Application Note: SQ24345H

36V, 500mA LDO Regulator

General Description

The SQ24345H is a 500mA high current capacity linear regulator, which features ultra-low ground current and low drop out voltage. The SQ24345H has an adjustable output which can be set by two external resistors. The device with fully protection includes over current limit, output short protection and over temperature operation.

Ordering Information

SQ24345 □(□□□)

- Package Code
- Optional Spec Code

Ordering Number	Package type	Note
SQ24345HDGD	DFN2×3-8	----

Features

- 4V to 36V Input Voltage Range, V_{ABS}=40V
- V_{FB}: 1.235V (±1%)
- Output Voltage Tolerance: ±1%
- Line Regulation: 0.2%/V
- Load Regulation: 0.25%
- PSRR: 60dB
- Noise Level: 150μVRMS
- Operating T_J: -40°C to 125°C
- Auto Retry after All Faults
- Compact Package: DFN2×3-8

Applications

- Portable Consumer Equipment
- Portable Instrumentation
- Industrial Equipment
- SMPS Post Regulators

Typical Applications

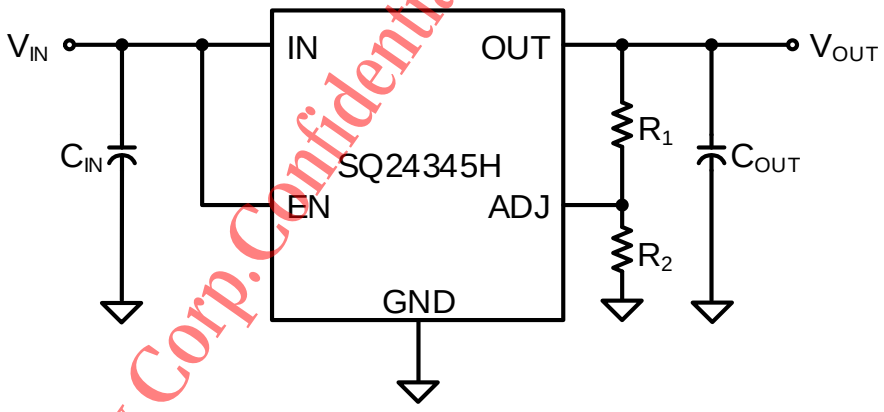
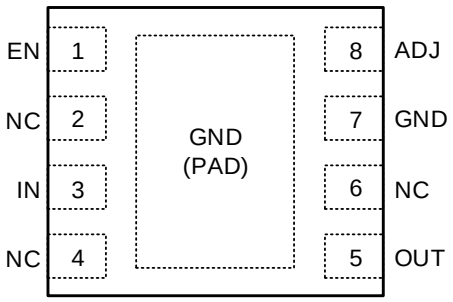


Figure 1. Schematic Diagram

Pinout (top view)



(DFN2×3-8)

Top mark: **4A*xyz for*** SQ24345HDGD (Device code: 4A, ***x=year code, y=week code, z= lot number code***)

Pin Name	Pin number	Pin Description
EN	1	Enable. CMOS compatible control input. Logic high = enable; Logic low or open = shutdown.
NC	2, 4, 6	No connection.
IN	3	Supply input.
OUT	5	Regulator output.
GND	7	Ground.
ADJ	8	Adjustable part only. Feedback input. Connect to resistive voltage-divider network.

