

## Low Dropout Regulators

### Description

The SL9650 Series is a low dropout, positive linear regulator with very low quiescent current. It can supply 600mA output current with an input range from 1.7V to 7V, which makes it suitable for all kinds of applications.

SL9650 Series use advanced CMOS technology to achieve very low dropout voltage (300mV @600mA). Fast structural design achieves 75dB PSRR at 1kHz while still maintaining a small 50uA quiescent current.

Trimming technique is used to guarantee output voltage accuracy within  $\pm 2\%$  (Fixed Output);  $\pm 1\%$  (Adjustable Output). SL9650 Series provides full fault protection including current limit, short circuit protection and thermal shutdown protection.

### Features

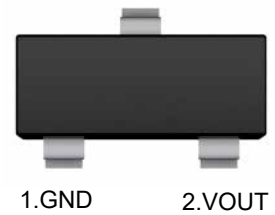
- Fixed Output Voltages:  
0.7V, 1.0V, 1.2V, 1.5V, 1.8V, 2.5V, 2.8V, 3.0V, 3.3V, 3.6V, Other output can be customized
- Adjustable Output from 0.6V to (VIN-VDROP)
- Maximum Output Current: 600mA
- Input Voltage Range: 1.7V~7V
- Low Quiescent Current: 50uA (Typ.)
- Very low dropout voltage:  
300mV @ 600mA (Vout=3.3V)
- Highly Accurate:  $\pm 2\%$  (Fixed Output)  
 $\pm 1\%$  (Adjustable Output)
- 0.02%/V Line Regulation
- Auto discharge function
- 75dB PSRR @ 1KHz
- -40°C~125°C Wide Operating Temperature
- 2000V HBM ESD
- 150 °C Thermal Protection

### Applications

- Battery powered portable devices
- Smart phone, tablet
- Hi resolution camera sensor power
- Wireless modules
- RF, PLL, VCO clock power

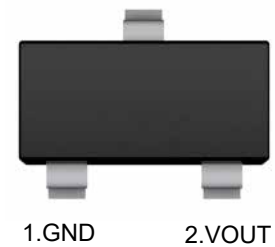
**SOT-23**

3.VIN



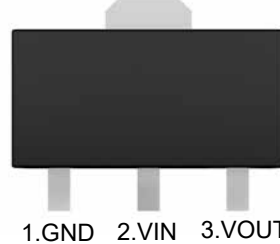
**SOT-23-3**

3.VIN



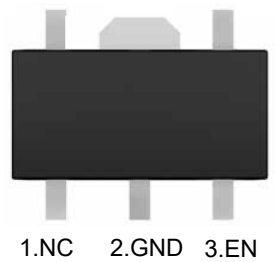
**SOT-89**

2.VIN

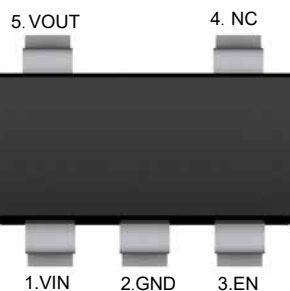


**SOT-89-5**

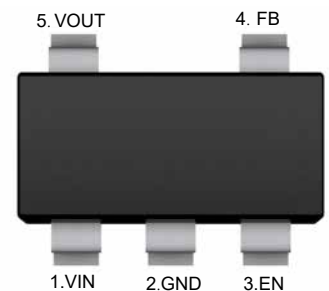
5.VOUT 4.VIN



**SOT-23-5 Fixed**

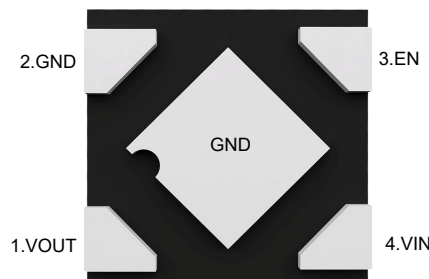


**SOT-23-5 ADJ**



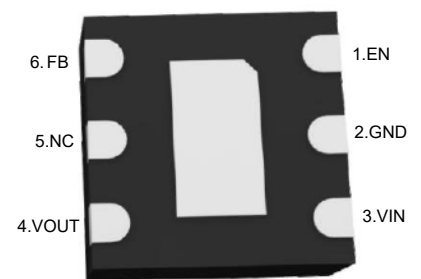
**DFN1x1-4L**

Bottom View



**DFN2x2C-6L**

Bottom View

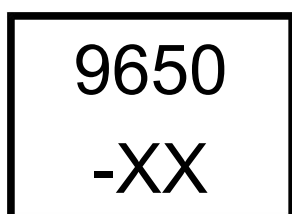


## Functional Pin Description

| Pin Name | Pin Function                                                                                                                                  |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| VIN      | Power Input Voltage                                                                                                                           |
| GND      | Ground                                                                                                                                        |
| EN       | Chip Enable (Active High). Note that this pin is high impedance                                                                               |
| NC       | NO Connected                                                                                                                                  |
| FB       | Feedback Pin (adjustable voltage version only). Connect this pin to the midpoint of an external resistor divider to adjust the output voltage |
| VOUT     | Output Voltage                                                                                                                                |

