SY20418

0.7V Minimum Input Voltage Synchronous Boost

General Description

The SY20418 is a high efficiency, synchronous boost converter with an input voltage range of 0.7V to 5V which can provide an output voltage range between 1.8V and 5.25V.

The device uses a current mode hysteretic control architecture to enable good transient performance and stable operation. The low start-up voltage and low operating current, makes this converter ideal for battery operated applications using single-cell or dual-cell alkaline, NiMH or NiCad batteries. The low Iq during shutdown mode enables long battery life. Low Rdson MSOFETs are used for the main and synchronous switches to obtain a good efficiency.

The SY20418 is available in a compact SOT-363 package.

Features

- 0.7V to 5V Input Voltage Range
- Low Quiescent Current
- 1 uA Shutdown Current (Max.)
- 95% Peak Efficiency
- Input Under Voltage Lockout
- Pass-through Function During Shutdown
- Low $R_{DS(ON)}$ (Main Switch/Synchronous Switches): 0.5/0.7Ω
- Typical 350mA Peak Current Limit
- RoHS Compliant and Halogen Free
- Compact Package: SOT-363

Applications

- Battery Powered Applications
- Consumer and Portable Medical Products
- Personal Care Products
- Smartphones
- White or Status LEDs

Typical Application

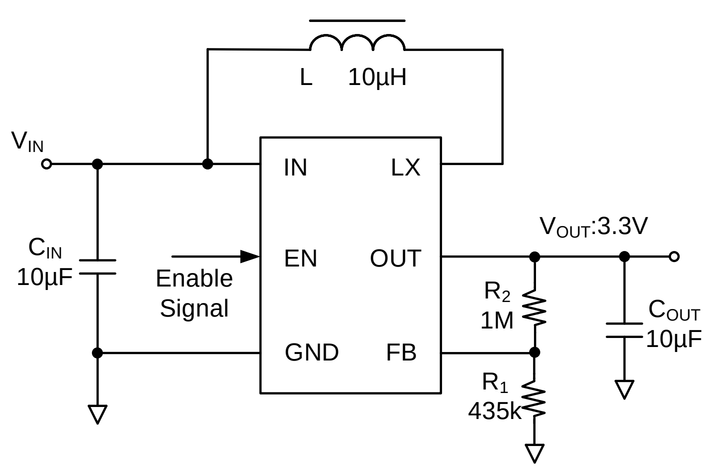


Figure 1. Schematic Diagram

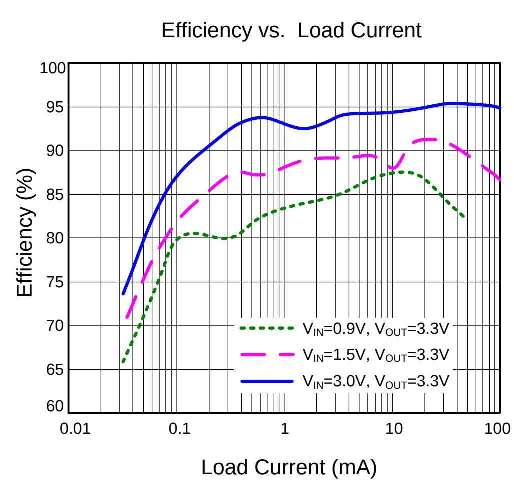


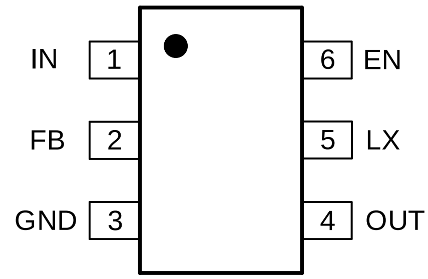
Figure 2. Efficiency vs. Load Current

Ordering Information

Ordering Part Number	Package Type	Top Mark
SY20418AHC	SOT-363 RoHS Compliant and Halogen Free	**MExyz**

