SY21212A

High Efficiency 1MHz, 2A Current Limit Step-Up Regulator

General Description

The SY21212A high efficiency step-up regulator operates using current mode control, over a wide input voltage range from 3V to 8V. It integrates an N-channel MOSFET with low 130mΩ $R_{DS(ON)}$ to minimize conduction loss.

The 1MHz switching frequency and internal compensation reduce external inductor and capacitor sizes, and the built-in internal soft-start circuitry minimizes inrush current at startup.

The SY21212A is available in a compact SOT23-6 package.

Features

- 3V to 8V Input Voltage Range
- Up to 2A Output Current
- 15 µA Shutdown Current (Max.)
- 100 µA Iq (Typ.)
- Low $R_{DS(ON)}$ for Internal N-Channel MOSFET: 130mΩ
- 1MHz Switching Frequency
- Minimum On-Time: 100ns Typical
- Minimum Off-Time: 100ns Typical
- Internal Soft-Start Limits Inrush Current
- ±2% 0.6V Reference
- RoHS-Compliant and Halogen-Free
- Compact SOT23-6 Package

Applications

- WLED Drivers
- Networking Cards Powered From PCI Or PCI-Express Slots

Typical Application

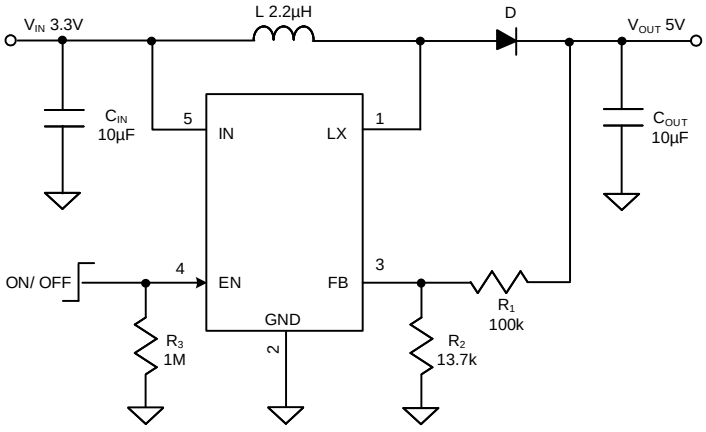


Figure 1. Typical Application Circuit

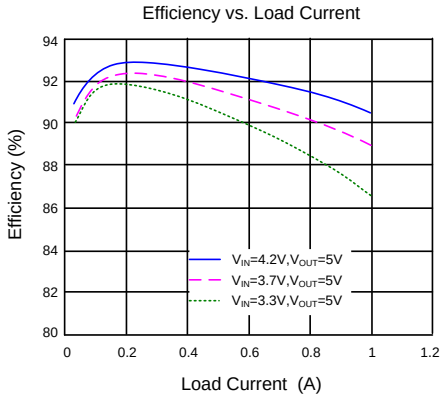


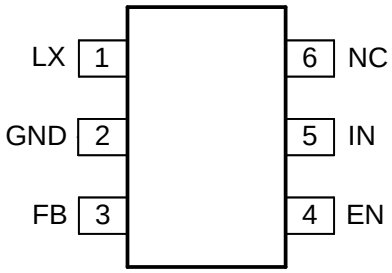
Figure 2. Efficiency vs. Output Current

Ordering Information

Ordering Part Number	Package type	Top Mark
SY21212AABC	SOT23-6 RoHS-Compliant and Halogen-Free	**UB*xyz***

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

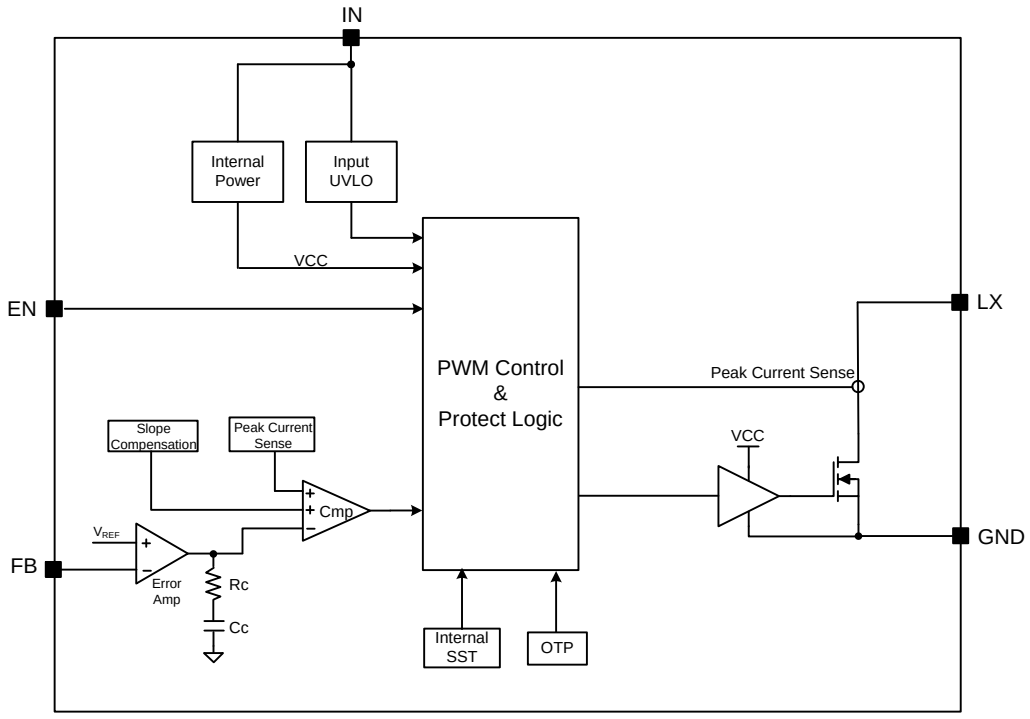
Pinout (top view)