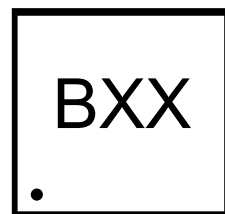
## Marking Code

### 1.SOT



XX:Output Voltage  
e.g. 3.0:3.0V  
AJ:ADJ

### 2.DFN



B:Product Code  
XX:Output Voltage  
e.g. 30:3.0V

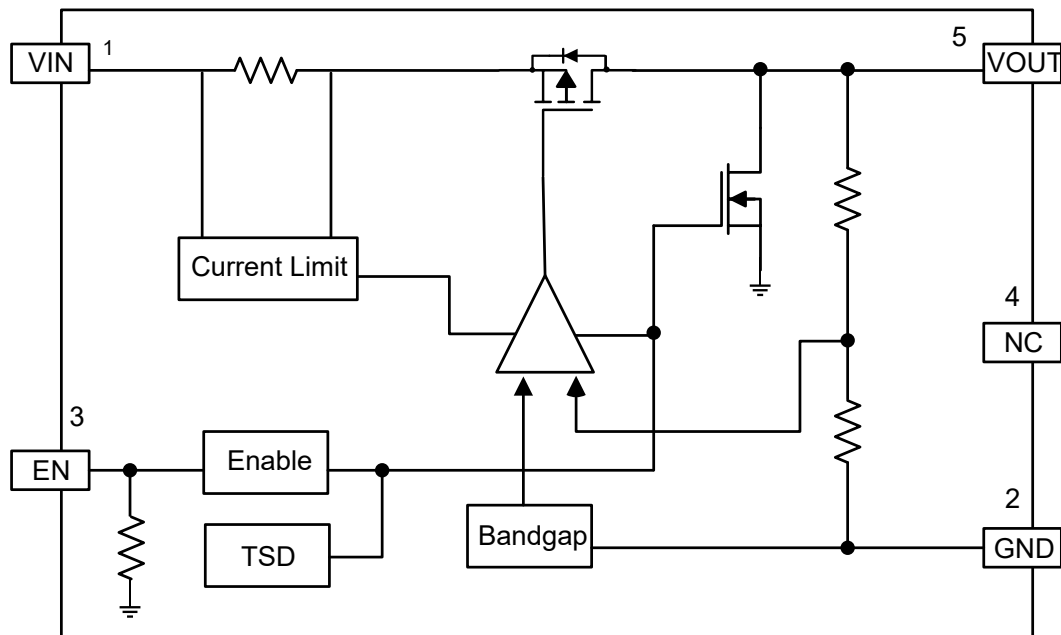
## Ordering Information

SL9650 □□□□

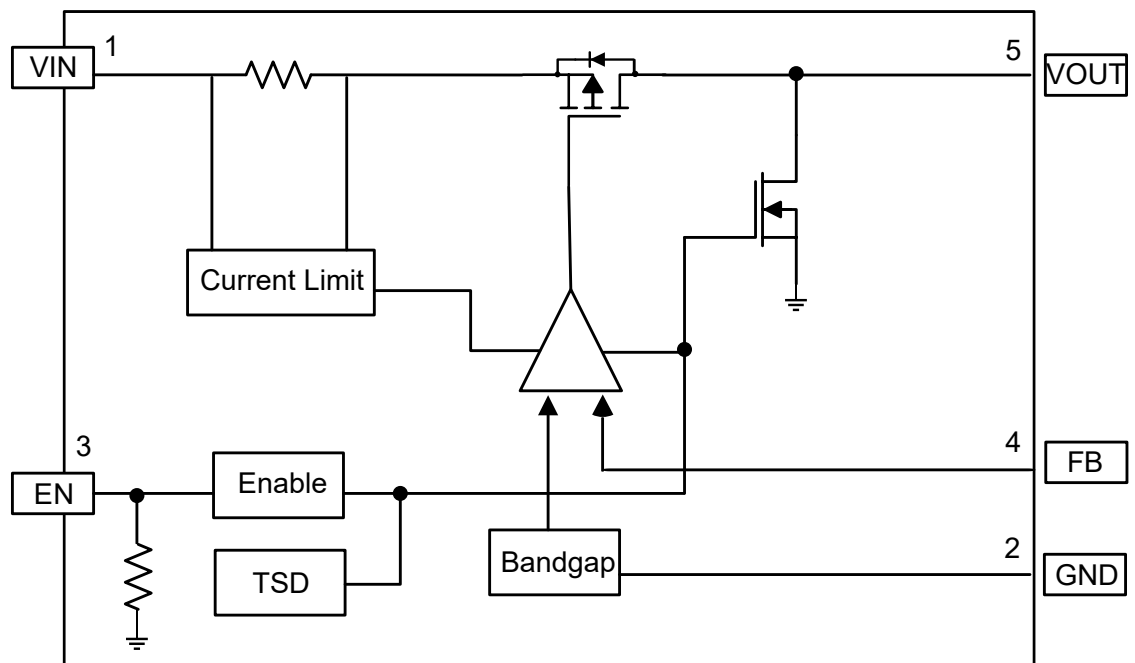
- Package Type
  - SA:SOT-23 SC:SOT-23-3
  - SQ:SOT-89 SR:SOT-89-5
  - SE:SOT-23-5 DE:DFN1x1-4L
  - DFC:DFN2x2C-6L
- Fixed Output Voltage Version
  - 10 : 1.0V 12 : 1.2V 15 : 1.5V
  - 18 : 1.8V 25 : 2.5V 28 : 2.8V
  - 30 : 3.0V 33 : 3.3V 36 : 3.6V