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

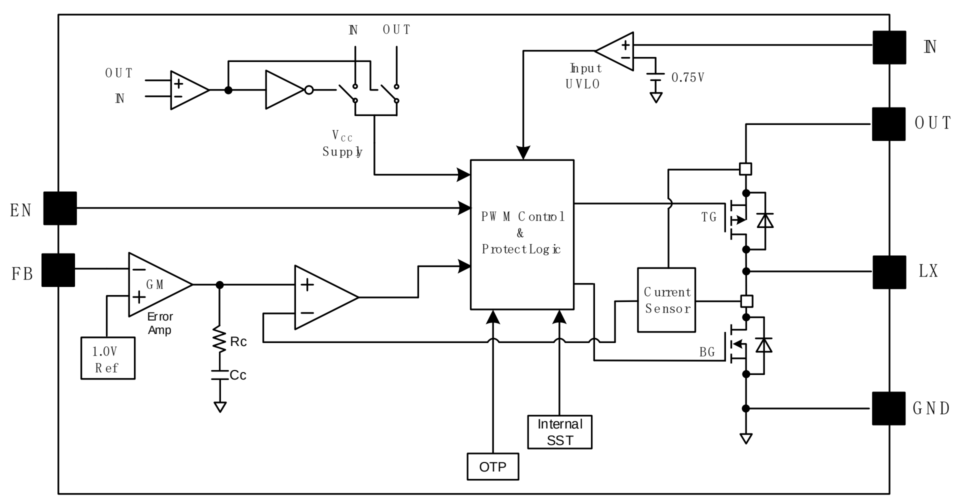
Pinout (top view)



Pin Description

Pin Name	Pin Number	Pin Description
IN	1	Input pin. Decouple this pin to the GND pin with a 10µF ceramic capacitor.
FB	2	Feedback pin. Connect a resistor R_1 between OUT and FB, and a resistor R_2 between FB and GND to program the output voltage. $V_{OUT}=1.0V\times(R_2/R_1+1)$
GND	3	Ground pin.
OUT	4	Output pin. Decouple this pin to the GND pin with a minimum of 10µF ceramic capacitor.
LX	5	Inductor pin. Connect an inductor between the IN pin and the LX pin.
EN	6	Enable pin. Pull it high to turn on or pull it low to shut down the part. Do not leave it floating.

Functional Block Diagram



Absolute Maximum Ratings

Parameter (Note 1)	Min	Max	Unit
All Pins to GND		6	V
Lead Temperature (Soldering, 10s)		260	°C
Junction Temperature, Operating	-40	150	°C
Storage Temperature	-65	150	°C

Thermal Information

Parameter (Note 2)	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 (Note 3)	Min	Max	Unit
IN	0.7	5.0	V
EN	0	V_{OUT}+0.3	
FB, OUT, LX	0	5.0	
Junction Temperature, Operating	-40	125	°C
Ambient Temperature	-40	85	

Electrical Characteristics

(V_{IN} =1.2V, V_{OUT}=3.3V, I_{OUT}=10mA, T_A = 25°C unless otherwise specified.)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage		V_{IN}		0.7		5.0	V
Minimum V_{IN} at start-up		V_{START}		0.75			V
Output Voltage Range		V_{OUT}		1.8		5.25	V
Quiescent Current	V_{IN}	I_Q	Io=0mA, VEN=V_{IN}=1.2V, V_{OUT}=3.4V		0.5		μA
	V_{OUT}				5		
Shut Down Current		I_{SHDN}	V_{EN}=0V, V_{IN}=3.0V			1	μA
EN Rising Threshold		V_{ENH}	V_{IN}≤1.6	0.75xV_{IN}			V
			1.6<V_{IN}<5.0	1.2			V
EN Falling Threshold		V_{ENL}	V_{IN}≤1.6			0.2×V_{IN}	V
			1.6<V_{IN}<5.0			0.32	V
Low Side Main FET R_{ON}		$R_{DS(ON)1}$	V_{OUT}=3.3V		0.5		Ω
Synchronous FET R_{ON}		$R_{DS(ON)2}$	V_{OUT}=3.3V		0.7		Ω
Main FET Current Limit		I_{LIM}		300	350		mA
Reference Voltage		V_{REF}		0.97	1.0	1.03	V
Output Over Voltage Protection		V_{OVP}			5.8	6	V
Thermal Shutdown Temperature		T_{SD}			150		℃
Thermal Shutdown Hysteresis		T_{HYS}			20		℃
Under Voltage Lockout for Turn Off Protection		V_{UVLO}	V_{IN} decreasing		0.6		V

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.