Pin Description

Pin Number	Pin Name	Pin Description
1	LX	Inductor output. Connect an inductor between the IN and LX pins.
2	GND	Ground pin
3	FB	Feedback pin. Connect a resistor R1 between V_{OUT} and FB, and a resistor R2 between FB and GND to program the output voltage: V_{OUT} = 0.6V × (R1/R2+1).
4	EN	Enable pin. A low level disables the device and high level enables it. Do not leave floating.
5	IN	Input pin. Decouple this pin to the GND pin with a 1μF ceramic capacitor.
6	NC	No connection.

Block Diagram



Absolute Maximum Ratings

Parameter (Note1)	Min	Max	Unit
LX, IN, EN	-0.3	18	V
FB	-0.3	3.6	
Lead Temperature (Soldering, 10 sec.)		260	°C
Junction Temperature, Operating	-40	125	
Storage Temperature	-65	150	

Thermal Information

Parameter (Note2)	Typ	Unit
θ_{JA} Junction-to-ambient Thermal Resistance	161	°C/W
θ_{JC} Junction-to-case Thermal Resistance	130	
P_D Power Dissipation T_A=25°C	0.6	W

Recommended Operating Conditions

Parameter (Note3)	Min	Max	Unit
IN	3	8	V
Junction Temperature, Operating	-40	125	°C
Ambient Temperature	-40	85	

Electrical Characteristics

(V_{IN} = 5V, V_{OUT} = 12V, I_{OUT} = 100mA, T_A = 25°C unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		3		8	V
Quiescent Current	I_Q	V_{FB} = 0.66V		100		μA
Shutdown Current	I_{SHDN}	EN = 0			15	μA
Low Side Main FET R_{ON}	$R_{DS(ON)}$			130		mΩ
Main FET Current Limit	I_{LIM1}		2			A
Switching Frequency	f_{SW}		0.8	1	1.2	MHz
Feedback Reference Voltage	V_{REF}		0.588	0.6	0.612	V
FB Pin Input Current	I_{FB}	V_{FB} = 3.6V	-50		50	nA
IN UVLO Rising Threshold	$V_{IN,UVLO}$				1.8	V
UVLO Hysteresis	$U_{VLO,HYS}$			0.1		V
Thermal Shutdown Temperature	T_{SD}			150		°C
Thermal Shutdown Recovery Hysteresis	T_{HYS}			15		°C
EN Rising Threshold	V_{ENH}		1.5			V
EN Falling Threshold	V_{ENL}				0.4	V
EN Pin Input Current	I_{EN}		0		100	nA
Maximum Duty Cycle				90		%

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 may affect device reliability.

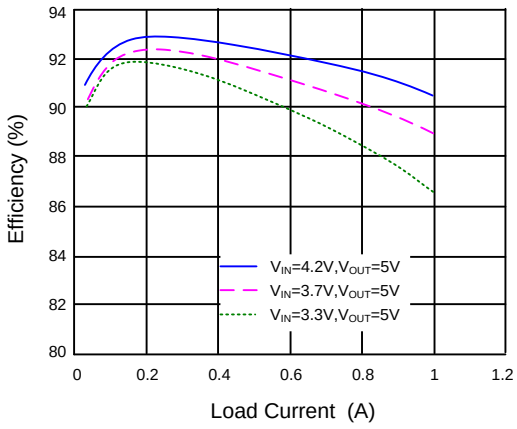
Note 2: θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Test condition: Device mounted on 2” x 2” FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

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

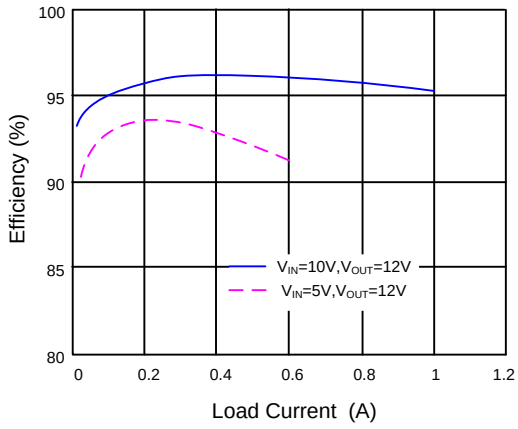
Typical Performance Characteristics

(T_A= 25℃, V_{OUT} = 12V and L = 4.7μH, V_{OUT} = 5V and L = 2.2μH, C_{OUT}= 10μF, unless otherwise specified)