  - ADJ: Adjustable Output Voltage Version
- Output current tap
  - M : 600mA

## Function Block Diagram(Package in SOT-23-5)

### Fixed Output Voltage

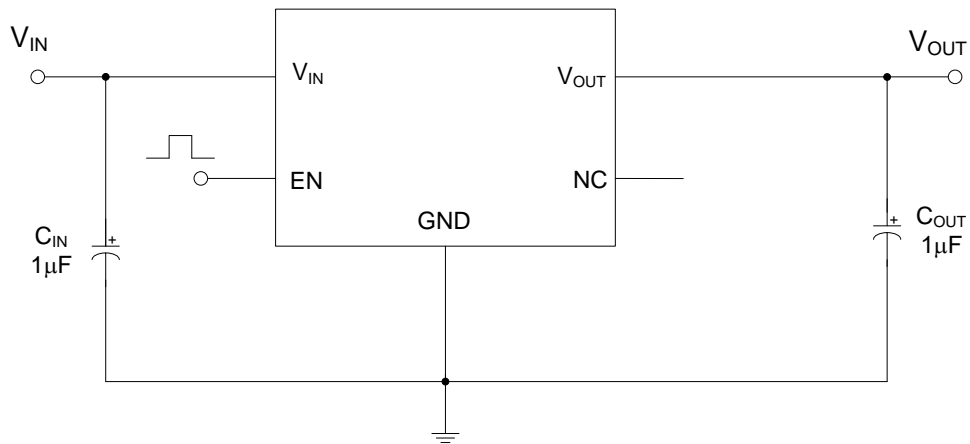


### Adjustable Output Voltage

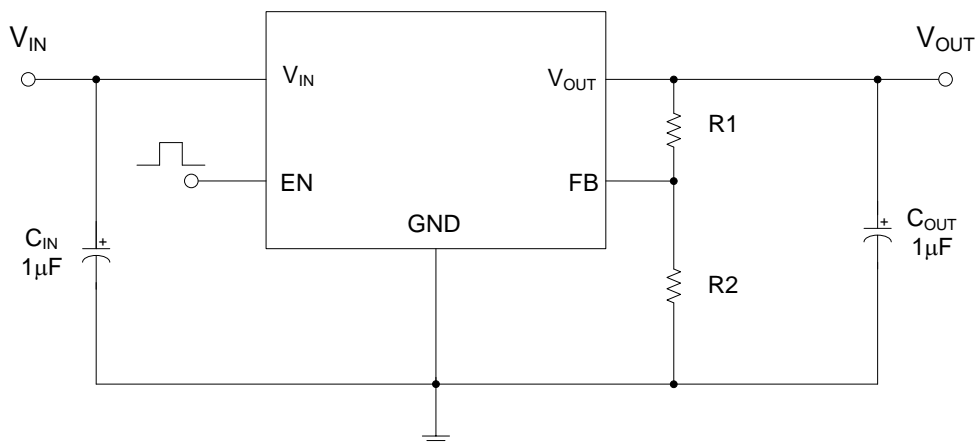


## Typical Application Circuit

### Fixed Output Voltage



### Adjustable Output Voltage



**Note:**

1. Input capacitor ( $C_{IN}=1\mu F$ ) and Output capacitor ( $C_{OUT}=1\mu F$ ) are recommended in all application circuit.
2.  $V_{OUT}=V_{FB} \times (1+R1/R2)$ ,  $V_{FB}=0.6V$ .