Block Diagram

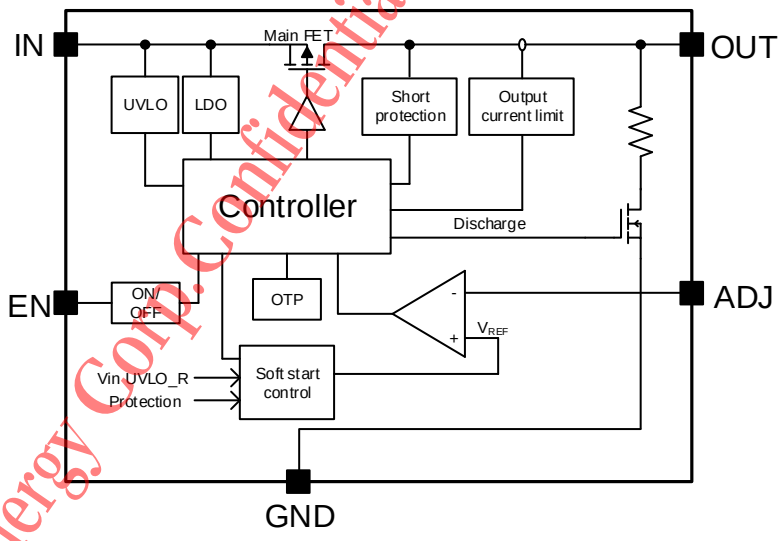


Figure2. Block Diagram

Absolute Maximum Ratings (Note 1)

IN, EN, OUT, ADJ ---------- -0.3V to 40V
Power Dissipation, P_D @ T_A = 25℃ ---------- 2.17W
Package Thermal Resistance (Note 2)
θ_{JA} ---------- 46℃/W
θ_{JB} ---------- 22.5℃/W
θ_{JC} ---------- 28℃/W
Junction Temperature---------- -40℃ to 150℃
Lead Temperature (Soldering, 10 sec.) ---------- 260℃
Storage Temperature Range ---------- -65℃ to 150℃

Recommended Operating Conditions (Note 3)

IN ---------- 4V to 36V
EN, OUT, ADJ ---------- 0V to 36V
Junction Temperature Range ---------- -40℃ to 125℃

Electrical Characteristics

(V_{IN} = V_{EN}=12V, T_J = -40℃~125℃, typical values are at T_J=25℃, unless otherwise specified, the values are guaranteed by test, design or statistical correlation)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage	V_{IN}		4		36	V
Reference Voltage	V_{REF}	T_A= 25℃	1.223	1.235	1.247	V
		T_J= -40℃~125℃	1.210	1.235	1.260	V
Line Regulation	ΔV_{LNR}	I_{OUT} = 10mA, 4V ≤ V_{IN} ≤36V		1	1.5	mV/V
Load Regulation	ΔV_{LDR}	V_{IN} = 5V, 10mA ≤ I_{OUT} ≤ 0.5A,		0.25	1.0	%
Dropout Voltage	ΔV_{DROP}	I_{OUT} = 10mA		10	20	mV
		I_{OUT} = 300mA		300	540	mV
		I_{OUT} = 500mA		500	750	mV
Shutdown Current	I_{SHDN}	V_{EN}=0V, V_{IN}=24V			5	μA
Ground Pin Current	I_{GND}	No Load		7	14	μA
		I_L=0.1mA		90	190	μA
		I_L=50mA		250	900	
		I_L=150mA		1.0	2.5	mA
		I_L=500mA		6.5	30.0	
Output Current	I_O	V_{IN}=V_{OUT}+1V	0		500	mA
Current Limit	I_{LIMIT}	V_{OUT}=0.9×V_{OUT}(normal)	600	900	1200	mA
Input Voltage UVLO Threshold	V_{UVLO}	V_{IN} rising			3.9	V
UVLO Hysteresis	$V_{UVLO,HYS}$			200		mV
Shutdown Discharge Resistance	R_{DIS}			600		Ω
Ripple Rejection	PSRR			60		dB
Output Noise	e_{NO}	I_L = 10mA, C_L = 1.0μF, C_{IN} = 1μF, (10Hz~100kHz)		150		μV_{RMS}
Enable Input Logic-low Voltage	V_{IL}	OFF			0.4	V
Enable Input Logic-high Voltage	V_{IH}	ON	1.5			V
Thermal Shutdown Temperature	T_{SD}			150		℃
Thermal Shutdown Hysteresis	T_{HYS}			20		℃