Efficiency vs. Load Current

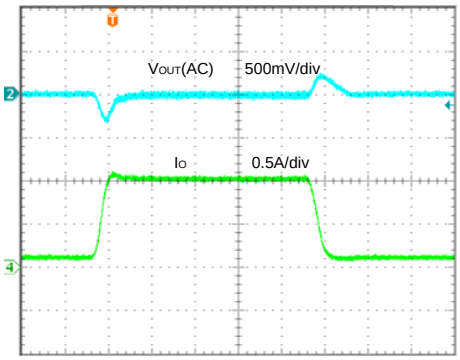


Efficiency vs. Load Current



Load Transient

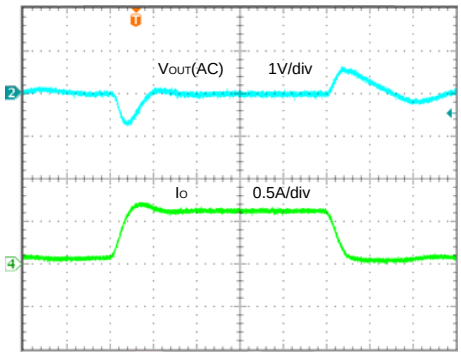
(V_{IN}=3.3V, V_{OUT}=5V, I_O=0.1~ 1A)



Time (100μs/div)

Load Transient

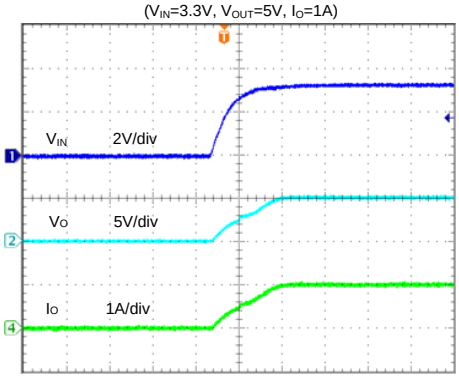
(V_{IN}=5V, V_{OUT}=12V, I_O=60~ 600mA)



Time (100μs/div)

Startup from V_{IN}

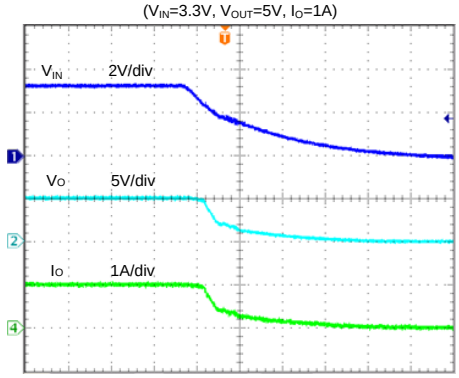
(V_{IN}=3.3V, V_{OUT}=5V, I_O=1A)



Time (2ms/div)

Shutdown from V_{IN}

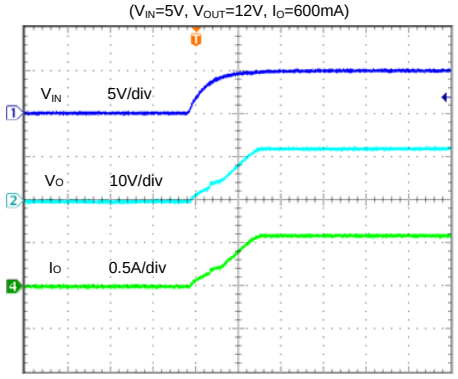
(V_{IN}=3.3V, V_{OUT}=5V, I_O=1A)



Time (2ms/div)

Startup from V_{IN}

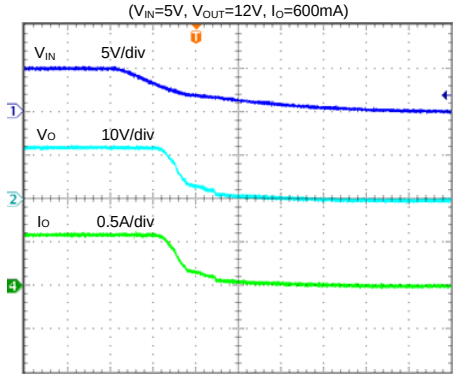
(V_{IN}=5V, V_{OUT}=12V, I_O=600mA)



Time (2ms/div)

Shutdown from V_{IN}

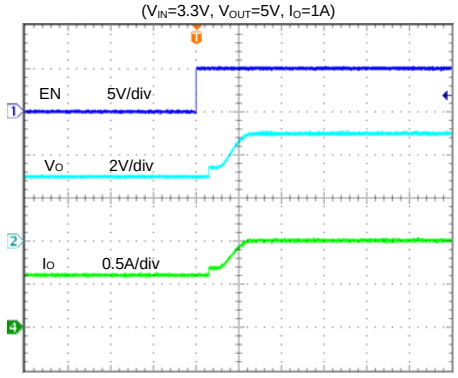
(V_{IN}=5V, V_{OUT}=12V, I_O=600mA)



Time (2ms/div)

