Application Note: SQ76004

High Efficiency 3MHz, 4A Inductor Built-in Synchronous Step Down Regulator

General Description

SQ76004 is a 3MHz, 4A synchronous step down regulator which integrates an inductor and a control IC in a tiny package (3.0mm×3.0mm, H=2.0mm). It operates over a wide input voltage range from 2.75V to 5.5V. It integrates a main switch and a synchronous switch with very low $R_{DS(ON)}$ to minimize the conduction loss.

Ordering Information

SQ76004 □(□□)□

- Temperature Code
- Package Code
- Optional Spec Code

Ordering Number	Package	Note
SQ76004QNC	QFN3x3-10	--

Features

- Low $R_{DS(ON)}$ for Internal Switches (Top/Bottom): 35/15 mΩ
- 2.75-5.5V Input Voltage Range
- 3 MHz Switching Frequency Minimizes the External Components
- Internal Soft-start Limits the Inrush Current
- 4A Continuous Output Current Capability
- Shutdown Mode Draws<0.1µA Supply Current
- 100% Dropout Operation
- Power Good Indicator
- OCP/UVLO/OTP Protections
- RoHS Compliant and Halogen Free
- Compact Package: QFN3x3-10

Applications

- Mobile Phone, Smart Phone
- Bluetooth Headsets
- WiMAX PDA, MID, UMPC
- Portable Game Console
- Digital Camera, Camcorder

Typical Applications

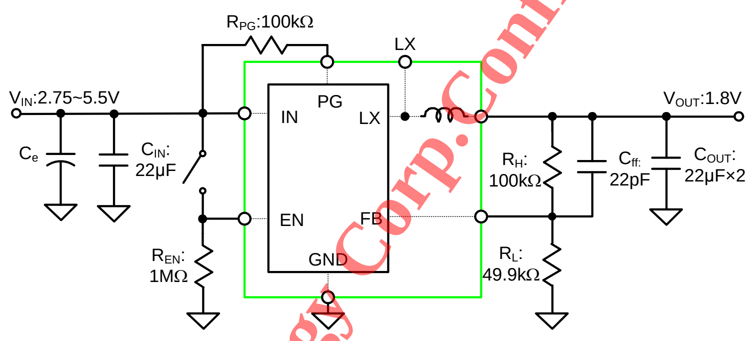


Figure1. Schematic Diagram

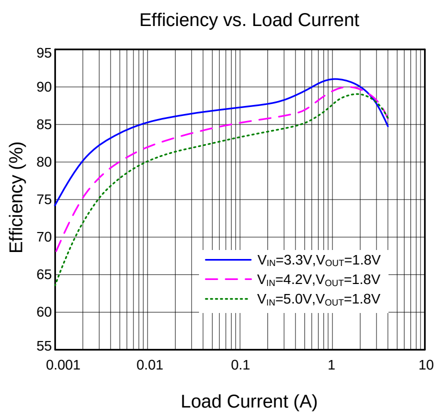
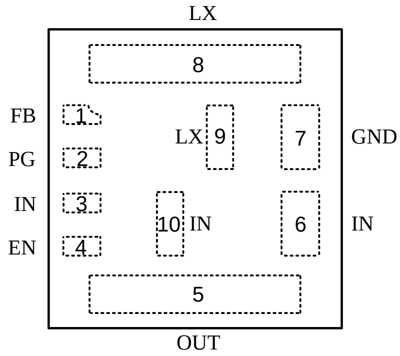


Figure 2. Efficiency vs. Load Current

Pinout (top view)



(QFN3x3-10)

Top Mark: BCYxyz for SQ76004QNC(device code: BCY, x=year code, y=week code, z= lot number code)

Pin Name	Pin Number	Description
FB	1	Output feedback pin. Connect this pin to the center point of the output resistor divider (as shown in Figure1) to program the output voltage: $V_{OUT}=0.6\times(1+R_H/R_L)$.
PG	2	Power good indicator, open drain. When the output voltage exceeds 90% of the regulation point, it becomes high; low otherwise.
IN	3,6,10	Power input pin.
EN	4	Enable control. Pull high to turn on. Do not leave it floating.
OUT	5	Output pin. Decouple this pin to GND with at least a 40μF ceramic capacitor.
GND	7	Ground pin.
LX	8,9	Built-in inductor node. Leave it floating.