## Absolute Maximum Ratings

Ratings at 25°C ambient temperature unless otherwise specified.

| Parameter                               |           | Value      | Unit |
|-----------------------------------------|-----------|------------|------|
| Maximum Input Voltage                   |           | 8.5        | V    |
| Output Current                          |           | 600        | mA   |
| Power Dissipation                       | SOT-23    | 350        | mW   |
|                                         | SOT-89    | 590        | mW   |
|                                         | SOT-23-3  | 450        | mW   |
|                                         | SOT-23-5  | 450        | mW   |
|                                         | DFN1x1-4L | 550        | mW   |
| Thermal Resistance, Junction-to-Ambient | SOT-23    | 280        | °C/W |
|                                         | SOT-89    | 170        | °C/W |
|                                         | SOT-23-3  | 220        | °C/W |
|                                         | SOT-23-5  | 220        | °C/W |
|                                         | DFN1x1-4L | 180        | °C/W |
| Maximum Junction Temperature            |           | 150        | °C   |
| Operating Ambient Temperature           |           | -40 ~ +125 | °C   |
| Storage Temperature Range               |           | -55~ +150  | °C   |
| Lead Temperature&Time                   |           | 260°C, 10S | --   |

Note1: Exceed these limits to damage to the device. Exposure to absolute maximum rating conditions may affect.

## Recommended Operating Conditions

| Parameter                     | Value      | Unit |
|-------------------------------|------------|------|
| Supply Voltage                | 1.7~7      | V    |
| Maximum Output Current        | 600        | mA   |
| Operating Ambient Temperature | -40 ~ +125 | °C   |