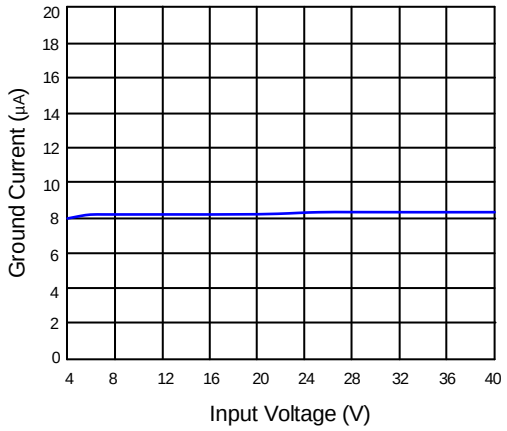
Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute 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 high effective single layer thermal conductivity test board of JESD51-2, -5, -7, -8, -14 thermal measurement standard.

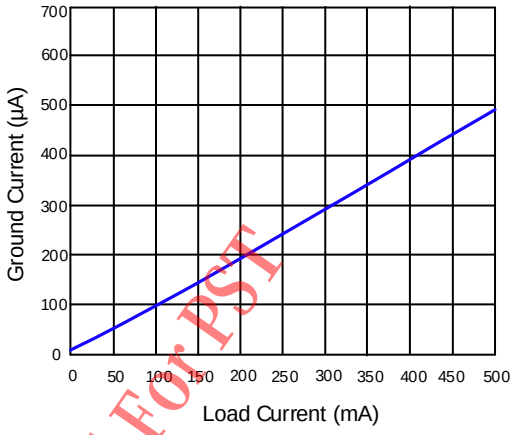
Note 3: The device is not guaranteed to function outside its operating conditions.

Typical Performance Characteristics

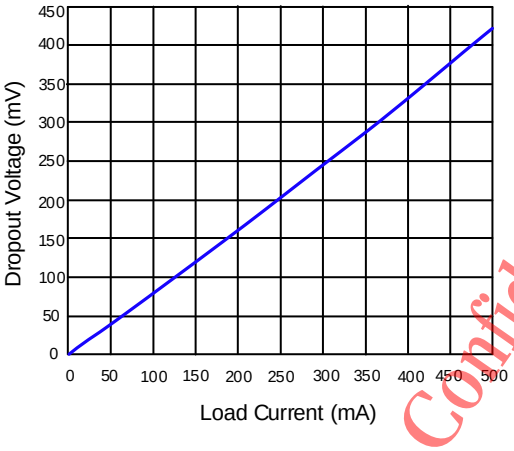
Ground Current vs. Input Voltage
(C_{IN}=10μF, C_{OUT}=4.7μF, Null Load)



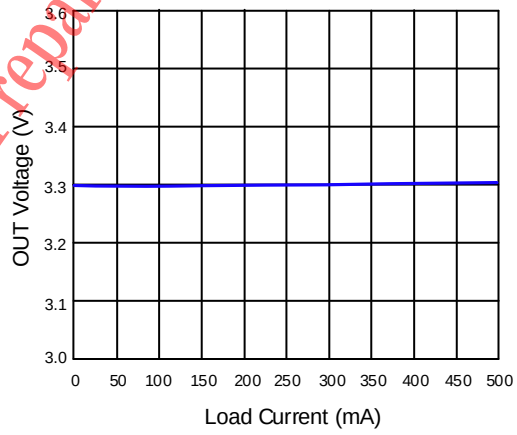
Ground Current vs. Load Current
(V_{IN}=5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF)



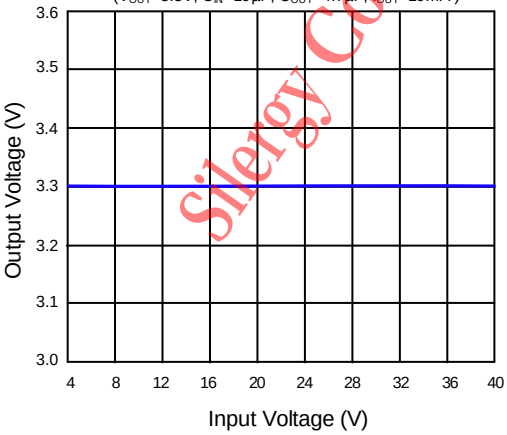
Dropout Voltage vs. Load Current
(V_{IN}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF, I_{OUT}=10mA)