Startup from Enable

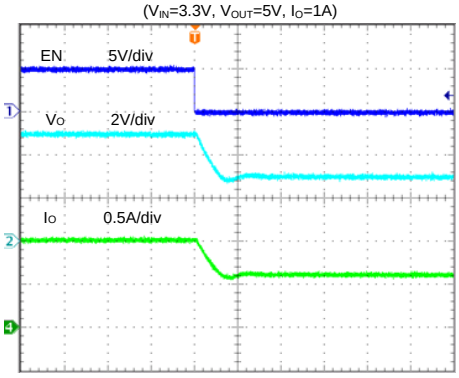
(V_{IN}=3.3V, V_{OUT}=5V, I_O=1A)



Time (2ms/div)

Shutdown from Enable

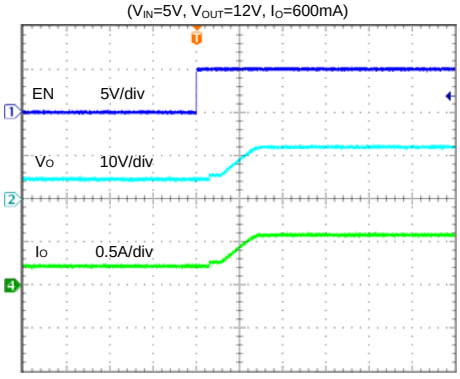
(V_{IN}=3.3V, V_{OUT}=5V, I_O=1A)



Time (40μs/div)

Startup from Enable

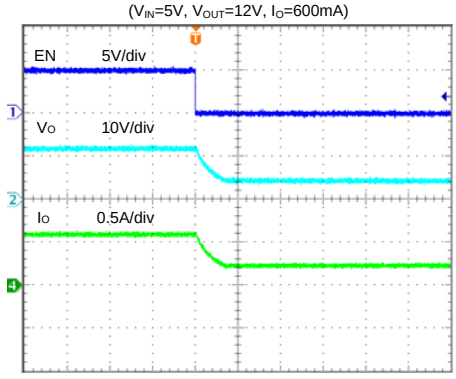
(V_{IN}=5V, V_{OUT}=12V, I_O=600mA)



Time (2ms/div)

Shutdown from Enable

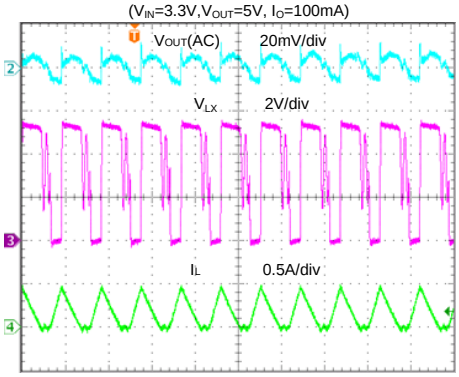
(V_{IN}=5V, V_{OUT}=12V, I_O=600mA)



Time (200μs/div)

Output Ripple

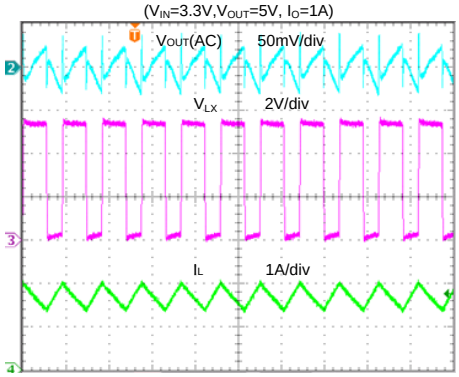
(V_{IN}=3.3V,V_{OUT}=5V, I_O=100mA)



Time (1μs/div)

Output Ripple

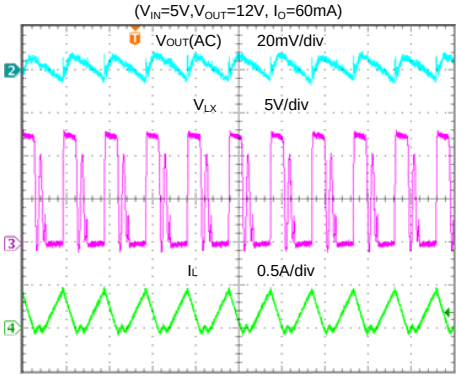
(V_{IN}=3.3V,V_{OUT}=5V, I_O=1A)



Time (1μs/div)

Output Ripple

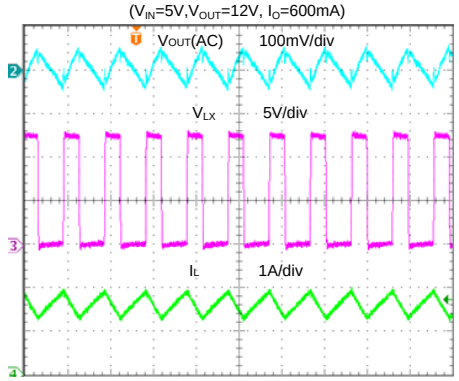
(V_{IN}=5V,V_{OUT}=12V, I_O=60mA)



Time (1μs/div)

Output Ripple

(V_{IN}=5V,V_{OUT}=12V, I_O=600mA)



Time (1μs/div)

Detailed Description

The SY21212A high efficiency step-up regulator operates using current mode control over a wide input voltage range from 3V to 8V. It integrates an N-channel MOSFET with low 130mΩ $R_{DS(ON)}$ to minimize conduction loss.

