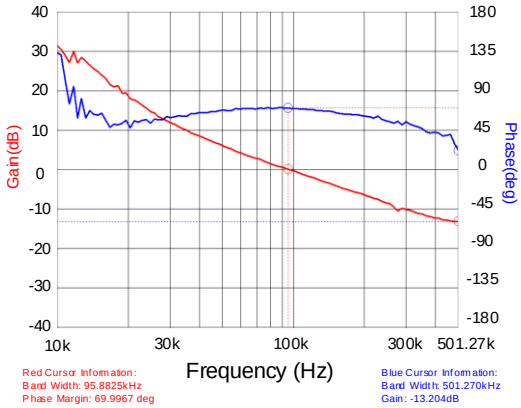
(V_{IN}=48V, V_{OUT}=5V,I_{OUT}=0.6A~Short)



Time (10ms/div)

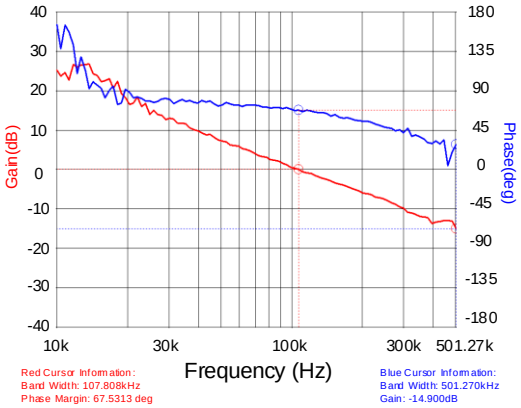
Bode Plot

(V_{IN}=48V, V_{OUT}=5V, I_{OUT}=0.6A , L=33µH)



Bode Plot

(V_{IN}=48V, V_{OUT}=12V, I_{OUT}=0.6A , L=68µH)



Detailed Description

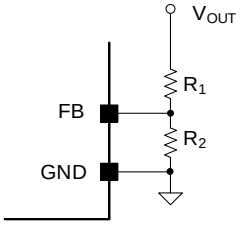
The SY26406 is highly integrated, so only the input capacitor C_{IN}, the output capacitor C_{OUT}, the output inductor L, and the feedback resistors R_H and R_L need to be selected for the targeted application specifications.

Output Voltage Program

Choose R_1 and R_2 to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both R_1 and R_2.

$$V_{OUT} = (1+\frac{R_1}{R_2}) \times V_{FB}$$

1.225V is a typical value for V_{FB}.



Output Inductor L

There are several considerations in choosing this inductor:

1) Choose the inductance to provide a ripple current that is approximately 40% of the maximum output current. The recommended inductance is calculated as:

$$L_1 = \frac{V_{OUT} \times (1 - V_{OUT} / V_{IN\_MAX})}{f_{SW} \times I_{OUT\_MAX} \times 40\%}$$

Where f_{SW} is the switching frequency and I_{OUT_MAX} is the maximum load current.

The SY26406 has high tolerance for ripple current amplitude variation. As a result, the final choice of inductance can vary slightly from the calculated value with no significant performance impact.

2) The saturation current rating of the inductor must be selected greater than the peak inductor current under full load:

$$I_{SAT\_MIN} > I_{OUT\_MAX} + \frac{V_{OUT} \times (1 - V_{OUT} / V_{IN\_MAX})}{2 f_{SW} \times L_1}$$

3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. It is desirable to choose an inductor with smaller DCR to achieve good overall efficiency.

Input Capacitor C_{IN}

The ripple current through the input capacitor is calculated as:

$$I_{CIN\_RMS} = I_{OUT\_MAX} \times \sqrt{D(1-D)}$$

The capacitance of the input capacitor is calculated as:

$$C_{IN} = \frac{I_{OUT} \times V_{OUT} \times (V_{IN} - V_{OUT})}{\Delta V_{IN} \times f_{SW} \times \eta \times V_{IN}^2}$$

ΔV_{IN} is desired input voltage ripple. η is the efficiency.

To minimize the potential noise problem, a typical X5R or better grade ceramic capacitor is placed really close to the IN and the GND pins. Care should be taken to minimize the loop area formed by the C_{IN} and the IN/GND pins. In this case, a 1μF low ESR ceramic capacitor is recommended.