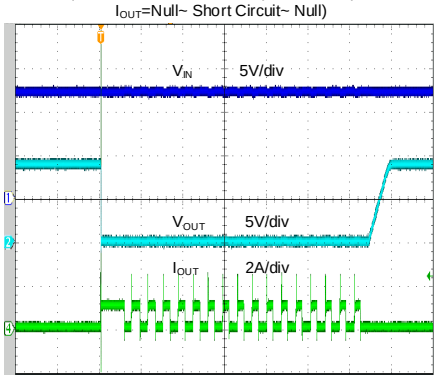
OUT Voltage vs. Load Current
(V_{IN}=5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF)



Output Voltage vs. Input Voltage
(V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF, I_{OUT}=10mA)

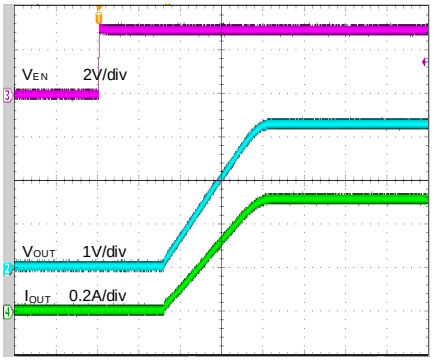


Short Protect
(V_{IN}=12V, V_{OUT}=9V, C_{IN}=10μF,C_{OUT}=4.7μF,
I_{OUT}=Null~ Short Circuit~ Null)



Startup from Enable

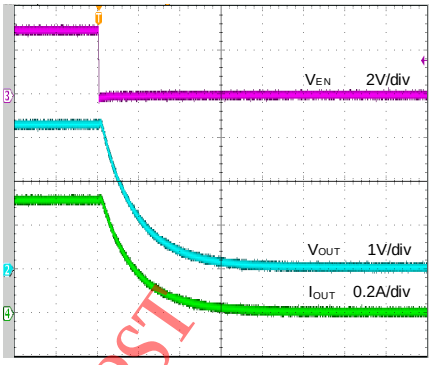
(V_{IN}=5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF, I_{OUT}=500mA)



Time (400μs/div)

Shutdown from Enable

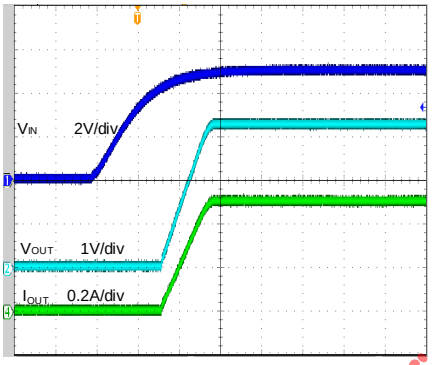
(V_{IN}=5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF, I_{OUT}=500mA)



Time (40μs/div)

Startup from V_{IN}

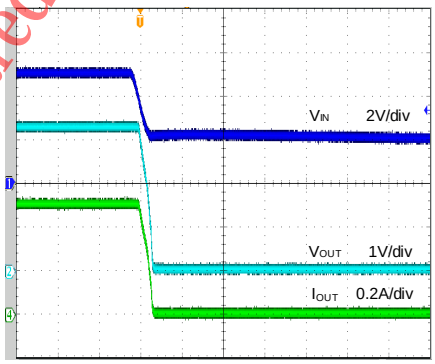
(V_{IN}=5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF, I_{OUT}=500mA)



Time (800μs/div)