The 1MHz switching frequency and internal compensation reduce external inductor and capacitor sizes, and the built-in internal soft-start circuitry minimizes inrush currents at startup.

Enable Operation

Driving the EN pin high (>1.5V) enables normal operation. Driving the EN pin low (<0.4V) will shut down the device. During shutdown mode, the SY21212A shutdown current drops to less than 15μA.

Soft-Start (EN Control)

The SY21212A has a built-in soft-start to control the rising slew rate of the output voltage and limit the input current surge during device startup. With a 200μs turn-on delay time before the initial soft-start, the typical soft-start time is 1ms.

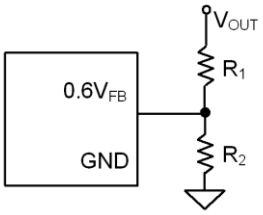
Application Information

The following paragraphs describe the selection process for the feedback resistors (R1 and R2), input capacitor C_{IN}, output capacitor C_{OUT}, boost inductor L, and diode D.

Feedback Resistor-Divider R1 and R2

Choose R1 and R2 to program the proper output voltage. Choose large resistance values between 10kΩ and 1MΩ for both R1 and R2 to minimize power consumption under light loads. If R1 is selected, then R2 can be calculated for a given target voltage as:

$$R2 = \frac{0.6V}{V_{OUT}\text{-}0.6V} R1$$



Input Capacitor C_{IN}

Input filter capacitors reduce the ripple voltage on the input, filter the switched current drawn from the input supply, and reduce EMI. When selecting an input capacitor, be sure to select a voltage rating at least 20% greater than the maximum voltage of the input supply and a temperature rating higher than the system requirements. X5R series ceramic capacitors are most often selected due to their small size, low cost, surge-current capability, and high RMS current ratings over a wide temperature and voltage range. However, systems that are powered by a wall adapter or other long and therefore inductive cabling may be susceptible to significant inductive ringing at the input to the device. In these cases, consider adding some bulk capacitance like electrolytic, tantalum, or polymer type capacitors. Using a combination of bulk capacitors (to reduce overshoot or ringing) in parallel with ceramic capacitors (to meet the RMS current requirements) is helpful in these cases.

Consider the RMS current rating of the input capacitor, paralleling additional capacitors if required to meet the RMS ripple current requirements.

$$I_{CIN\_RMS} = \frac{V_{IN} \cdot (V_{OUT} - V_{IN})}{2\sqrt{3} \cdot L \cdot F_{SW} \cdot V_{OUT}}$$

For the best performance, select a typical X5R or better grade low ESR 10μF ceramic capacitor and place it as close as possible to the IN and GND pins. Minimize the loop area formed by C_{IN} and the IN/GND pins.

Output Capacitor C_{OUT}

Select the output capacitor C_{OUT} to handle the output ripple requirements. Both steady state ripple and transient requirements must be taken into consideration when selecting the component. For the best performance, use an X5R or better grade ceramic capacitor with a 25V rating and capacitance of at least 10μF.

For applications where the design must meet stringent ripple requirements, the following considerations must be followed:

The output voltage ripple at the switching frequency is caused by the inductor current ripple (ΔI_L) on the output capacitor's ESR (ESR ripple), as well as the stored charge (capacitive ripple). When calculating total ripple, both should be considered.

$$V_{RIPPLE,\ ESR1} = I_{LPEAK} \times ESR$$

$$V_{RIPPLE,\ ESR2} = I_{LVALLEY} \times ESR$$

$$V_{RIPPLE,CAP} = \frac{I_{OUT} \times (1\text{-}D)}{C_{OUT} \times f_{SW}}$$

The measured ripple might be higher because the effective capacitance for ceramic capacitors decreases with the voltage across the terminals. The voltage derating is usually included as a chart in the capacitor datasheet, and the ripple can be recalculated after taking the target output voltage into account.

Boost Inductor L

Consider the following when 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:

$$L = \left(\frac{V_{IN}}{V_{OUT}}\right)^2 \frac{V_{OUT} - V_{IN}}{f_{SW}\, I_{OUT,MAX} \times 0.4}$$

where f_{SW} is the switching frequency and $I_{OUT,MAX}$ is the maximum load current.

The SY21212A 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 inductor's saturation current rating must be greater than the peak inductor current under full load:

$$I_{SAT,MIN} = \left(\frac{V_{OUT}}{V_{IN}}\right) \times I_{OUT,MAX} + \frac{V_{IN}(V_{OUT} - V_{IN})}{2 \times f_{SW} \times L \times V_{OUT}}$$

3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. Choose an inductor with DCR less than 50mΩ to achieve good overall efficiency.

The maximum current that the converter can provide to the load depends on the output voltage / input voltage ratio.

Use the following formulas to evaluate an approximate max current that the converter can deliver when driving the load.