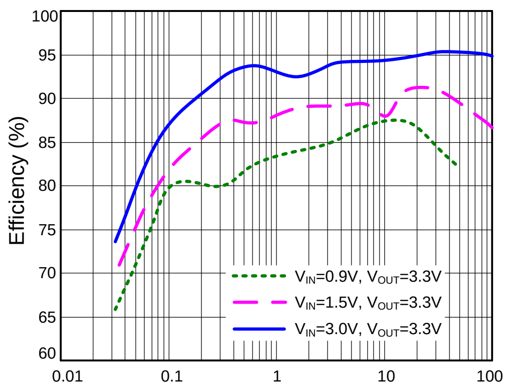
Note 2: θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Test condition: Device mounted on 2" x 2" FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal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

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

Typical Performance Characteristics

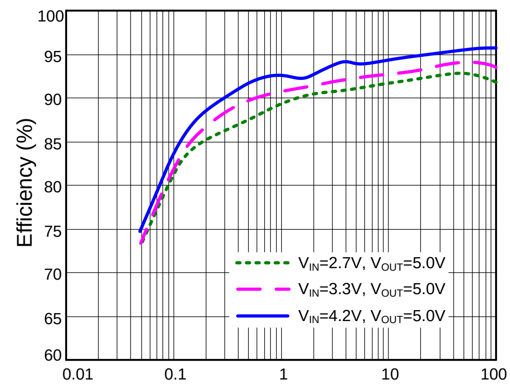
(T_A = 25°C, V_{IN} =1.2V, V_{OUT}=3.3V, unless otherwise specified)

Efficiency vs. Load Current



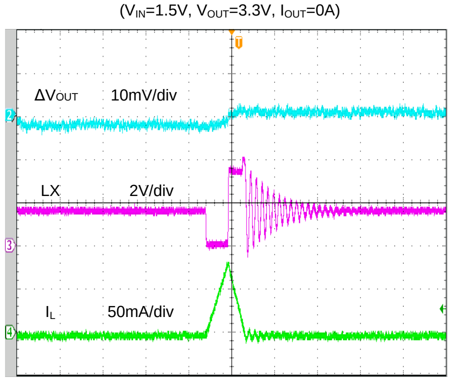
Load Current (mA)

Efficiency vs. Load Current



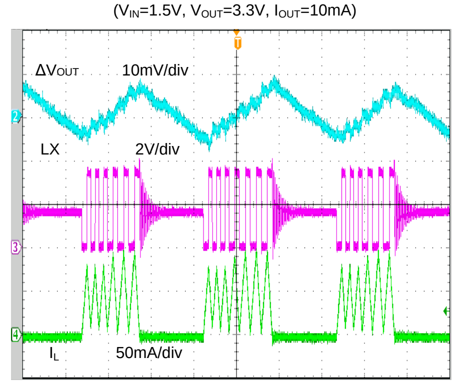
Load Current (mA)

Output Ripple
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=0A)



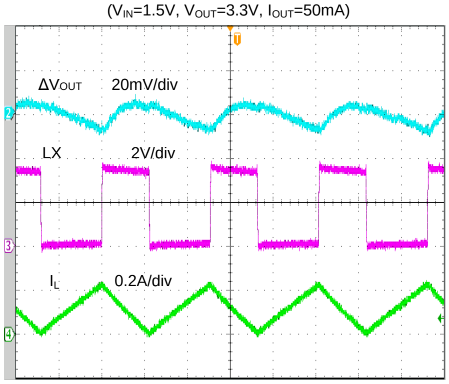
Time (1μs/div)