## Electrical Characteristics

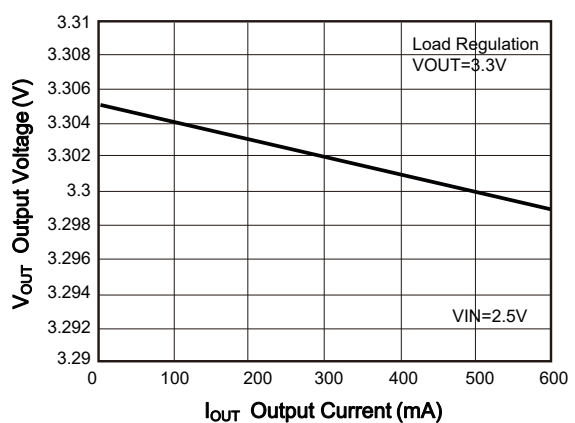
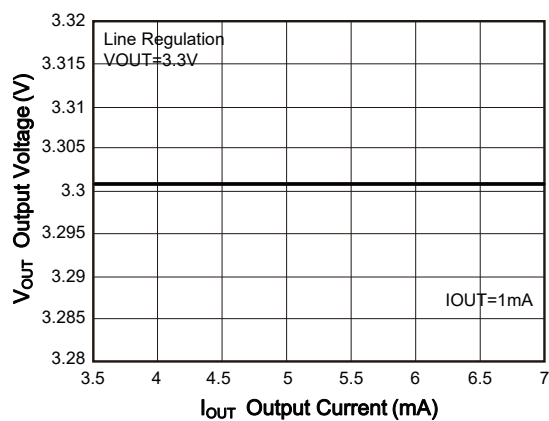
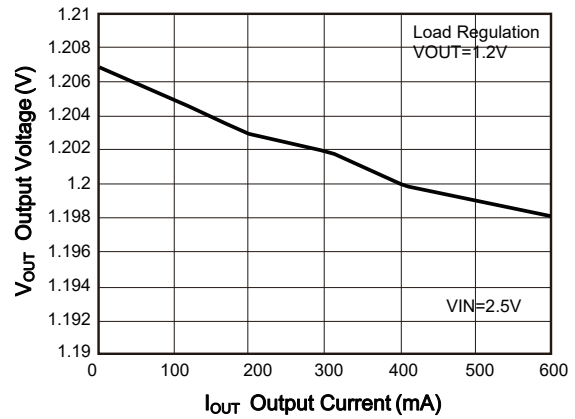
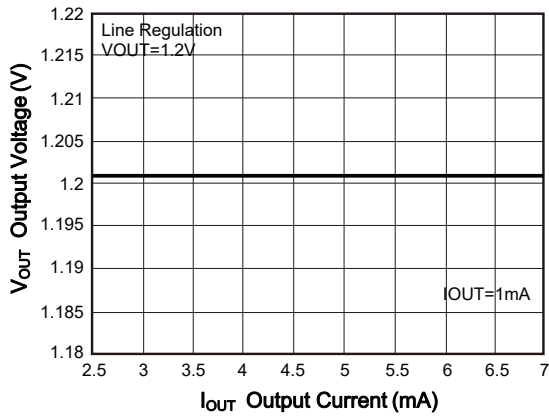
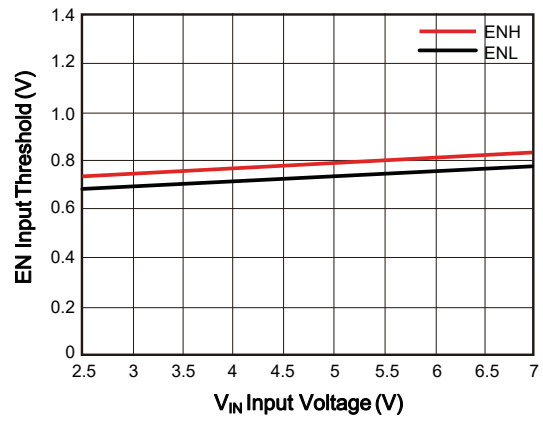
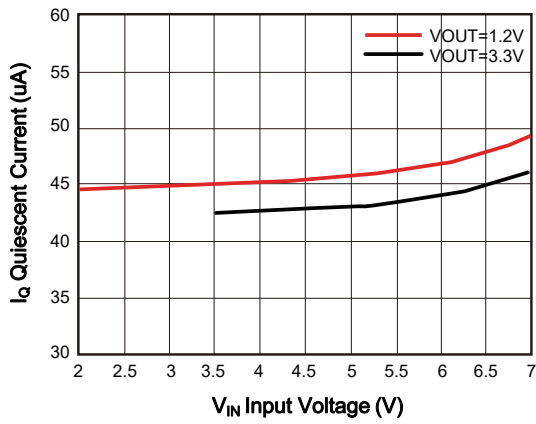
$C_{IN}=1\mu F$ ,  $C_{OUT}=1\mu F$ ,  $T_A=25^\circ C$ , unless otherwise noted.)

| Parameter                              | Symbol            | Test Conditions                                      | Min.                       | Typ. | Max.                       | Unit            |   |
|----------------------------------------|-------------------|------------------------------------------------------|----------------------------|------|----------------------------|-----------------|---|
| Input Voltage                          | $V_{IN}$          |                                                      | 1.7                        | --   | 7                          | V               |   |
| Output Voltage Range                   | $V_{OUT}$         | $V_{IN}=V_{OUT}+1V$<br>$1mA < I_{OUT} < 30mA$        | $V_{OUT}$<br>$\times 0.98$ | --   | $V_{OUT}$<br>$\times 1.02$ | V               |   |
| Feedback Voltage                       | $V_{FB}$          | Adjustable Output Version                            | --                         | 0.6  | --                         | V               |   |
| Output Voltage Accuracy                | $\Delta V_{OUT}$  | Fixed Output Version                                 | -2                         | --   | +2                         | %               |   |
|                                        |                   | Adjustable Output Version                            | -1                         | --   | +1                         | %               |   |
| Quiescent Current                      | $I_Q$             | $I_{OUT}=0mA$                                        | --                         | 50   | 75                         | $\mu A$         |   |
| Max. Output Current                    | $I_{OUT} (Max.)$  | $V_{IN}-V_{OUT}=1V$                                  | 600                        | --   | --                         | mA              |   |
| Dropout Voltage                        | $V_{DROP}$        | $V_{OUT}=3.3V$ , $I_{OUT}=600mA$                     | --                         | 300  | 500                        | mV              |   |