Output Capacitor C_{OUT}

The output capacitor is selected to handle the output ripple noise requirements. Both steady-state ripple and transient requirements must be taken into consideration when selecting this capacitor. It is recommended to use an X5R or a better grade ceramic capacitor with at least 10μF capacitance.

On-time

The on-time for the SY26406 is determined by the R_{ON} resistor, and is inversely proportional to the input voltage, resulting in a nearly constant frequency as V_{IN} is varied over its range. The required on-time adjust resistance for various frequencies and output voltages is given in Table 1.

Frequency vs. R_{ON} Resistor:

$$f_{SW}(kHz) = \frac{11 \times V_{OUT}(V) + 500}{R_{ON}(M\Omega)}$$

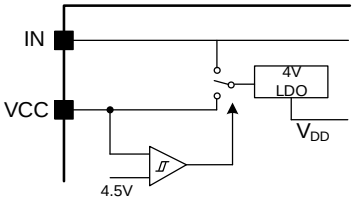
Table 1. On-Time Adjust Resistance for Various Frequencies and Output Voltages

F_{SW} (kHz)	R_{ON}(MΩ)			
	V_{OUT} = 1.8V	V_{OUT} = 5V	V_{OUT} = 12 V	V_{OUT} = 24 V
200	2.6	2.8	3.15	3.8
400	1.3	1.4	1.6	1.9
600	0.85	0.9	1.05	1.3
800	0.65	0.7	0.8	0.95
1000	0.5	0.55	0.65	0.75

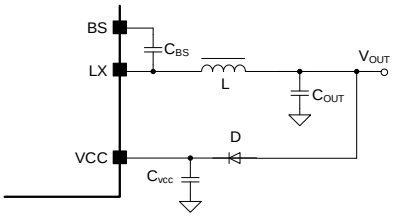
Notice: Final switch frequency is not only affected by component tolerant but also minimum off and on time limit.

Internal LDO Regulator

The SY26406 has two power supply ways for 4V LDO. Upon power up, the 4V LDO regulator is power supplied by V_{IN}. When the voltage on the V_{DD} reaches the under-voltage lockout threshold voltage, the Buck regulator is enabled. After soft start done, if the VCC pin voltage is larger than 4.5V, the power supply of 4V LDO will be switched to VCC. A 0.1μF ceramic capacitor is recommended for C_{VCC} at most applications.



In applications, the input pin (IN) can be connected directly to the line voltages up to 100 Volts, where power dissipation in the 4V LDO regulator is a concern; an auxiliary voltage can be connected to the VCC pin via a diode. Setting the auxiliary voltage to 4.8 -28V will shut off the LDO power supply from IN and reduce internal LDO power dissipation.



Soft-start

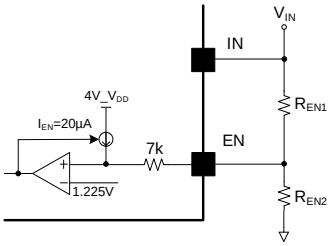
The SY26406 has a built-in soft-start to control the rise rate of the output voltage and limit the input current surge during IC start-up. The typical soft-start time is 2ms.

Adjusting Under Voltage Lockout

The EN pin provides electrical on/off control of the device. Once the EN pin voltage exceeds the threshold voltage, the device will start to operate. If the EN pin voltage is pulled below the threshold, the regulator will stop switching and enter shutdown state. An external set-point voltage divider from V_{IN} to GND can be used for setting the minimum operating voltage of the regulator. Minimum V_{UVLO} value must be greater than 6.5V.

$$V_{IN,UVLO}(V)=(1+\frac{R_{EN1}}{R_{EN2}})\times V_{EN}$$

1.225V is a typical value for V_{EN}.

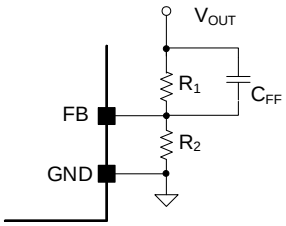


UVLO hysteresis is accomplished with an internal 20μA current source that is switched on or off into the impedance of the set-point divider. When the EN threshold is exceeded, the current source is activated to quickly raise the voltage at the EN pin. The UVLO hysteresis is calculated as

$$V_{HYS}(V)=I_{EN}\times R_{EN1}+I_{EN}\times 7k\times(1+\frac{R_{EN1}}{R_{EN2}})$$

Load Transient Considerations

The SY26406 regulator adopts the instant PWM architecture to achieve good stability and fast transient responses. Adding a C_{FF} ceramic capacitor in parallel with R_1 is recommended.