Absolute Maximum Ratings (Note 1)

VIN, LX -- 6.0V
All Other Pins-- V_{IN} + 0.5V
Power Dissipation, P_D @ T_A = 25℃ QFN3x3 -- 2W
Package Thermal Resistance (Note 2)
θ_{JA} -- 50℃/W
θ_{JC} -- 5℃/W
Junction Temperature Range -- 150℃
Lead Temperature (Soldering, 10 sec.) --- 260℃
Storage Temperature Range -- -65℃ to 150℃

Recommended Operating Conditions (Note 3)

Supply Input Voltage -- 2.75V to 5.5V
Junction Temperature Range -- -40℃ to 125℃
Ambient Temperature Range --- -40℃ to 85℃

Electrical Characteristics

(V_{IN} = 5V, V_{OUT} = 2.5V, C_{OUT} = 22μFx2, T_A = 25℃, I_{OUT} = 1A unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		2.75		5.5	V
Quiescent Current	I_Q	I_{OUT}=0, EN=1, FB=105%×V_{REF}		68		μA
Shutdown Current	I_{SHDN}	EN=0		0.1	1	μA
Feedback Reference Voltage	V_{REF}		0.591	0.6	0.609	V
NFET $R_{DS(ON)}$	$R_{DS(ON)N}$			15		mΩ
PFET $R_{DS(ON)}$	$R_{DS(ON)P}$			35		mΩ
Input Peak Current Limit	I_{LIM}		5			A
Internal Soft-start Time	t_{SS}			0.8		ms
PGOOD Under Voltage Threshold	$V_{FB,LV}$			0.54		V
Short Circuit Protection Threshold	V_{SCP}			0.25		V
Min ON Time				60		ns
Max Duty Cycle			100			%
EN Rising Threshold	V_{ENH}		1.2			V
EN Falling Threshold	V_{ENL}				0.4	V
Input UVLO Threshold	V_{UVLO}				2.75	V
UVLO Hysteresis	V_{HYS}			0.3		V
Oscillator Frequency	f_{OSC}			3		MHz
Thermal Shutdown Temperature	T_{SD}			150		℃
Thermal Shutdown Hysteresis	T_{HYS}			15		℃
LX Node Discharge Resistor	R_{DSH}			50		Ω

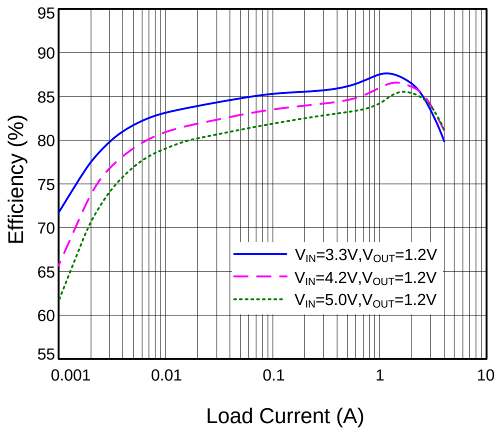
Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute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

Note 2: θ_{JA} is measured in the natural convection at T_A = 25℃ on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Paddle of QFN3x3-10 package is the case position for θ_{JC} measurement.

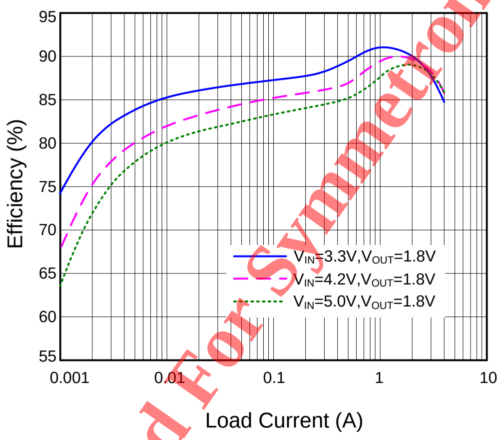
Note 3: The device is not guaranteed to function outside its operating conditions.

