# Application Note: SY6301

## Super Low Dropout 1A LDO Regulator

## General Description

The SY6301 is a super low dropout LDO regulator with small package, capable of delivering up to 1A output current.

## Features

- Input Voltage Range: 1.6-5.5V
- Output Voltage Accuracy: ±3%
- Up to 1A Output Current
- Low Dropout Voltage:
  Typ. 0.32V at $I_{OUT}$=1A, $V_{OUT}$=1.5V
  Typ. 0.18V at $I_{OUT}$=1A, $V_{OUT}$=2.8V
- Current Limiting Protection
- Thermal Shutdown Protection
- Quiescent Current: 60μA
- Output Auto-discharge Function
- Over Temperature Protection
- RoHS Compliant and Halogen Free
- Compact Package: DFN3×3-6

## Ordering Information

SY6301 □(□□)□

- Temperature Code
- Package Code
- Optional Spec Code

| Ordering Number | Package type | Note |
|---|---|---|
| SY6301DSC | DFN3×3-6 | ---- |

## Applications

- Portable Communication Equipments
- Hand-Held Instruments, Notebook PC
- Camcorders and Cameras

## Typical Applications

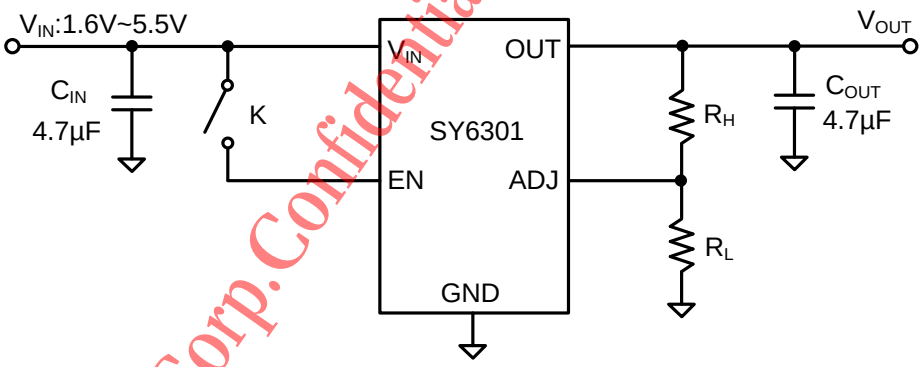
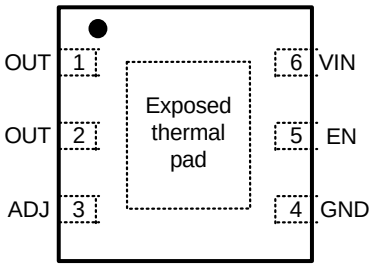



**Figure1. Schematic Diagram**

## Pinout (top view)




(DFN3×3-6)

Top mark: **RB*xyz*** for SY6301DSC (Device code: RB, ***x=year code, y=week code, z=lot number code***)

| Pin Name | Pin Number | Pin Description |
|---|---|---|
| OUT | 1, 2 | Output pin. Decouple this pin to the GND pin with at least a 4.7μF ceramic capacitor. |
| ADJ | 3 | Output voltage programming pin. Connect this pin to the center point of the output resistor divider (as shown in Figure 1) to program the output voltage: $V_{OUT}$=1.0V×(1+$R_H$/$R_L$). |
| GND | 4 | Ground pin. |
| EN | 5 | Enable control pin. A 5MΩ pull-down resistor is integrated. |
| VIN | 6 | Input pin. Decouple this pin to the GND pin with at least a 4.7μF ceramic capacitor. |