External Boot-strap Capacitor

This capacitor provides the gate driver voltage for internal high side MOSEFET. A 100nF low ESR ceramic capacitor connected between the BS pin and the LX pin is recommended.

Over Current Protection

The SY26406 provides cycle-by-cycle over current limit on both high side MOSFET and low-side MOSFET. Under over current condition, if the output voltage drops below 33% of set-point, the device will fold back valley current limit to 0.5×typical value.

Over-temperature Protection (OTP)

The device includes over-temperature protection (OTP)

circuitry to prevent overheating due to excessive power dissipation. This will shut down switching operation when the junction temperature exceeds 150°C. Once the junction temperature cools down by approximately 15°C, the IC will resume normal operation after a complete soft-start cycle. For continuous operation, providing adequate cooling so that the junction temperature will not exceed the OTP threshold.

Application Schematic (V_{OUT} = 5V)

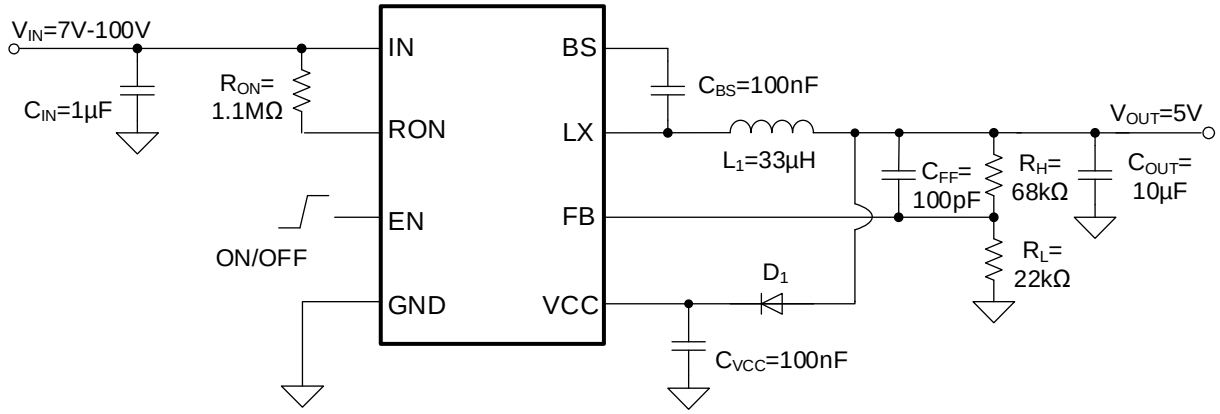


Figure 4. Buck Schematic

BOM List

Designator	Description	Part Number	Manufacturer
C_{IN}	1μF/100V/X7R,1206	C3216X7R2A105K	TDK
C_{OUT}	10μF/25V/X5R, 1206	C3216X5R1E106M	TDK
C_{VCC}	0.1μF/50V/X7R, 0603	C1608X7R1H104K	TDK
C_{BS}	0.1μF/50V/X7R, 0603	C1608X7R1H104K	TDK
C_{FF}	100pF/50V/X5R, 0603	C1608C0G1H101J	TDK
L	33μH, inductor	CDRH8D43-330NC	Sumida
R_{ON}	1.1MΩ, 1%, 0603		
R_H	68kΩ, 1%, 0603		
R_L	22kΩ, 1%, 0603		
D_1	BAT54		

Recommend Table for Typical Applications

V_{OUT}(V)	R_H(kΩ)	R_L(kΩ)	C_{FF}(pF)	L_1/Part Number
5	68	22	100	33μH/CDRH8D43-330NC
12	105	12	220	68μH/CDRH8D43-680NC

Application Schematic (V_{OUT} = 5V)