Typical Performance Characteristics

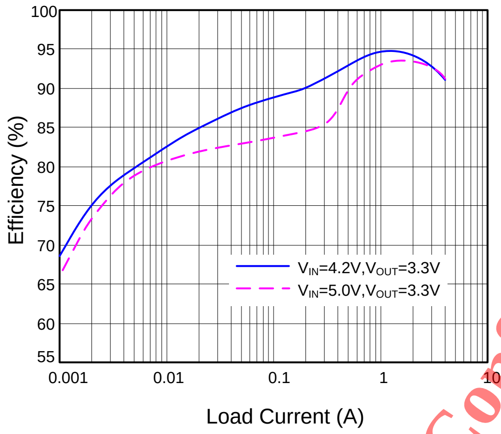
Efficiency vs. Load Current



Efficiency vs. Load Current

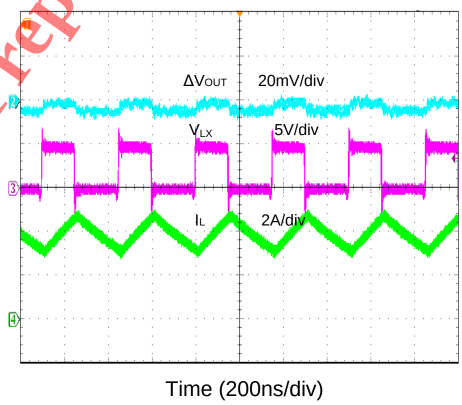


Efficiency vs. Load Current



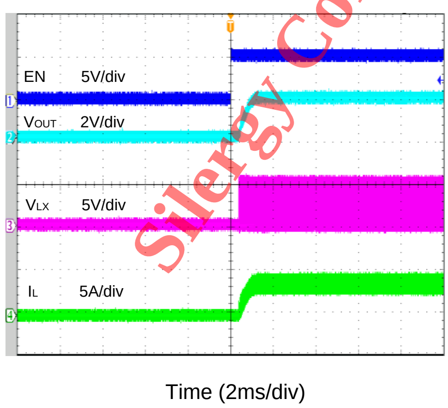
Output Ripple

(V_{IN}=5.0V,V_{OUT}=1.8V, I_{OUT}=4.0A)



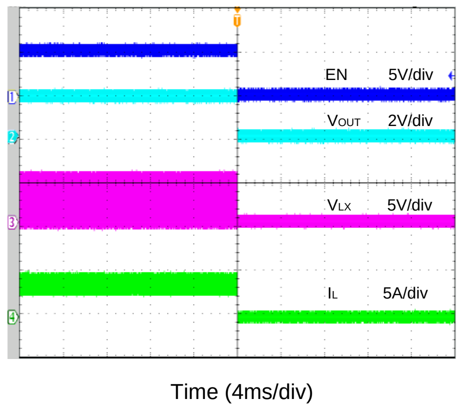
Startup From Enable

(V_{IN}=5.0V, V_{OUT}=1.8V, I_{OUT}=4.0A)



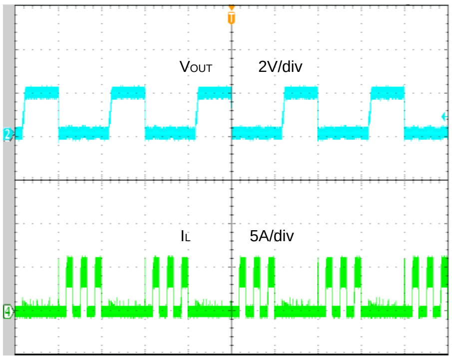
Shutdown From Enable

(V_{IN}=5.0V, V_{OUT}=1.8V, I_{OUT}=4.0A)



Short Circuit Protection

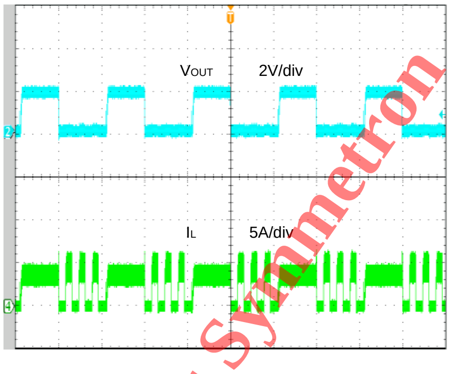
(V_{IN}=5.0V, V_{OUT}=1.8V, 0A to Short)



Time (20ms/div)

Short Circuit Protection

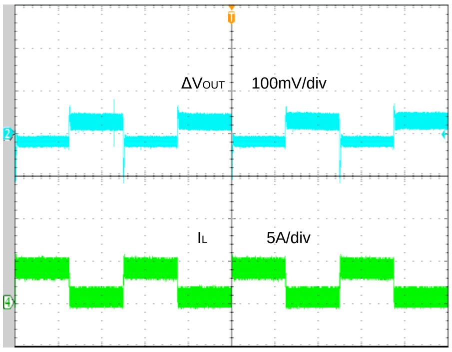
(V_{IN}=5.0V, V_{OUT}=1.8V, 4.0A to Short)