## Block Diagram

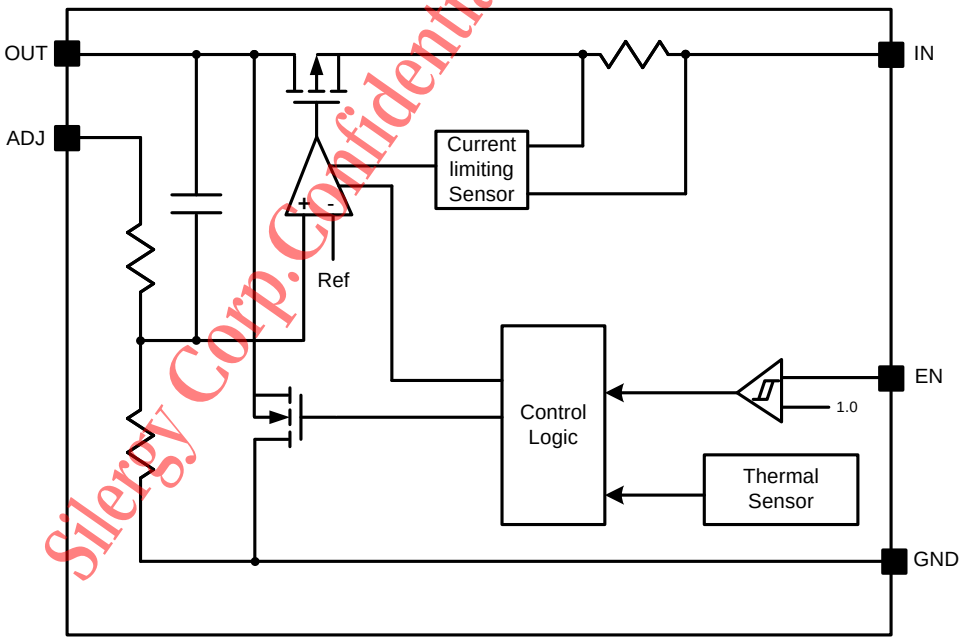



**Figure2. Block Diagram**

## Absolute Maximum Ratings (Note 1)

IN, EN ---------- 6.0V
Power Dissipation, $P_D$ @ $T_A$ = 25℃ DFN3×3-6 ---------- 2W
Package Thermal Resistance (Note 2)
$\theta_{JA}$ ---------- 50℃/W
$\theta_{JC}$ ---------- 15℃/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 ---------- 1.6V to 5.5V
Junction Temperature Range ---------- -40℃ to 125℃
Ambient Temperature Range ---------- -40℃ to 85℃

## Electrical Characteristics

($V_{IN}$ = 5V, $C_{IN}$=4.7μF, $C_{OUT}$=4.7μF, $T_A$ = 25℃ unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Input Voltage Range | $V_{IN}$ | | 1.6 | | 5.5 | V |
| Supply Current | $I_{SS}$ | $V_{EN}$=$V_{IN}$=2V, $V_{OUT}$=$V_{ADJ}$, $I_{OUT}$=0A | | 60 | 100 | μA |
| Shutdown Current | $I_{SD}$ | $V_{IN}$=6.0V, $V_{EN}$=0 | | 0.1 | 1 | μA |
| Output Voltage Accuracy | Δ $V_{OUT}$ | $V_{OUT}$=$V_{ADJ}$, $V_{IN}$=2.0V, $I_{OUT}$=100mA | 0.970 | | 1.030 | V |
| Output Voltage Range | | | 1.0 | | $V_{IN}$ | V |
| Current Limit | $I_{LIM}$ | | 1.0 | | | A |
| Load Regulation | Δ $V_{OUT}$/Δ $I_{OUT}$ | $V_{OUT}$=$V_{ADJ}$, $V_{IN}$=2.0V 1mA≤$I_{OUT}$≤1A | | -3 | | mV/A |
| Line Regulation | Δ $V_{OUT}$/ Δ $V_{IN}$ | $V_{OUT}$=$V_{ADJ}$, $I_{OUT}$=100mA 2.0≤$V_{IN}$≤5.5V | | 0.05 | 0.2 | %/V |
| EN Pull-down Resistance | $R_{EN}$ | | | 5 | | MΩ |
| Ripple Rejection | RR | f=1kHz, Ripple 0.5$V_{P-P}$ $V_{OUT}$=$V_{ADJ}$, $V_{IN}$=2.5V, $I_{OUT}$=100mA | | -60 | | dB |
| Output Voltage Temperature Coefficient | Δ $V_{OUT}$/Δ T | $I_{OUT}$=100mA -40℃≤T≤85℃ | | ±100 | | ppm/℃ |
| Short Current Limit | $I_{SHORT}$ | $V_{OUT}$=0V | | 250 | | mA |
| Discharge Resistor | $R_{DISCHG}$ | | | 100 | | Ω |
| EN Rising Threshold | $V_{ENH}$ | | 1.0 | | | V |
| EN Falling Threshold | $V_{ENL}$ | | | | 0.4 | V |
| Thermal Shutdown Temperature | $T_{SD}$ | | | 150 | | ℃ |
| Thermal Shutdown Hysteresis | $T_{HYS}$ | | | 20 | | ℃ |
| Dropout Voltage | $V_{DROP}$ | Refer to following table | | | | |