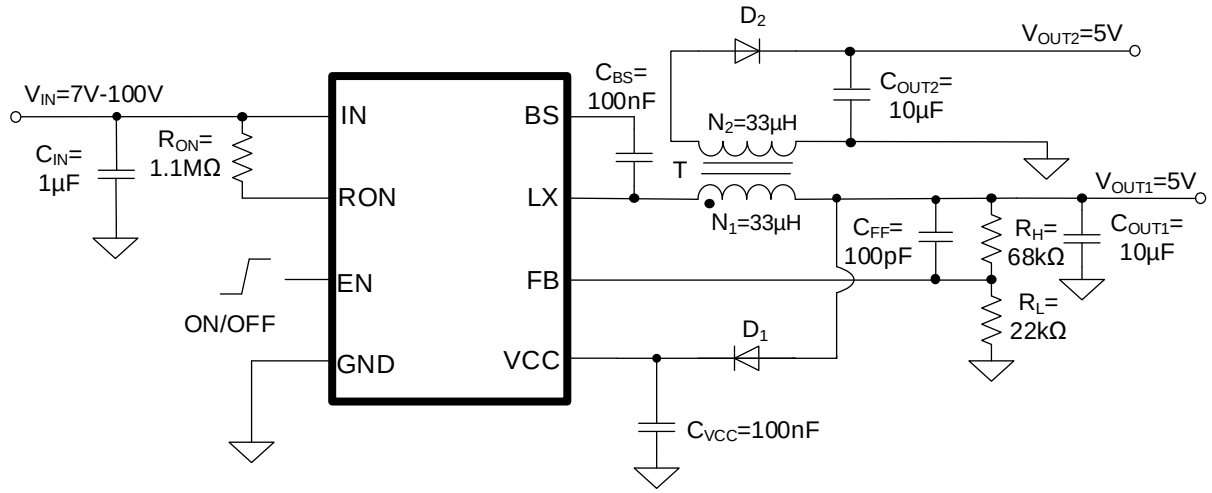


Figure 5. Fly-Buck Schematic

BOM List

Designator	Description	Part Number	Manufacturer
C_{IN}	1μF/100V/X7R,1206	C3216X7R2A105K	TDK
C_{OUT1}	10μF/25V/X5R, 1206	C3216X5R1E106M	TDK
C_{OUT2}	10μF/25V/X5R, 1206	C3216X5R1E106M	TDK
C_{VCC}	0.1μF/50V/X7R, 0603	C1608X7R1H104K	TDK
C_{BS}	0.1μF/50V/X7R, 0603	C1608X7R1H104K	TDK
C_{FF}	100pF/50V/X5R, 0603	C1608C0G1H101J	TDK
T	N_1:33μH, N_2:33μH		
R_{ON}	1.1MΩ, 1%, 0603		
R_H	68kΩ, 1%, 0603		
R_L	22kΩ, 1%, 0603		
D_1	BAT54		
D_2	SS310		

Recommend Table for Typical Applications

V_{OUT}(V)	R_H(kΩ)	R_L(kΩ)	C_{FF}(pF)	T(μH)
5	68	22	100	33
12	105	12	220	68

Application Schematic (V_{OUT} = -5V)