Time (20ms/div)

Load Transient

(V_{IN}=5.0V, V_{OUT}=1.8V, I_{OUT}=0.4 ~ 4.0A)



Time (400μs/div)

Operation

SQ76004 is a 3MHz, 4A synchronous step down regulator which integrates an inductor and a control IC in a tiny package (3.0mm×3.0mm, H=2.0mm). It operates over a wide input voltage range from 2.75V to 5.5V. It integrates a main switch and a synchronous switch with very low $R_{DS(ON)}$ to minimize the conduction loss.

Applications Information

Because of the high integration in the SQ76004, the application circuit based on this regulator is rather simple. Only the input capacitor C_{IN}, the output capacitor C_{OUT} and the feedback resistors (R_H and R_L) need to be selected for the targeted applications.

Feedback Resistor Divider R_H and R_L

Choose R_H and R_L to program the proper output voltage. To minimize the power consumption under light load, it is desirable to choose large resistance values for both R_H and R_L. A value of between 100kΩ and 1MΩ is highly recommended for both resistors. If R_L=120kΩ is chosen, then R_H can be calculated to be:

$$R_H = \frac{(V_{OUT} - 0.6V) \times R_L}{0.6V}$$

Input Capacitor C_{IN}

A typical X7R or better grade ceramic capacitor larger than 10μF capacitance is recommended. To minimize the potential noise problem, place this ceramic capacitor really close to the IN and GND pins. Care should be taken to minimize the loop area formed by C_{IN}, and IN/GND pins.

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. For the best performance, it is recommended to use an X7R or better grade ceramic capacitor with 6V rating and greater than 40uF capacitance.

Load Transient Considerations

SQ76004 integrates the compensation components to achieve good stability and fast transient response. In some applications, adding a 22pF ceramic capacitor in parallel with R_H may further speed up the load transient responses and is thus recommended for applications with large load transient step requirements.

Layout Design

For the minimum noise problem, the following components should be placed close to the IC: C_{IN} and C_{OUT}.

1) 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 allows, a ground plane is highly desirable.

2) C_{IN} must be close to the IN and GND pins. The loop area formed by C_{IN} and GND must be minimized.

3) Connect the LX pins together to reduce the inductor DCR. It is strongly recommended to reduce the LX routing area to avoid the potential noise problem.

4) The trace connecting to the FB pin must NOT be adjacent to the LX node on the PCB layout to minimize the noise coupling to the FB pin.

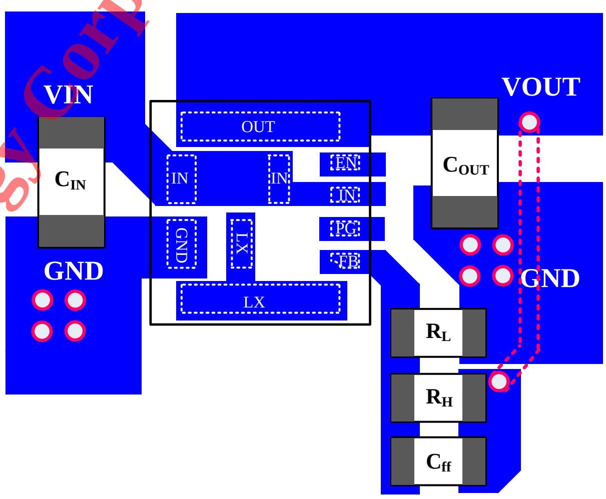
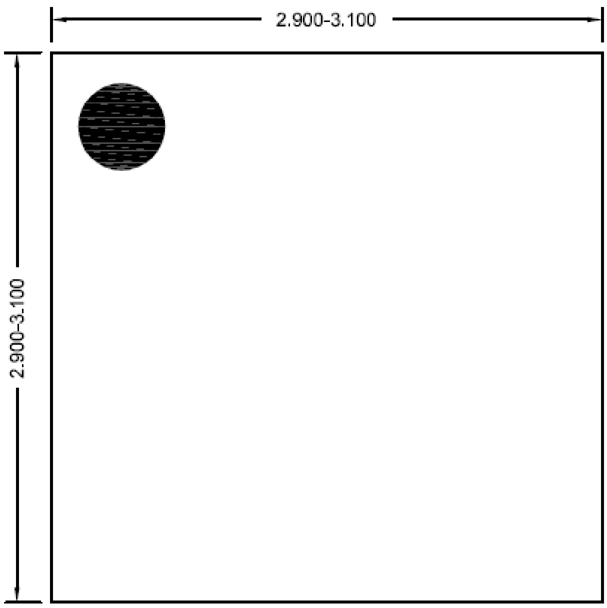
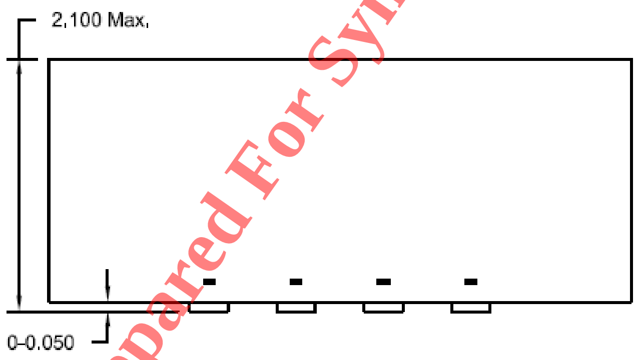