| Line Regulation                        | $\Delta V_{LINE}$ | $I_{OUT}=1mA$                                        | --                         | 0.02 | 0.1                        | %/V             |   |
| Load Regulation                        | $\Delta V_{LOAD}$ | $0mA \leq I_{OUT} \leq 600mA$                        | --                         | 15   | 30                         | mV              |   |
| Short Circuit Current                  | $I_{SHORT}$       |                                                      | --                         | 250  | --                         | mA              |   |
| Current Limit                          | $I_{LIM}$         | $V_{IN}-V_{OUT}=1V$                                  | 0.7                        | 0.75 | --                         | A               |   |
| Standby Current                        |                   | EN=0                                                 | --                         | --   | 1                          | $\mu A$         |   |
| EN Input Threshold                     | Logic Low         | $V_{CEL}$                                            | EN Low Voltage             | --   | --                         | 0.4             | V |
|                                        | Logic High        | $V_{CEH}$                                            | EN High Voltage            | 1    | --                         | --              | V |
| Power Supply Rejection Rate            | PSRR              | $V_{IN}=V_{OUT}+0.5V$ ,<br>$f=1KHz$ , $I_{OUT}=10mA$ | --                         | 75   | --                         | dB              |   |
| Startup Time                           | $t_{start}$       |                                                      | --                         | 80   | --                         | $\mu S$         |   |
| Output Voltage Temperature Coefficient | $TC_{VOUT}$       |                                                      | -100                       | --   | 100                        | ppm/ $^\circ C$ |   |
| OTP                                    |                   |                                                      | 130                        | 150  | 170                        | $^\circ C$      |   |
| OTP Hysteresis                         |                   |                                                      | --                         | 40   | --                         | $^\circ C$      |   |