Shutdown from V_{IN}

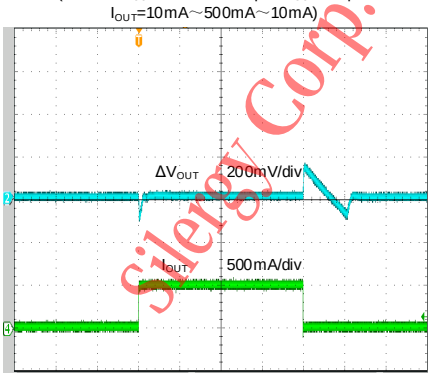
(V_{IN}=5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF, I_{OUT}=500mA)



Time (2ms/div)

Load Transient

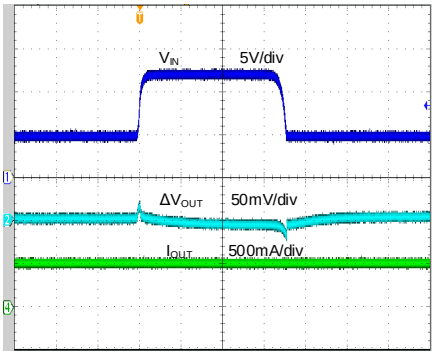
(V_{IN}=5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF,
I_{OUT}=10mA~500mA~10mA)



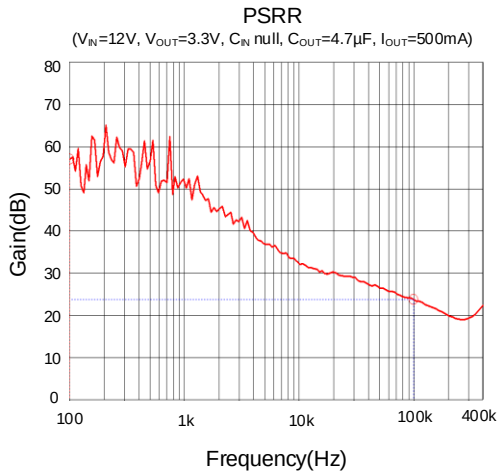
Time (100μs/div)

Line Transient

(V_{IN}=5V~12V~5V, V_{OUT}=3.3V, C_{IN}=10μF, C_{OUT}=4.7μF,
I_{OUT}=500mA)



Time (2ms/div)



Operation

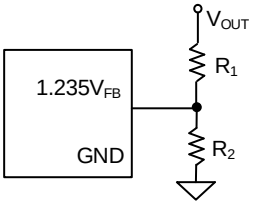
The SQ24345H is a 500mA high current capacity linear regulator, which features ultra-low ground current and low dropout voltage. The SQ24345H has an adjustable output which can be set by two external resistors. The device with fully protection includes over current limit, output short protection and over temperature operation.

Applications Information

Feedback Resistor Dividers R_1 and R_2:

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. A value of between 10kΩ and 10MΩ is highly recommended for both resistors. If V_{OUT} is 3.3V, R_1=50.1kΩ is chosen, then using the following equation, R_2 can be calculated to be 30kΩ:

$$R_2=\frac{1.235V}{V_{OUT}-1.235V}\times R_1$$



Input Capacitor C_{IN}:

An input capacitor about 10μF is required between the device input pin and the ground pin. A typical X5R or better grade ceramic capacitor is recommended in this application. This input capacitor must be located close to the device to minimize the input noise.

Output Capacitor C_{OUT}:

For transient stability, the SQ24345H is designed specifically to work with very small ceramic output capacitors. A 4.7μF output capacitance can be used in this application. Higher capacitance values help to improve transient. The output capacitor's ESR is critical because it forms a zero to provide phase lead which is required for loop stability.

Dropout Voltage:

The SQ24345H has a very low dropout voltage due to its extra low $R_{DS(ON)}$ of the main PMOS determines the lowest usable supply.

$$V_{DROPOUT}=V_{IN}-V_{OUT}=R_{DS(ON)}\times I_{OUT}$$

Over Current and Short Circuit Protection:

The device includes over current and short circuit protection. The current limitation circuit regulates the output current to its limitation threshold to protect the IC from damage. Under over current or short circuit condition, the power loss of the IC is relative high. And that may trigger the thermal protection.