**Dropout Voltage by output Voltage** $T_A$ = 25℃

| Output Voltage(V) $V_{OUT}$ | Dropout Voltage $V_{DROP}$ (V) | | |
|---|---|---|---|
| | I=300mA | | I=1A |
| | Typ. | Max | Typ |
| 1.0V≤$V_{OUT}$ < 1.5V | 0.18 | 0.32 | 0.50 |
| 1.5V≤ $V_{OUT}$ < 2.6V | 0.10 | 0.15 | 0.28 |
| 2.6V≤$V_{OUT}$ | 0.05 | 0.10 | 0.18 |

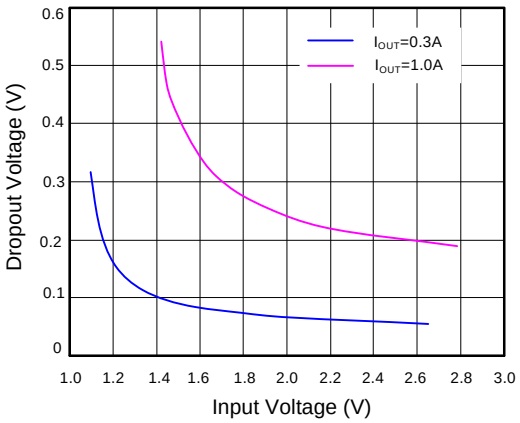
**Note 1**: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute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

**Note 2**: $\theta_{JA}$ is measured in the natural convection at $T_A$ = 25℃ on a two-layer Silergy evaluation board.

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

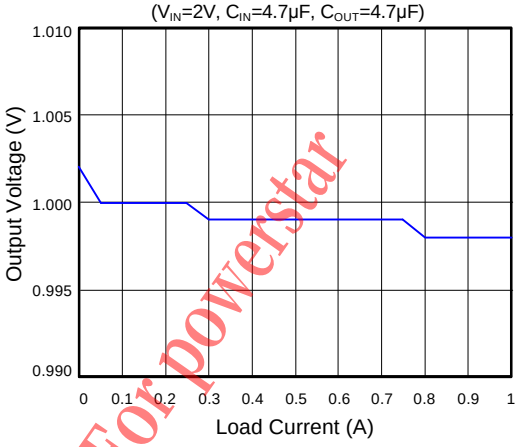
# Typical Operating Characteristics

Dropout Voltage vs. Input Voltage



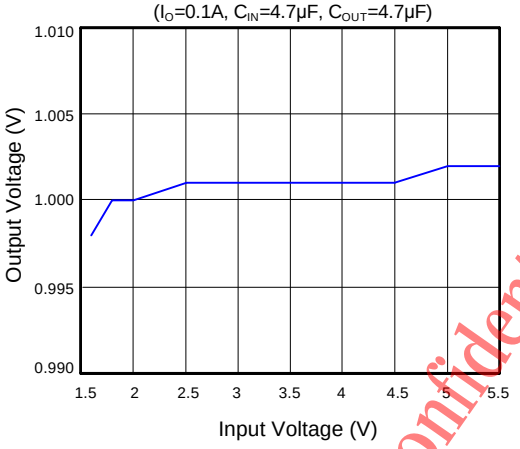

Load Regulation

($V_{IN}$=2V, $C_{IN}$=4.7μF, $C_{OUT}$=4.7μF)



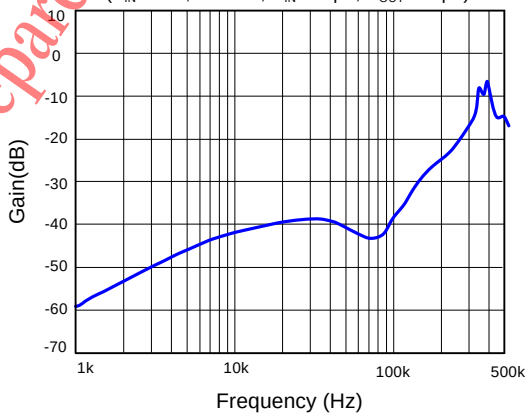

Line Regulation

($I_O$=0.1A, $C_{IN}$=4.7μF, $C_{OUT}$=4.7μF)