Output Ripple
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=10mA)



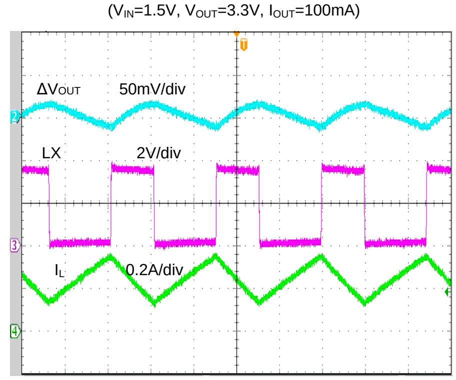
Time (4μs/div)

Output Ripple
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=50mA)



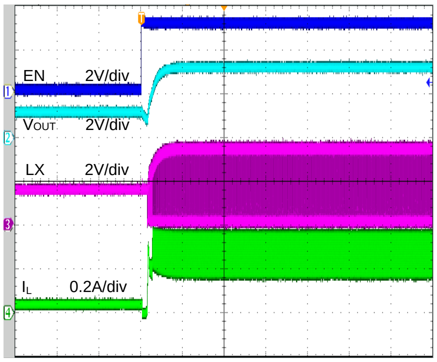
Time (1μs/div)

Output Ripple
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=100mA)



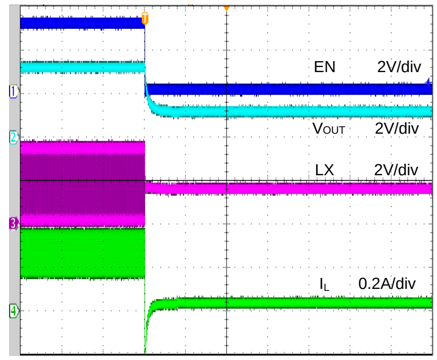
Time (1μs/div)

Startup from Enable
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=100mA)



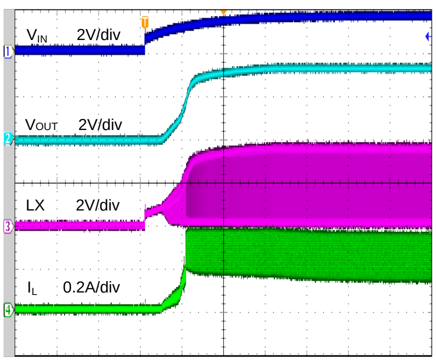
Time (800μs/div)

Shutdown from Enable
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=100mA)



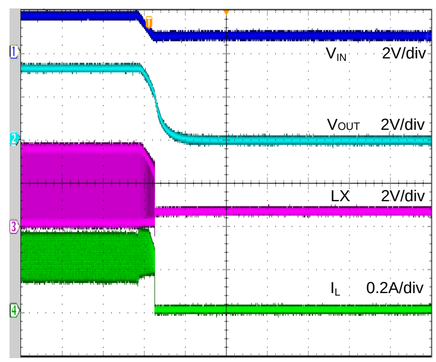
Time (800μs/div)

Startup from V_{IN}
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=100mA)



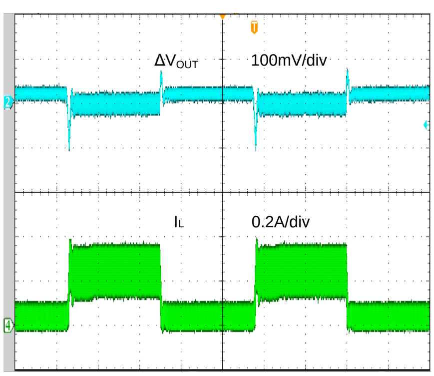
Time (2ms/div)

Shutdown from V_{IN}
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=100mA)



Time (2ms/div)

Load Transient
(V_{IN}=1.5V, V_{OUT}=3.3V, I_{OUT}=10mA ~ 100mA)