Thermal Considerations:

The SQ24345H can deliver a current of up to 500mA over the full operating temperature range. However, the maximum output current must be derated at higher ambient temperature. With all possible conditions, the junction temperature must be within the range specified under operating conditions. Power dissipation can be calculated based on the output current and the voltage drop across regulator.

$$P_D=(V_{IN}-V_{OUT})\times I_{OUT}+V_{IN}\times I_{GND}$$

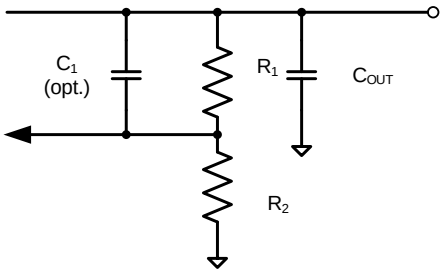
The final operating junction temperature for any set of condition can be estimated by the following thermal equation:

$$P_{D(MAX)}=(T_{J(MAX)}-T_A)/\theta_{JA}$$

Where $T_{J(MAX)}$ is the maximum junction temperature of die and T_A is the maximum ambient temperature. The junction to ambient thermal resistance (θ_{JA}) footprint is 46℃/W for DFN2×3-8 package.

Load Transient Considerations:

The SQ24345H integrates the compensation components to achieve good stability and fast transient responses. In some applications, adding a small ceramic cap in parallel with R_1 may further speed up the load transient responses and is thus recommended for applications with large load transient step requirements.



PCB Layout Guide:

For the best performance of the SQ24345H, the following guidelines must be strictly followed:

1. Keep all power trace as short and wide as possible. And it is desirable to use 2-layer or 4-layer board for thermal performance and better capability of current flow.
2. Place input/output capacitor close to the IC for better transient performance.

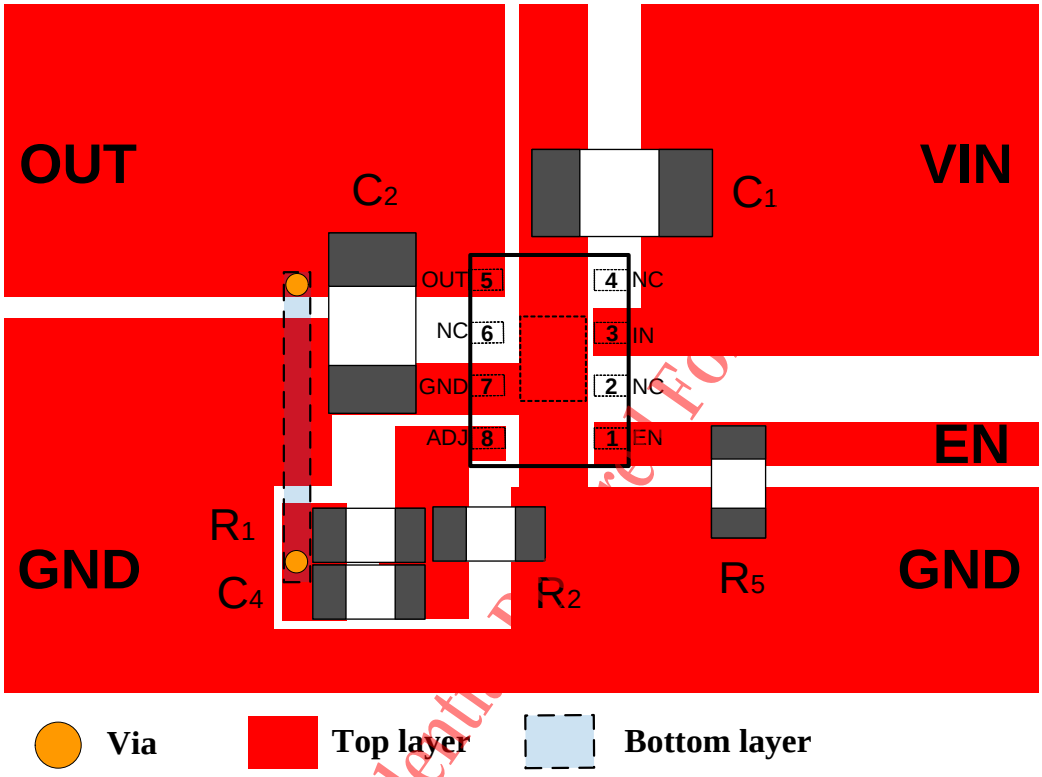
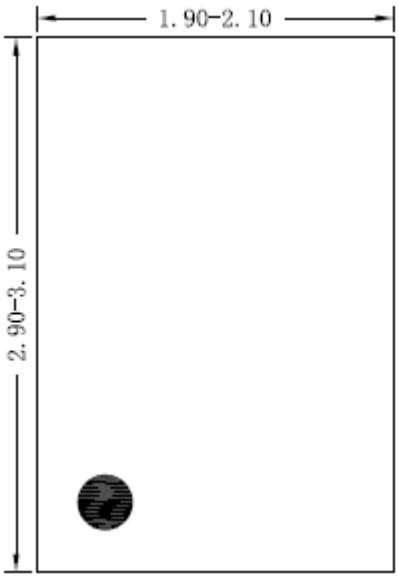
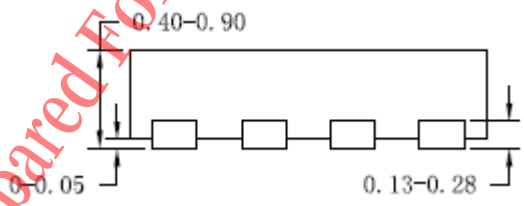