Note: All test are conducted under ambient temperature  $25^\circ C$  and within a short period of time 20ms.

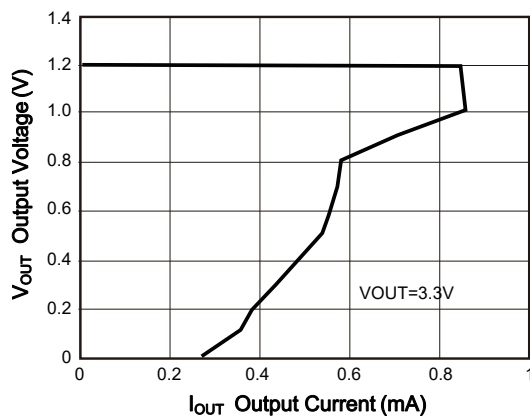
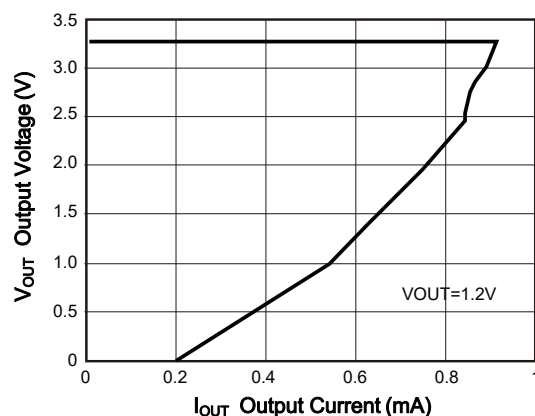
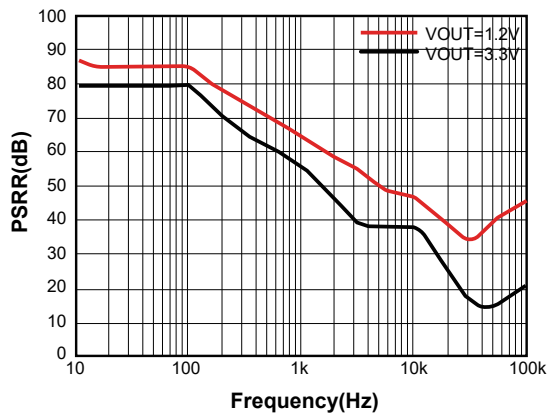
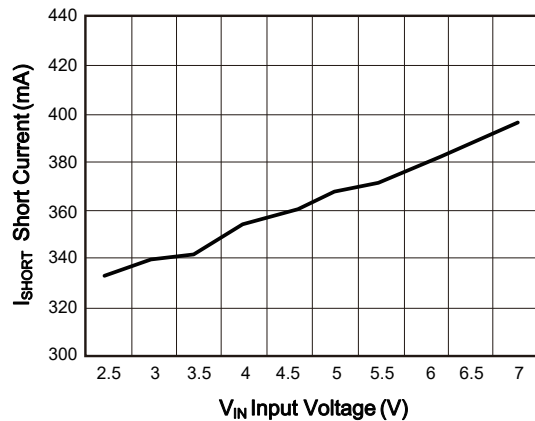
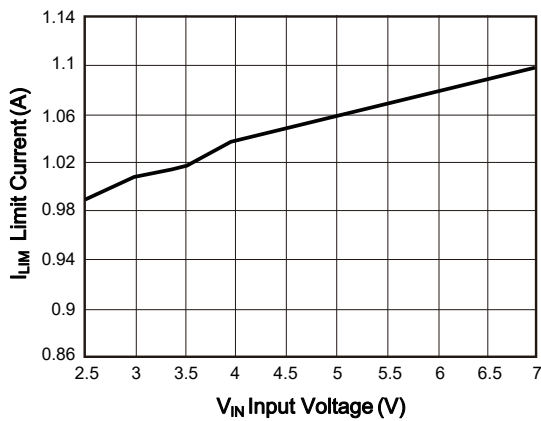
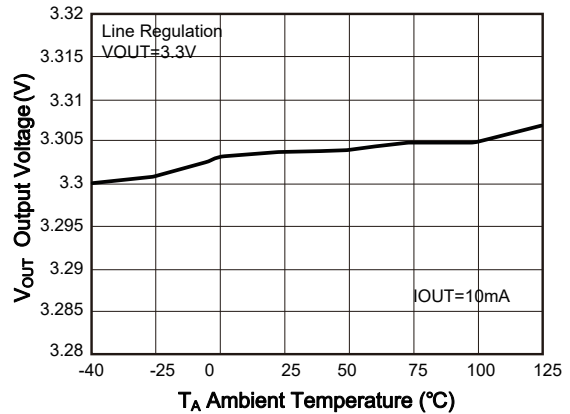
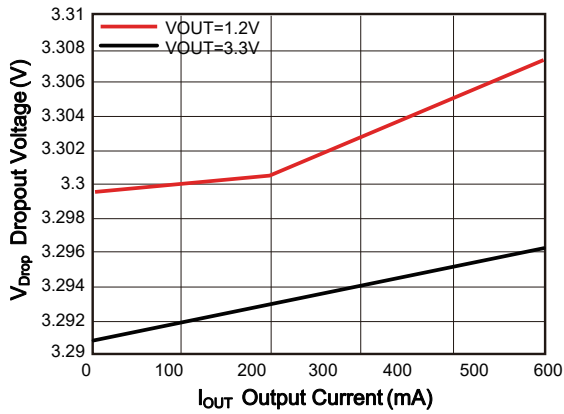
## Typical Electrical Curves