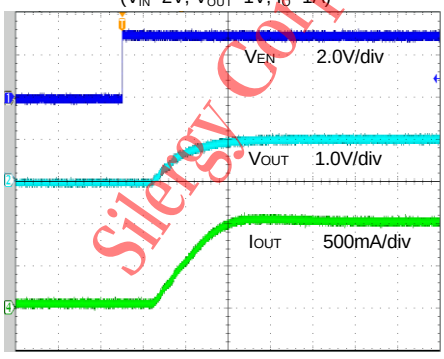

Power Supply Rejection Ratio

($V_{IN}$=2.5V, Io=0.1A, $C_{IN}$=4.7μF, $C_{OUT}$=4.7μF)



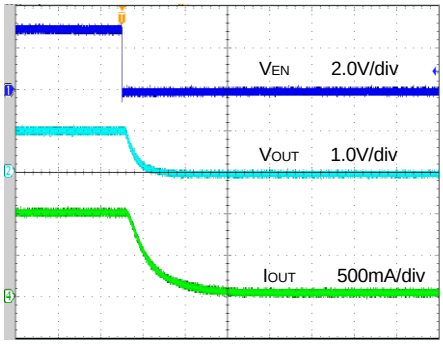

Startup from EN

($V_{IN}$=2V, $V_{OUT}$=1V, $I_O$=1A)



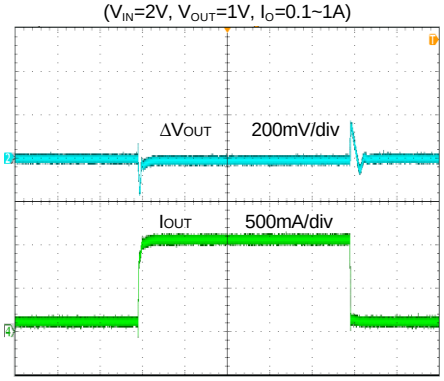

Shutdown from EN

($V_{IN}$=2V, $V_{OUT}$=1V, $I_O$=1A)



Load Transient

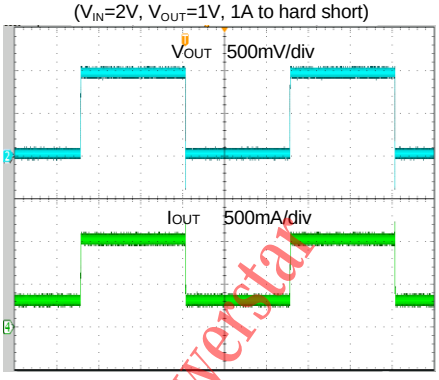
($V_{IN}$=2V, $V_{OUT}$=1V, $I_O$=0.1~1A)




Time (40μs/div)

Short Circuit Protection

($V_{IN}$=2V, $V_{OUT}$=1V, 1A to hard short)




Time (2ms/div)

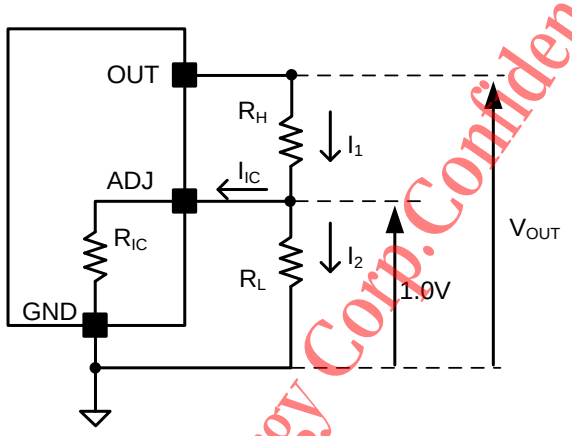
# Operation Information

The SY6301 is a super low dropout LDO regulator with small package, capable of delivering up to 1A output current.

**Input Capacitor CIN:**
An input capacitor about 4.7μF is required between the device input pin and ground pin. A typical X5R or better grade ceramic capacitor with 6V rating is recommended in this application. This input capacitor must be located close to the device to assure the input stability. A lower ESR capacitor allows the use of less capacitance, while higher ESR type requires more capacitance.

**Output Capacitor COUT:**
For transient stability, the SY6301 is designed specifically to work with very small ceramic output capacitors. A 4.7μF input capacitor with 10mΩ to 50mΩ ESR range (like X7R or X5R) 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.

**Output Voltage Setting:**




The Output Voltage may be adjustable for any output voltage between its 1.0V reference and its VIN setting level. An external pair of resistors is required, as shown above.
The complete equation for the output voltage is described as follows;

$V_{OUT}=1.0+R_H(I_{IC}+1.0/R_L)$;
Thus, $V_{OUT}=1.0(1+R_H/R_L)+R_H \times I_{IC;}$
Therefore, $R_H \times I_{IC}$ will produce an error in $V_{OUT}$.