Time (800μs/div)

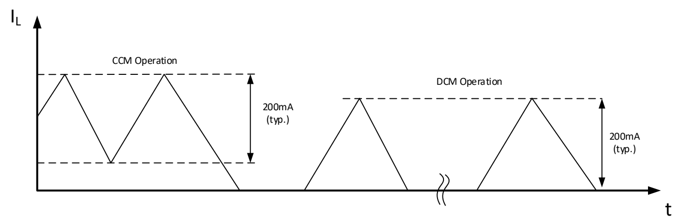
Application Information

The SY20418 is a high efficiency, synchronous boost converter with an input voltage range of 0.7V to 5V which can provide an output voltage range between 1.8V and 5.25V.

Operation

The SY20418 uses a hysteretic current control architecture, which regulates the output voltage by keeping the inductor ripple current constant in the range of 200mA. During light load operation, the device switches to discontinuous mode to reduce switching loses and enable high efficiency across the entire load range.

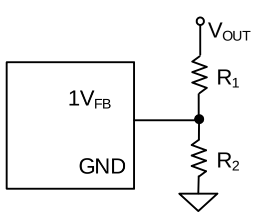
This hysteretic current mode is inherently stable and allows fast response to load transitions. This architecture also allows using a wide range of inductor and output capacitor values.



Feedback Resistor Divider R1 and R2:

The output voltage can be configured be selecting R_1 and R_2 in the feedback resistor divider. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both R_1 and R_2. A value of between 10kΩ and 100 kΩ is recommended for both resistors. If R_1 is chosen, then R_2 can be calculated using the following formula:

$$R_2 = (R_1 \times 1V)/(V_{OUT} - 1V)$$



Input Capacitor C_{IN}

For the best performance, select a typical X5R or better grade ceramic capacitor. The component should be placed as close as possible to the IN and GND pins, while also minimizing the loop area formed by C_{IN} and the IN/GND pins. In this case, a 10µF low ESR ceramic capacitor is recommended to improve transient behavior of the regulator and EMI behavior of the total power supply circuit.

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 this capacitor. For the best performance, it is recommended to use an X5R or better grade ceramic capacitor with 10V rating and greater than 10µF capacitance.

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 capacitive 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.
Note that the voltage rating of the output capacitors has to be higher than the OVP level for this device (5.85V). An operating voltage of 6.3V or higher is recommended.

Inductor L

A proper inductor must be connected between the VIN pin and the LX pin of the SY20418. A 10µH inductor value is recommended for most applications.
Choosing inductance values will affect the switching frequency f, which is proportional to 1/L as shown in the following equation:

$$L = \frac{1}{f \times 200mA} \times \frac{V_{IN} \times (V_{OUT} - V_{IN})}{V_{OUT}}$$

For a selected inductance value, the peak current in steady-state operation can be calculated using the equation below. It provides a suitable current rating for selecting the inductor. However, the load transients and error conditions may cause higher inductor currents.

$$IL_{MAX} = \begin{cases} \dfrac{V_{OUT} \times I_{OUT}}{\eta \times V_{IN}} + 100mA; & CCM \quad Operation \\ 200mA; \quad DCM \quad Operation & \end{cases}$$

Where, η is the efficiency of the regulator.

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 (300 mA for SY20418), ΔIL is the current ripple (200 mA typ) and η is the efficiency, which can be substituted with a value of 0.8 for simplicity.

For example, when $V_{IN(MIN)}$ = 1.2V and VOUT = 3.3V the calculated I_{MAXOUT} is shown below:

$$I_{MAXOUT}(\mathrm{mA}) = (300 - \frac{200}{2}) \times \frac{0.8 \times 1.2}{3.3}$$
$$= 58.2$$

EN Input

Driving the EN pin to a level above V_{ENH} enables normal operation (rising edge). Driving the EN pin low below the V_{ENL} threshold will shut down the device (falling edge). During the shutdown mode, the SY20418 shut down current drops to lower than 1μA.