Figure3. PCB Layout Suggestion

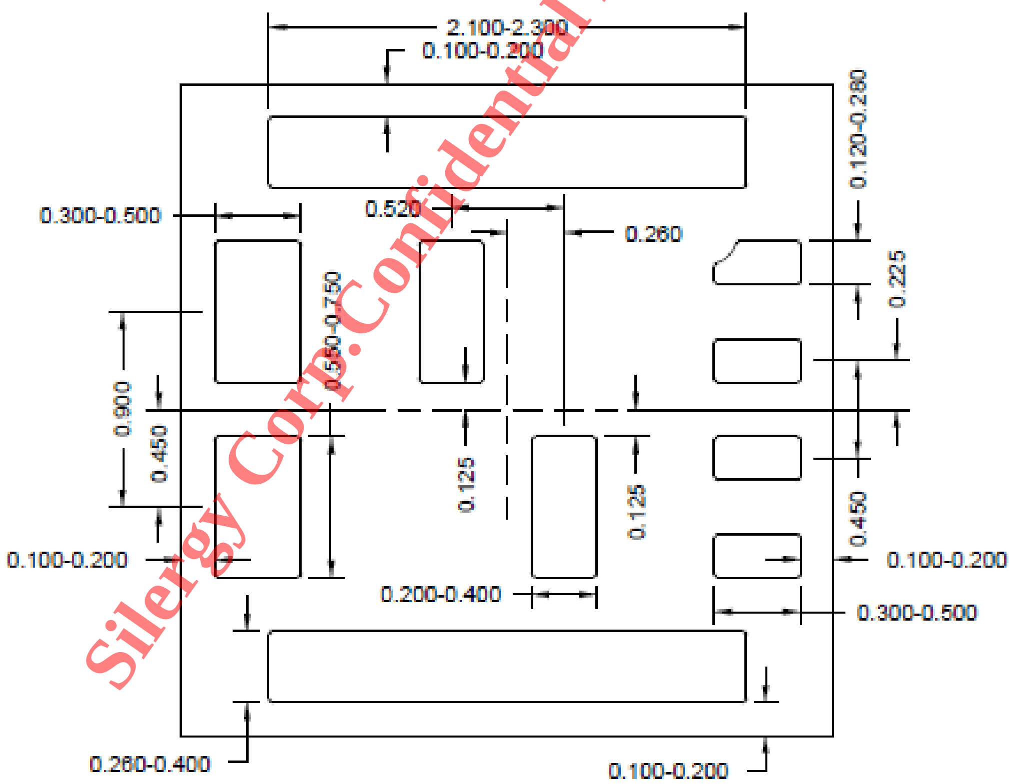
QFN3x3-10 Package Outline Drawing



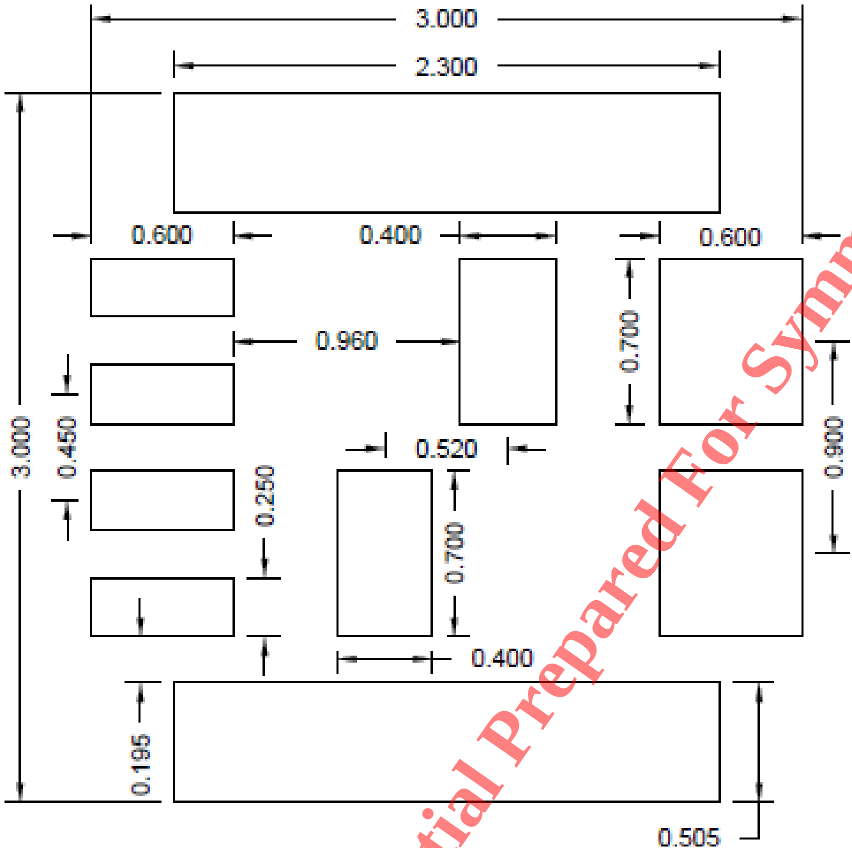
Top View



Side View



Bottom View

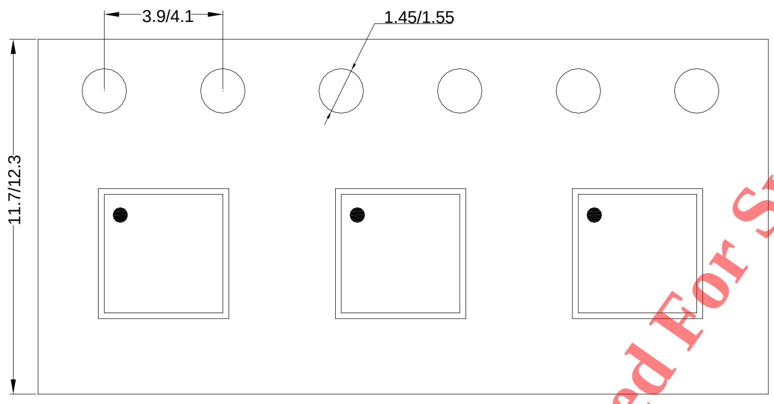


Recommended PCB layout
(Reference only)

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