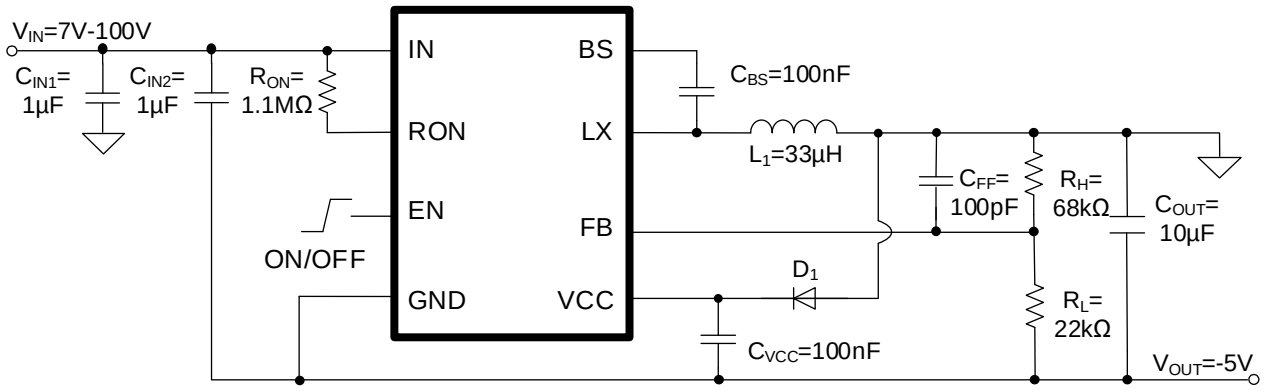


Figure 6. Buck-Boost Schematic

BOM List

Designator	Description	Part Number	Manufacturer
C_{IN1}	1µF/100V/X7R,1206	C3216X7R2A105K	TDK
C_{IN2}	1µF/100V/X7R,1206	C3216X7R2A105K	TDK
C_{OUT}	10µF/25V/X5R, 1206	C3216X5R1E106M	TDK
C_{VCC}	0.1µF/50V/X7R, 0603	C1608X7R1H104K	TDK
C_{BS}	0.1µF/50V/X7R, 0603	C1608X7R1H104K	TDK
C_{FF}	100pF/50V/X5R, 0603	C1608C0G1H101J	TDK
L	33µH, inductor	CDRH8D43-330NC	Sumida
R_{ON}	1.1MΩ, 1%, 0603		
R_H	68kΩ, 1%, 0603		
R_L	22kΩ, 1%, 0603		
D_1	BAT54		

Recommend Table for Typical Applications

V_{OUT}(V)	R_H(kΩ)	R_L(kΩ)	C_{FF}(pF)	L_1/Part Number
5	68	22	100	33µH/CDRH8D43-330NC
12	105	12	220	68µH/CDRH8D43-680NC

Layout Design

For optimal design, follow these PCB layout considerations:

- It is desirable to maximize the PCB copper area connecting to the GND pin to achieve the best thermal and noise performance. If the board space allowed, a ground plane is highly desirable.
- C_{IN} must be close to the pins IN and GND. The loop area formed by C_{IN} and GND must be minimized.
- C_{VCC} should be placed close to the VCC pin and the GND pin.
- The PCB copper area associated with the LX pin must be minimized to avoid the potential noise problem.
- The feedback components R_H and R_L and the trace connecting to the FB pin must not be adjacent to the LX net on the PCB layout to avoid the noise problem.
- If the system chip interfacing with the EN pin has a high impedance state at shutdown mode and the IN pin is connected directly to a power source such as a Li-Ion battery, it is desirable to add a pull-down 1MΩ resistor between the EN and the GND pins to prevent the noise from falsely turning on the regulator at shutdown mode.

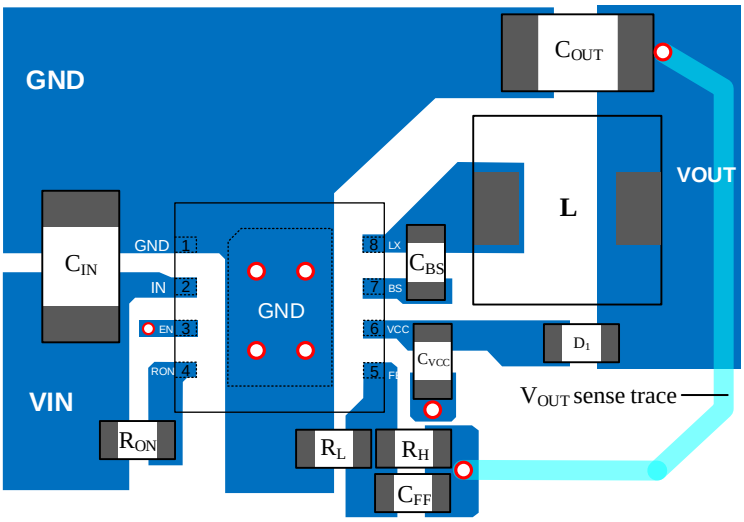
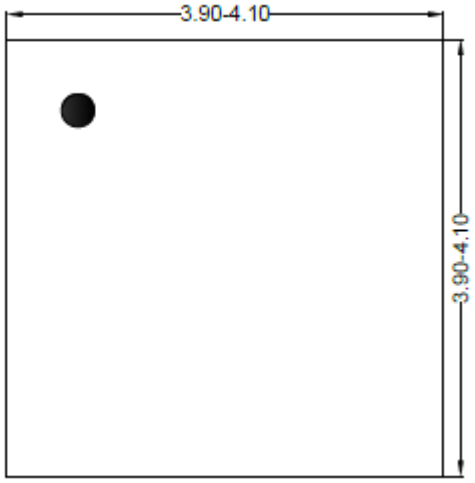
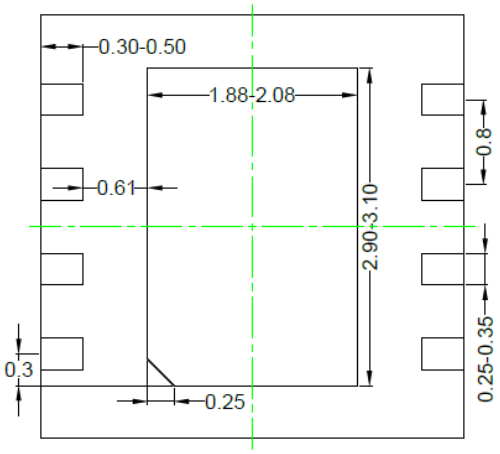