Soft-start (EN Control)

The SY20418 has a built-in soft-start to control the rise rate of the output voltage and limit the inrush current during the start-up.

Under Voltage Lockout

The SY20418 stops the operation, and the switching is disabled if the input voltage drops below the V_{UVLO} threshold (0.6V typ.).

Over Voltage Protection

The SY20418 includes an output over voltage protection. If the output voltage exceeds V_{OVP} (typ. 5.8V), the part stops switching, and the main switch is turned off. When the output voltage returns to the normal operating range, the device resumes operation.

Thermal Protection

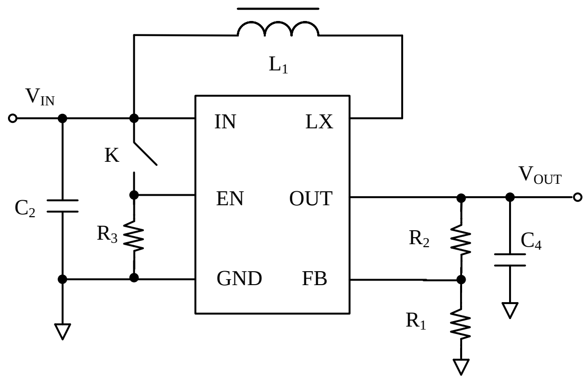
The SY20418 includes over temperature protection circuitry to prevent overheating due to excessive power dissipation. This will shut down the device when the junction temperature exceeds 150°C. When the junction temperature cools down by approximately 20°C, the device will resume normal operation after a complete soft-start cycle. For continuous operation, provide adequate cooling so that the junction temperature does not exceed the thermal protection threshold.

Over Current Protection

The SY20418 provides a cycle-by-cycle overcurrent protection and turns off the main power MOSFET once the inductor current reaches the overcurrent limit threshold. During the overcurrent protection, the output voltage drops as a function of the load. If the output voltage drops below the input voltage, the body diode of the MOSFET becomes forward biased, and this diode cannot be turned off. In this case the current is only limited by the DC resistance in the path during the event. As soon as the overload condition is removed, the converter resumes operation.

Typical Design

Typical Schematic



Design Specifications

Input Voltage (V)	Output Voltage (V)	Output Current Limit (A)
0.7-3.3	3.3	0.1

BOM List

Reference Designator	Description	Part Number	Manufacturer
L_1	10µH		
C_2	10µF/6.3V, 0603, X5R	C1608X5R0J106M	TDK
C_4	10µF/6.3V, 0603, X5R	C1608X5R0J106M	TDK
R_1	435kΩ, 0603		
R_2	1MΩ, 0603		
R_3	1MΩ, 0603		

Recommend Table for Typical Applications

V_{OUT}(V)	R_2(kΩ)	R_1(kΩ)	L(µH)	C_{OUT}
5	1000	250	10	22µF/10V/X5R,1206
3.3	1000	435	10	22µF/6.3V/X5R,1206

Recommended PCB Layout

For optimal design, follow the following PCB layout guidelines:

1) It is desirable to maximize the PCB copper area connecting to GND pin to achieve the best thermal and noise performance. If the board space allows, using a large copper pour connected to GND ground plane is recommended.

2) C_{OUT} must be close to Pins OUT and GND. The loop area formed by C_{OUT} and GND must be minimized.

3) The PCB copper area associated with LX pin must be minimized to reduce EMI emissions.

4) The trace connecting to the FB pin must not be adjacent to the LX net on the PCB layout to avoid the crosstalk.

5) If the system chip controlling the EN pin has a high impedance state during low power modes, the IN pin is connected directly to a power source such as a Li-Ion battery, it is recommended to add a pull-down resistor with a value of 1MΩ between the EN and GND, to prevent potential noise from falsely turning on the regulator during shutdown.