Estimate the maximum output current:

$$I_{MAXOUT} = (IL_{MIN} - \frac{\Delta IL}{2}) \times \frac{\eta \times V_{IN(MIN)}}{V_{OUT}}$$

Where: $V_{IN(MIN)}$ is the minimum voltage at the boost input in the application, IL_{MIN} is the minimum device current datasheet limit (2A for SY2121A), ΔIL is the current ripple and η is the efficiency, which can be substituted with a value of 0.8 for simplicity.

For example, when $V_{IN(MIN)}$ = 5V and VOUT = 12V and a value of 40% is used for the ripple current, the calculated IMAXOUT is shown below:

$$I_{MAXOUT}(\text{mA}) = (2000 - \frac{2000 \times 0.4}{2}) \times \frac{0.8 \times 5}{12}$$
$$= 533.3$$

Rectifier Diode

For high efficiency, choose a Schottky diode with low forward voltage drop and fast reverse recovery. The average diode current is equal to the output current: $I_{AVG} = I_{OUT}$.

The diode reverse voltage is equal to the output voltage. The reverse breakdown voltage of the Schottky diode should be greater than the output voltage.

Applications with Large Bulk Capacitance

In applications with large bulk capacitance present on the output, a very high inrush current could flow through the inductor during power-on. In order to limit the current flowing into the device and prevent damage, a Schottky diode connected from the power input to the output or an RC delay circuit added on the EN pin are recommended, as shown in Figure 3.

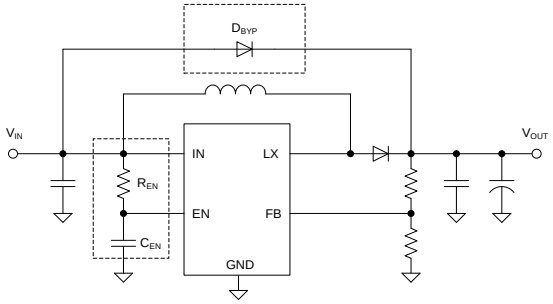
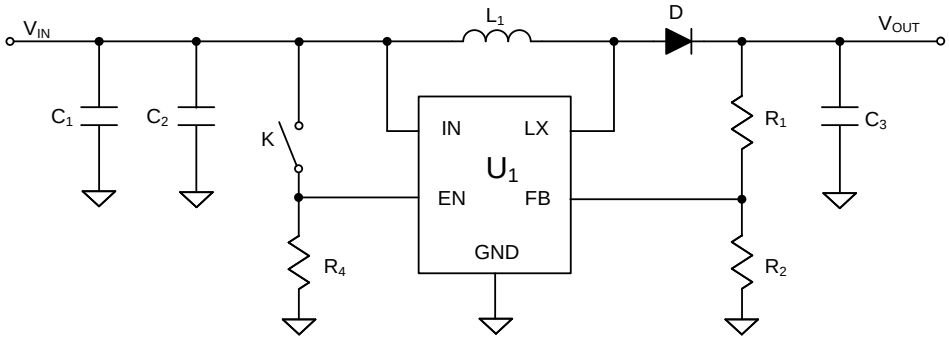


Figure 3. Inrush Current Limiting

Application Schematic



Design Specifications

Input Voltage (V)	Output Voltage(V)	Input Current (A)
3–4.2	5	2

BOM List

Reference Designator	Description	Part Number	Manufacturer
U1	1MHz Boost (SOT23-6)	SY21212AABC	Silergy
L1	2.2μH/4.8A	VLC6045T-2R2N	TDK
D	3A Schottky diode	SS34	
C1	47μF/50V (electronic capacitor)		
C2, C3	10μF/16V,1206	C3216X7R1C106K	TDK
R1	100kΩ, 1%, 0603	RC0603FR-07100KL	YAGEO
R2	13.7kΩ, 1%, 0603	RC0603FR-0713K7L	YAGEO
R4	1MΩ, 0603	RC0603FR-071ML	YAGEO

Recommend Components for Typical Applications

V_{OUT}(V)	R1(kΩ)	R2(kΩ)	L(μH)	C3
5	100	13.7	2.2	10μF/16V
12	100	5.23	4.7	10μF/25V

Layout Design

To achieve optimal design, follow these PCB layout considerations:

- Place C_{IN}, L, R1, and R2 close to the device
- To achieve the best thermal and noise performance, maximize the PCB copper area connecting to the GND pin. A ground plane is highly recommended if cost allows it.
- C_{IN} must be close to pins IN and GND. Minimize the loop area formed by C_{IN} and GND.
- To reduce the switching noise, minimize the PCB copper area connected to the LX pin.
- In order to reduce crosstalk, R1, R2, and the trace connected to the FB pin must not be adjacent to the LX net on the PCB layout.
- If the system chip interfacing with the EN pin has a high impedance state during shutdown mode, and the IN pin is connected directly to a power source such as a Li-ion battery, add a 1MΩ pulldown resistor between the EN and GND pins to prevent noise from falsely triggering the regulator during shutdown mode.