Figure3. PCB Layout Suggestion

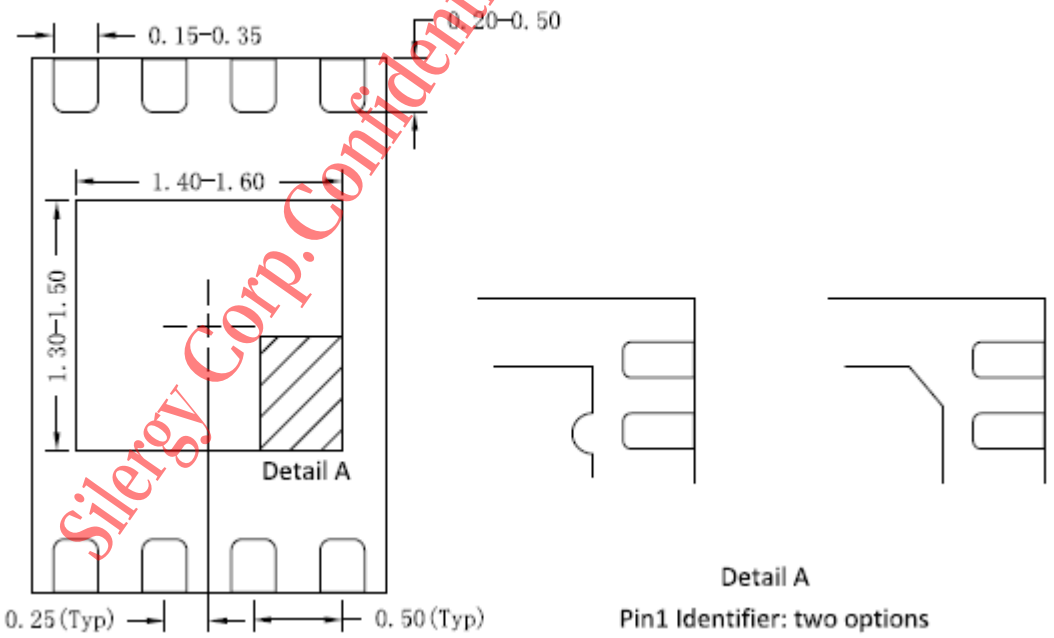
DFN2×3-8 Package Outline



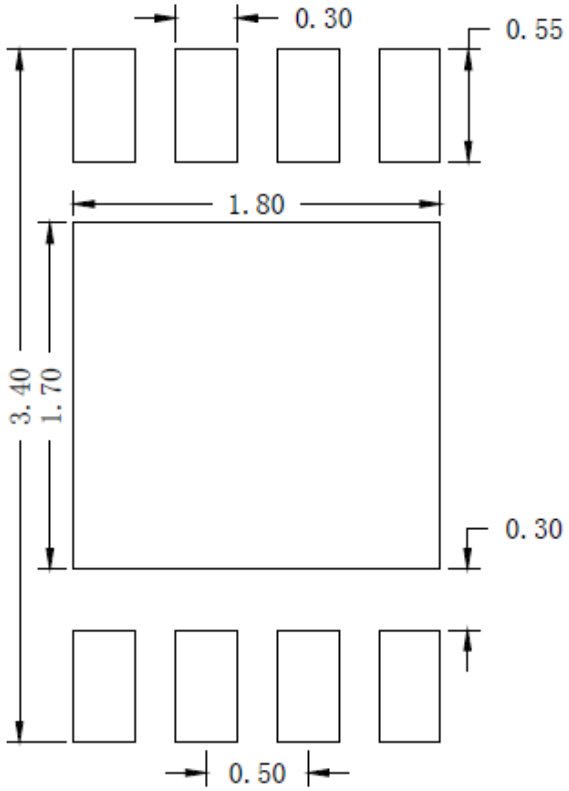
Top View



Side View



Bottom View

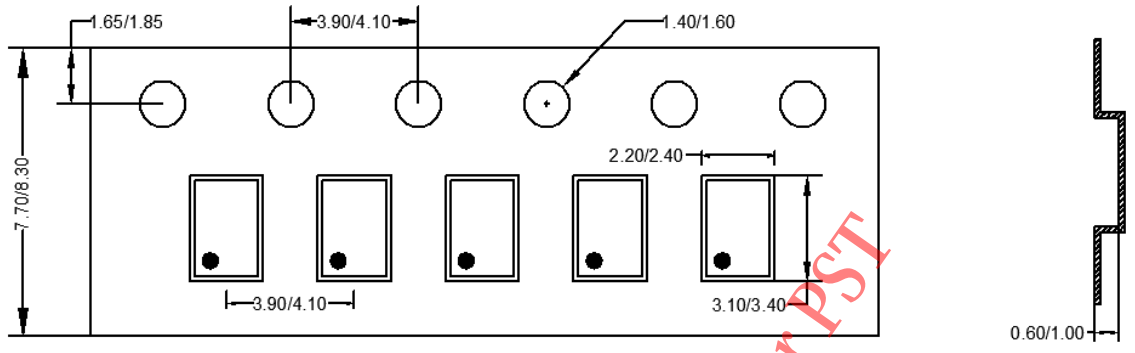


Recommended PCB layout
(Reference only)

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

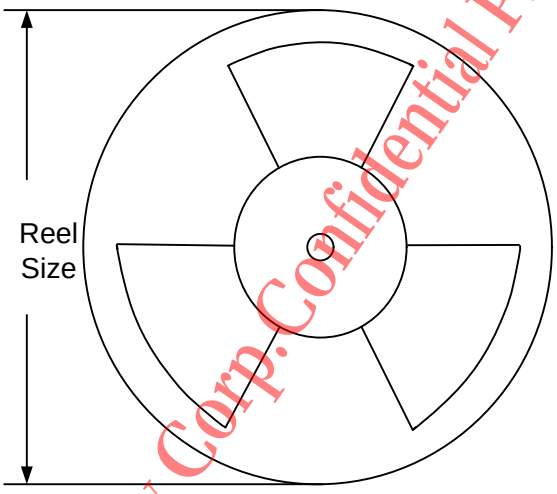
Taping & Reel Specification

1. DFN2×3-8 taping orientation



Feeding direction →

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
DFN2×3	8	4	7"	400	160	3000

3. Others: NA

Revision History

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

Date	Revision	Change
Jul.28, 2020	Revision 0.9	Initial Release

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