For better accuracy, choosing $R_L<<R_{IC}$ (1.45MΩ) reduces this error.

So, $V_{OUT}=1.0(1+R_H/R_L)$, $(R_L<<R_{IC})$.

**No Load Stability:**
The device will remain stable and in regulation with no external load. This is especially important in CMOS RAM keep-alive applications.

**Dropout Voltage:**
The SY6301 has a very low dropout voltage due to its extra low $R_{DS(ON)}$ of the main PMOS determines the lowest usable supply voltage. In battery-powered systems, the dropout voltage is a regulator's minimum $V_{IN}$-$V_{OUT}$, which determines the useful end-of-life battery voltage:

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

**Current Limit:**
The minimum current limit of the SY6301 is 1A.

**Short-circuit Protection**
The device is short circuit protected and in the event of a peak over-current condition, the short-circuit control loop will rapidly drive the output PMOS pass element off. The thermal shutdown and soft-start circuit will works cycle output on and off until the average power dissipation causes the thermal shutdown circuit to respond to servo the on/off cycling to a lower frequency.

**Thermal Considerations:**
The SY6301 can deliver a current of up to 1A over the full operating junction temperature range. However, the maximum output current must be derated at higher ambient temperature to ensure the junction temperature does not exceed 125℃. 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 conditions 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 the die and $T_A$ is the maximum ambient temperature.

**Layout Design:**

Good board layout practices must be used or instability can be induced because of ground loops and voltage drops, and large PCB copper area can improve the thermal performance. The input and output capacitors MUST be directly connected to the input, the output, and the ground pins of the device using traces which have no other currents flowing through them. The feed back loop formed by $R_L$, $R_H$ and the trace connecting to the ADJ pin and the OUT must be minimize.

The best way to do this is to layout $C_{IN}$ and $C_{OUT}$ near the device with short traces to the $V_{IN}$, $V_{OUT}$, and ground pins. The regulator ground pin should be connected to the external circuit ground so that the regulator and its capacitors have a "single point ground".

Below is the recommended PCB Layout diagram:

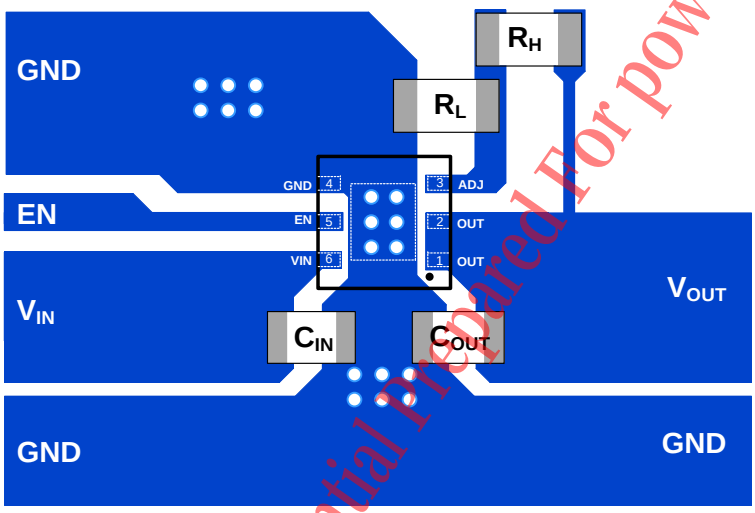
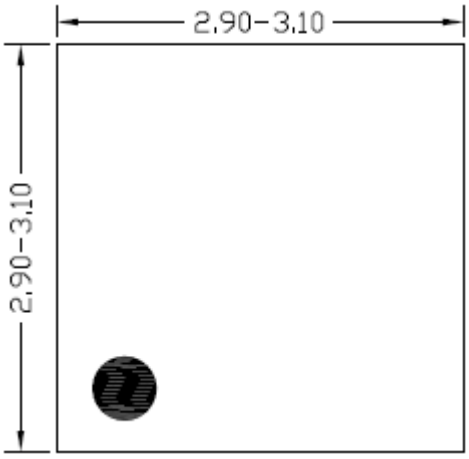
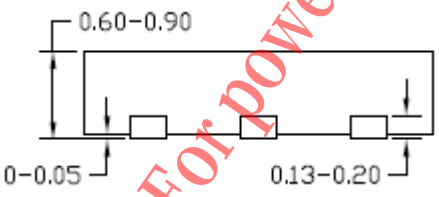