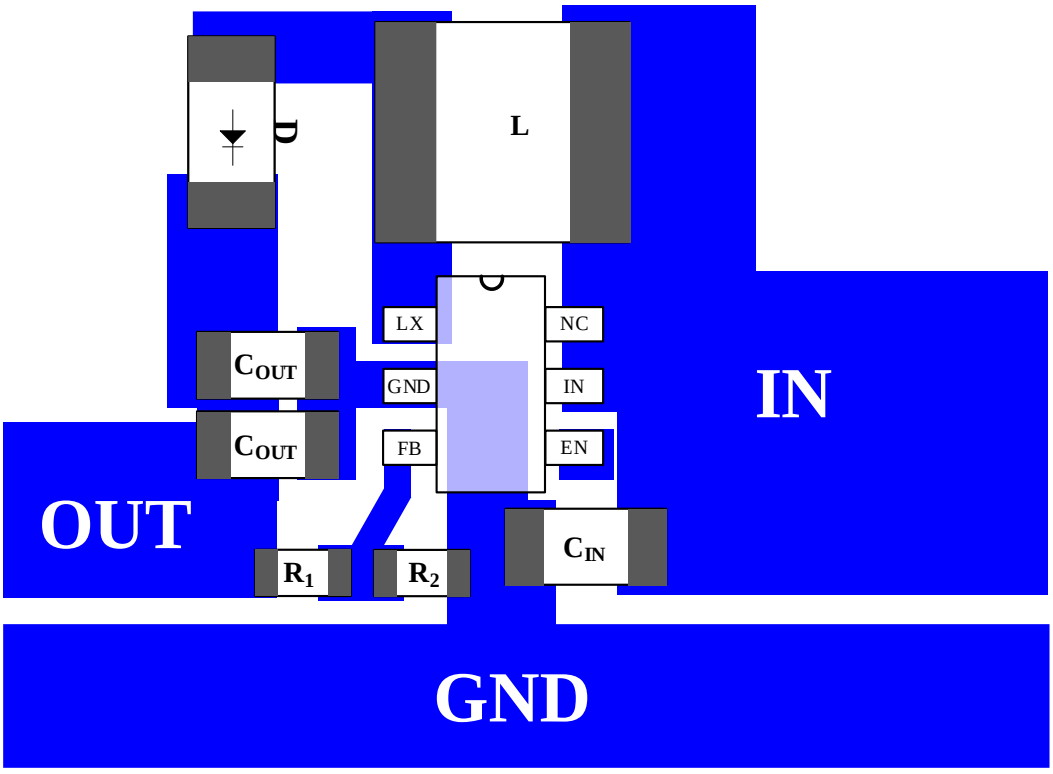
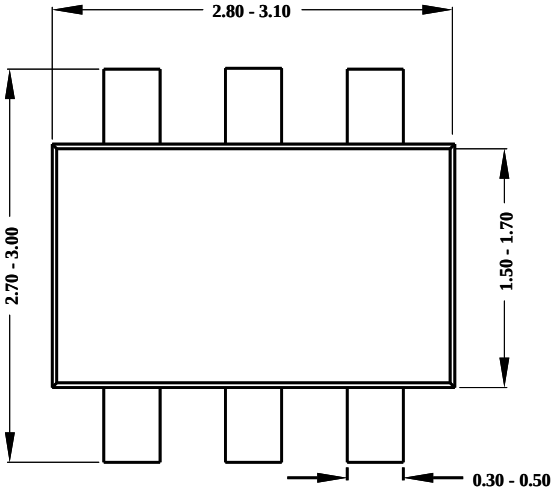
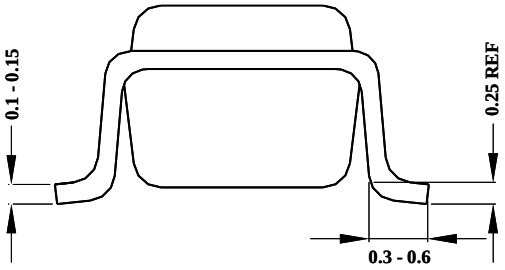