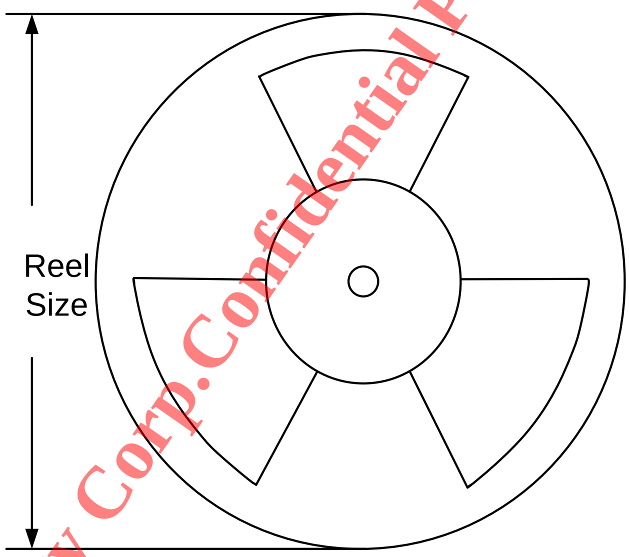
Taping & Reel Specification

1. QFN3x3 taping orientation



Feeding direction

2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
QFN3x3	12	8	13"	400	400	3000

3. Others: NA

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