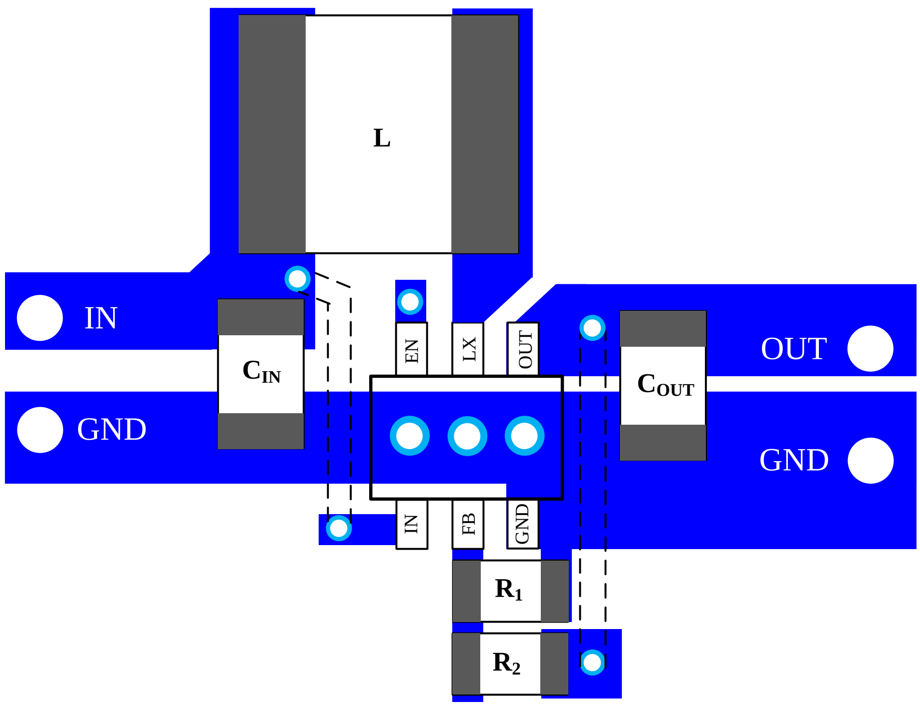
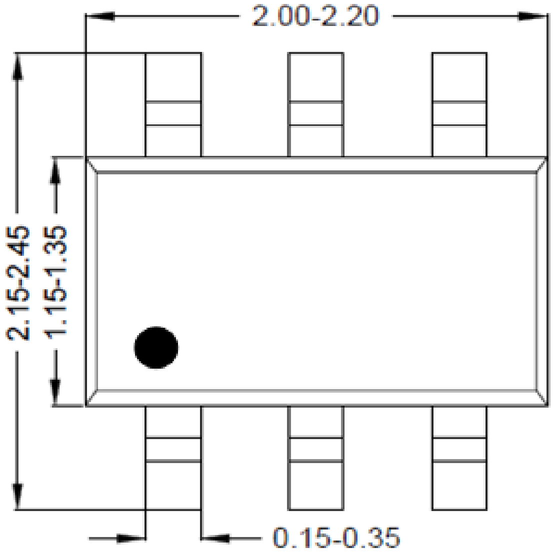
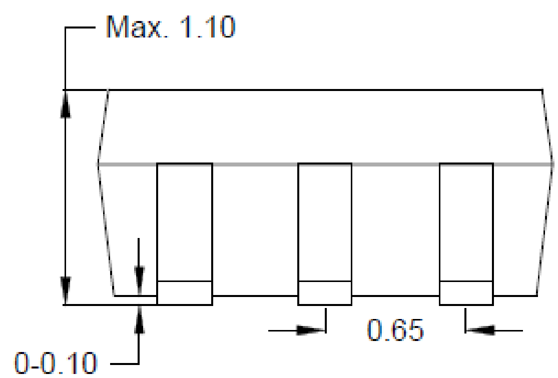