Figure 4. Suggested PCB Layout

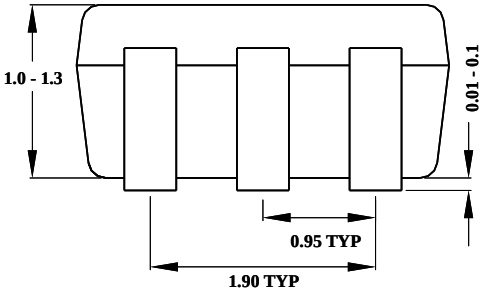
SOT23-6 Package Outline and PCB Layout



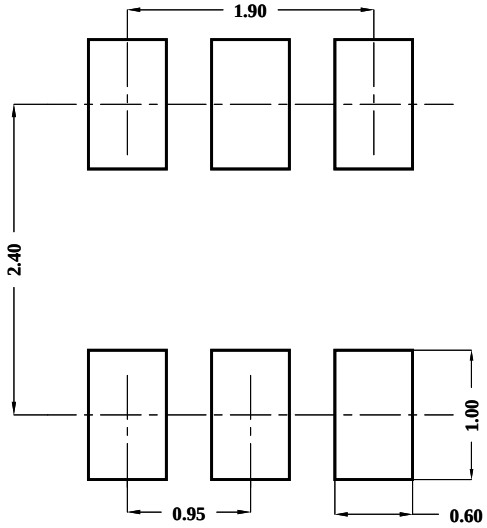
Top view



Side view



Side view

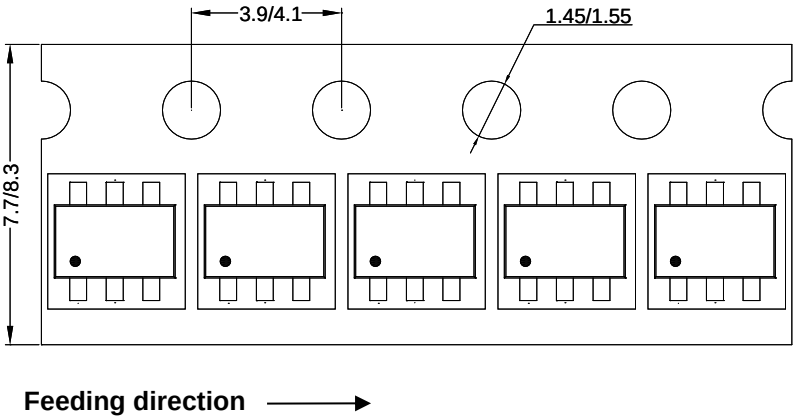


Recommended pad layout
(reference only)

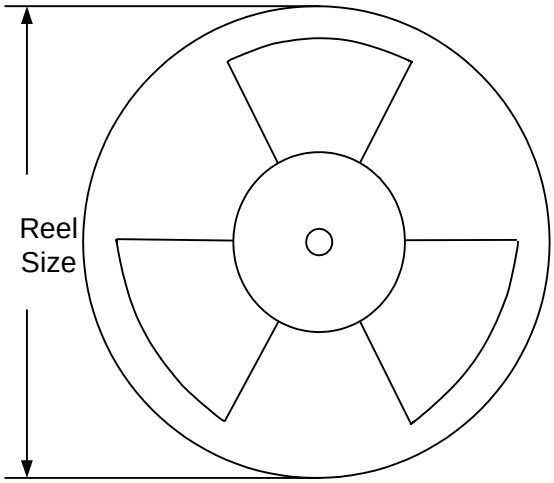
Note: *All dimensions are in millimeters and exclude mold flash and metal burr.*

Taping and Reel Specification

SOT23-6 taping orientation



Carrier tape and reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
SOT23-6	8	4	7"	280	160	3000

Others: NA

Revision History

The revision history provided is for informational purposes only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Jun. 09, 2023	Revision 1.0	Language improvements for clarity.
Apr. 07, 2013	Revision 0.9	Initial Release

IMPORTANT NOTICE

1. **Right to make changes.** Silergy and its subsidiaries (hereafter Silergy) reserve the right to change any information published in this document, including but not limited to circuitry, specification and/or product design, manufacturing or descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to Silergy's standard terms and conditions of sale.

2. Applications. Application examples that are described herein for any of these products are for illustrative purposes only. Silergy makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification. Buyers are responsible for the design and operation of their applications and products using Silergy products. Silergy or its subsidiaries assume no liability for any application assistance or designs of customer products. It is customer's sole responsibility to determine whether the Silergy product is suitable and fit for the customer's applications and products planned. To minimize the risks associated with customer's products and applications, customer should provide adequate design and operating safeguards. Customer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Silergy assumes no liability related to any default, damage, costs or problem in the customer's applications or products, or the application or use by customer's third-party buyers. Customer will fully indemnify Silergy, its subsidiaries, and their representatives against any damages arising out of the use of any Silergy components in safety-critical applications. It is also buyers' sole responsibility to warrant and guarantee that any intellectual property rights of a third party are not infringed upon when integrating Silergy products into any application. Silergy assumes no responsibility for any said applications or for any use of any circuitry other than circuitry entirely embodied in a Silergy product.

3. **Limited warranty and liability.** Information furnished by Silergy in this document is believed to be accurate and reliable. However, Silergy makes no representation or warranty, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. In no event shall Silergy be liable for any indirect, incidental, punitive, special or consequential damages, including but not limited to lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges, whether or not such damages are based on tort or negligence, warranty, breach of contract or any other legal theory. Notwithstanding any damages that customer might incur for any reason whatsoever, Silergy' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Standard Terms and Conditions of Sale of Silergy.

4. **Suitability for use.** Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of Silergy components in its applications, notwithstanding any applications-related information or support that may be provided by Silergy. Silergy products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of a Silergy product can reasonably be expected to result in personal injury, death or severe property or environmental damage. Silergy assumes no liability for inclusion and/or use of Silergy products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

5. **Terms and conditions of commercial sale**. Silergy products are sold subject to the standard terms and conditions of commercial sale, as published at http://www.silergy.com/stdterms, unless otherwise agreed in a valid written individual agreement specifically agreed to in writing by an authorized officer of Silergy. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. Silergy hereby expressly objects to and denies the application of any customer's general terms and conditions with regard to the purchase of Silergy products by the customer.

6. **No offer to sell or license**. Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights. Silergy makes no representation or warranty that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right. Information published by Silergy regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from Silergy under the patents or other intellectual property of Silergy.

For more information, please visit: www.silergy.com