Figure3. PCB Layout Suggestion

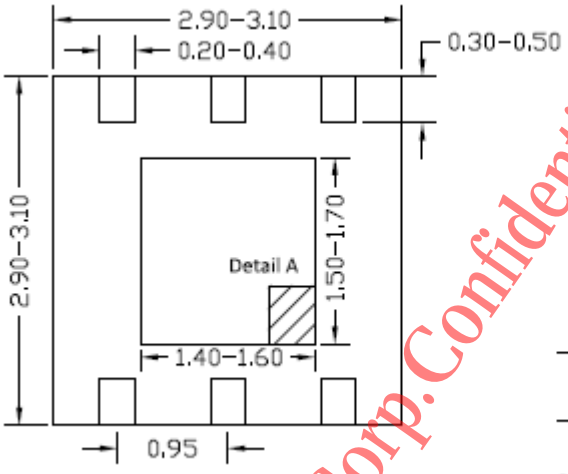
# DFN3×3-6 Package Outline Drawing

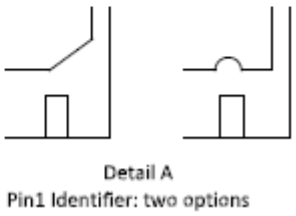



Top View




Side View



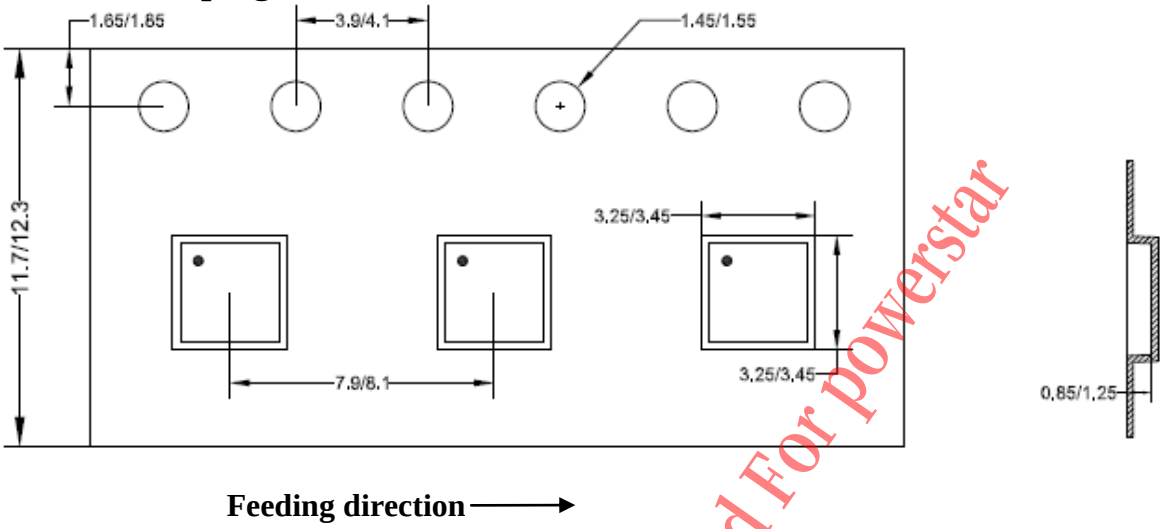




Bottom View

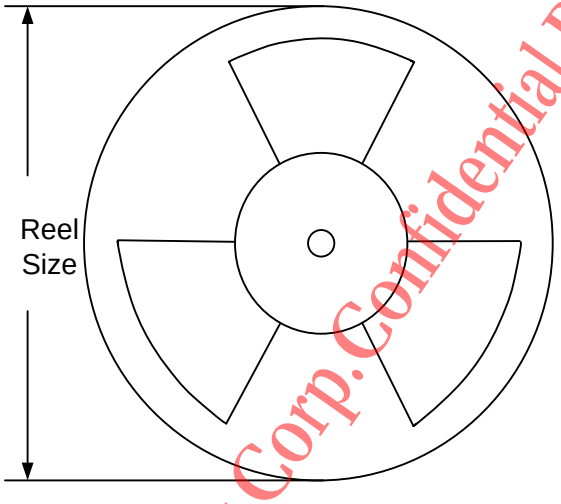
**Notes:** **All dimension in millimeter and exclude mold flash & metal burr**

# Taping & Reel Specification

## 1. DFN3×3 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 |
|---|---|---|---|---|---|---|
| DFN3×3 | 12 | 8 | 13" | 400 | 400 | 5000 |

## 3. Others: NA

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