Figure 3. PCB Layout Suggestion

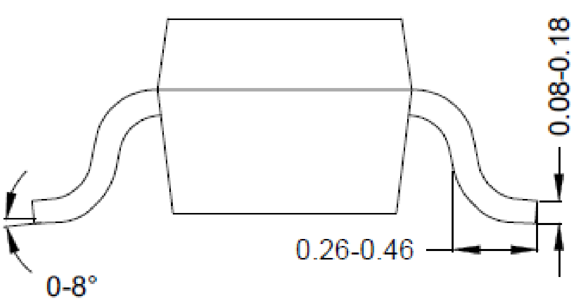
SOT-363 Package Outline Drawing



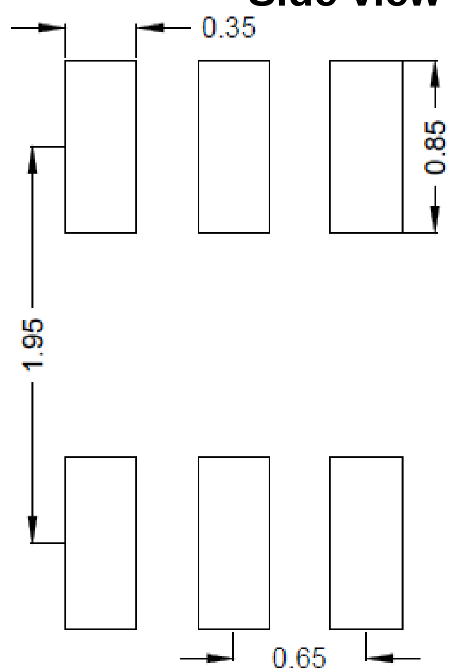
Top view



Side view A



Side view B

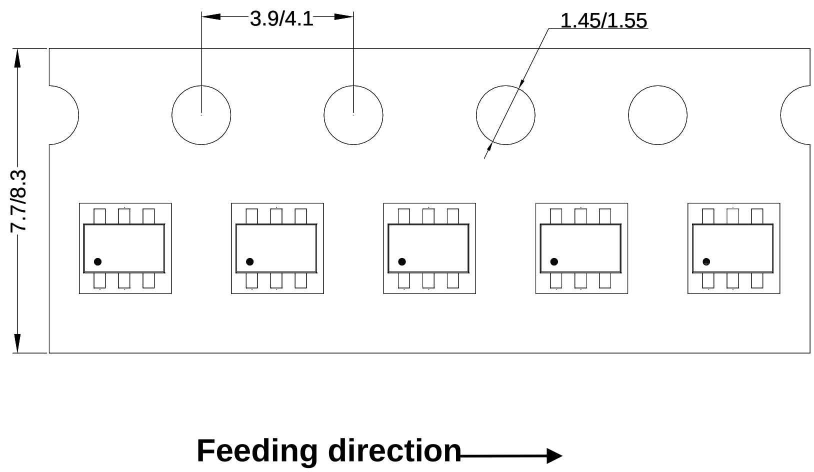


Recommended PCB layout (Reference only)

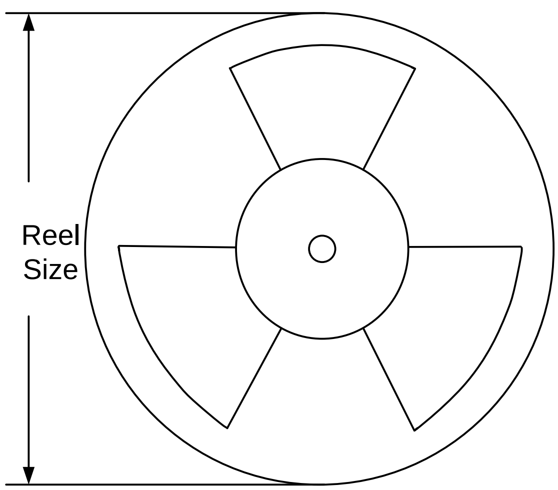
Notes: All dimension in millimeter and exclude mold flash & metal burr.

Taping & Reel Specification

1. SOT-363 taping orientation



2. 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 (pcs)
SOT363	8	4	7"	280	160	3000

3. Others: NA

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