Figure 7. PCB Layout Suggestion

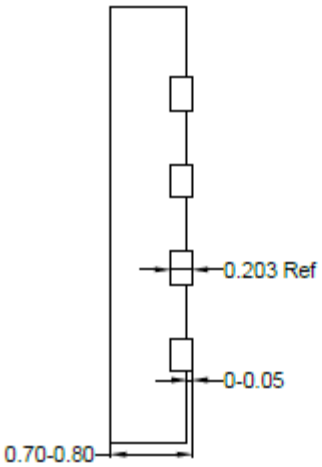
DFN4×4-8 Package Outline & PCB Layout



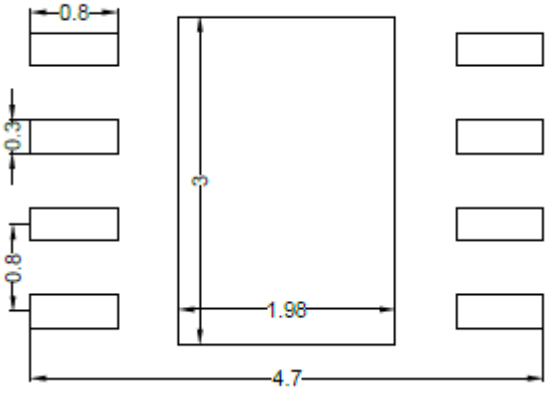
Top View



Bottom View



Side View



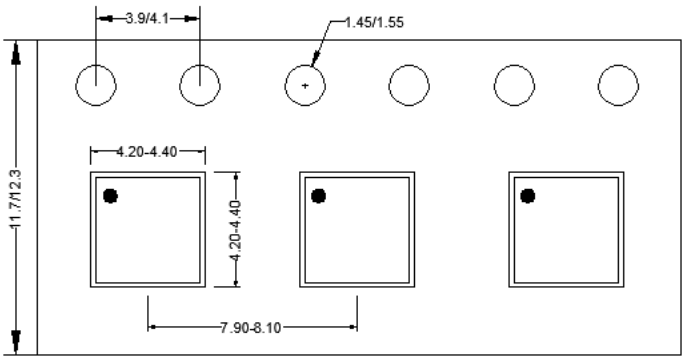
PCB Layout (Reference Only)

Notes: **All dimension in millimeter and exclude mold flash & metal burr.**

Taping & Reel Specification

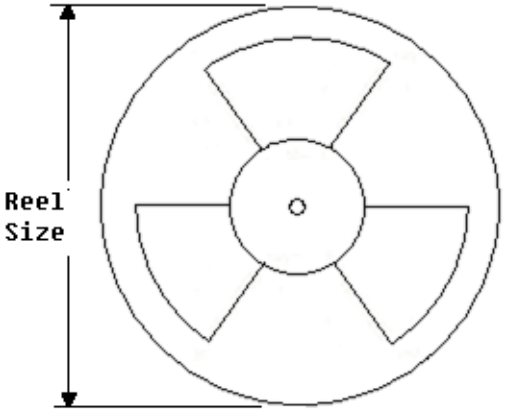
Taping Orientation

DFN4×4-8



Feeding Direction ⟶

Carrier Tape & Reel Specification for Packages



Package type	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
DFN4×4-8	12	8	13"	400	400	5000

Others: NA

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