Test conditions:  $V_{EN}=V_{IN}$ ,  $C_{IN}=C_{OUT}=1\mu F$ , all typical values are at  $T_A=25^\circ C$ (unless otherwise noted)



## Typical Electrical Curves

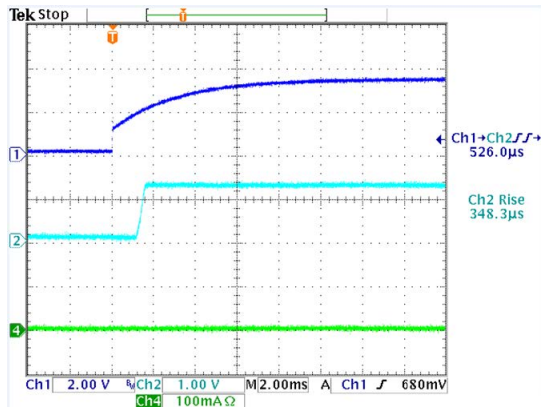
Test conditions:  $V_{EN}=V_{IN}$ ,  $C_{IN}=C_{OUT}=1\mu F$ , all typical values are at  $T_A=25^\circ C$  (unless otherwise noted)



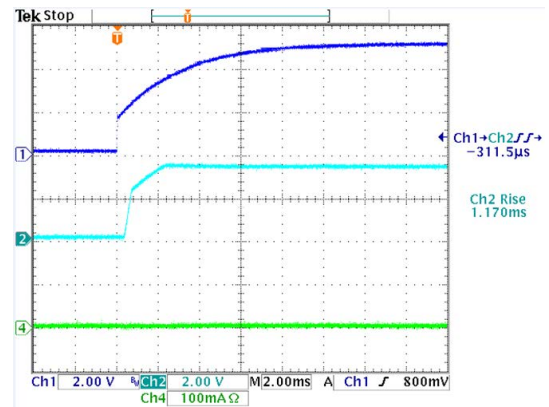


## Typical Electrical Curves

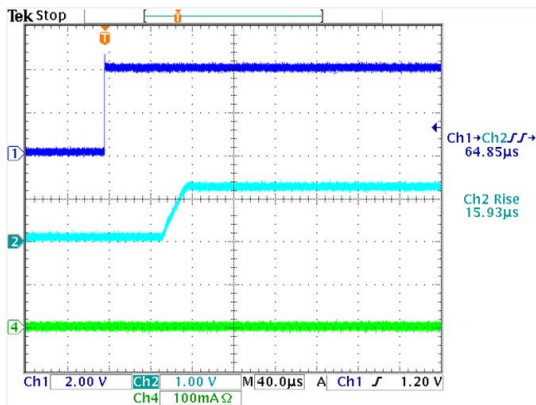
Test conditions:  $V_{EN}=V_{IN}$ ,  $C_{IN}=C_{OUT}=1\mu F$ , all typical values are at  $T_A=25^\circ C$ (unless otherwise noted)



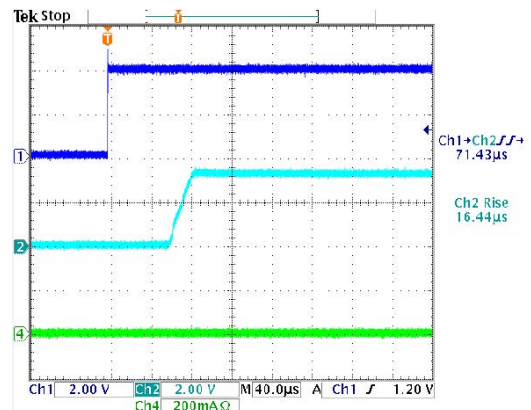
Power ON(VOUT=1.2V)



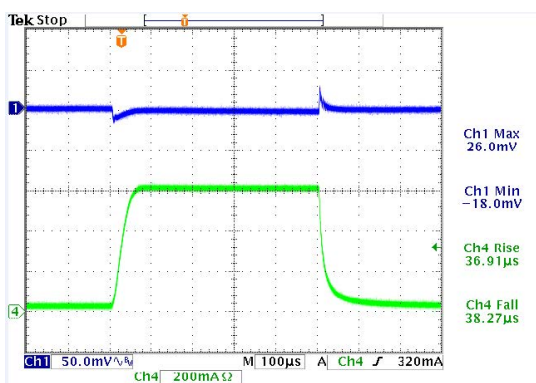
Power ON(VOUT=3.3V)



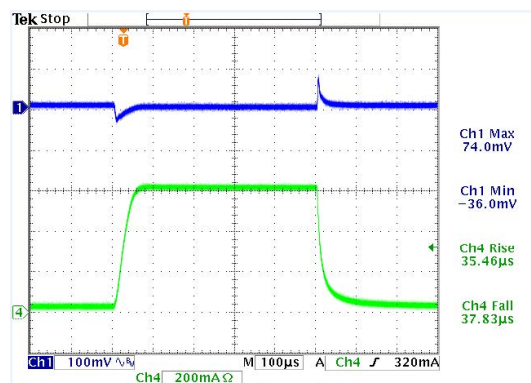
EN ON(VOUT=1.2V)



EN ON(VOUT=3.3V)



Load Transient VOUT=1.2V, VIN=3.3V



Load Transient VOUT=3.3V, VIN=5V

## Function Descriptions

A minimum of 1 $\mu$ F capacitor must be connected from Vout to ground to insure stability. Input capacitor of 1 $\mu$ F is recommended to ensure the input voltage does not sag below the minimum dropout voltage during load transient event. Vin pin must always be dropout voltage higher than Vout in order for the device to regulate properly.

## Application Information

SL9650 Series requires input and output decoupling capacitors. The device is specifically designed for portable applications requiring minimum board space and smallest components. These capacitors must be correctly selected for good performance. Please note that linear regulators with a low dropout voltage have high internal loop gains, which require care in guarding against oscillation caused by insufficient decoupling capacitors.

## Capacitor Selection

Normally, use a 1 $\mu$ F capacitor on the input and a 1 $\mu$ F capacitor on the output of the SL9650 Series. Larger input capacitor values and lower ESR (X5R, X7R) provide better supply noise rejection and transient response. A higher value output capacitor (2.2 $\mu$ F) may be necessary if large, fast transients are anticipated and the device is located several inches from the power source.

## Input-Output (Dropout) Voltage

A regulator's minimum input-to-output voltage differential (dropout voltage) determines the lowest usable supply voltage. In battery-powered systems, this determines the useful end-of-life battery voltage. Because the device uses a PMOS, its dropout voltage is a function of drain to source on resistance, RDS (on), multiplied by the load current:

$$VDROP = VIN - VOUT = RDS (on) \times IOUT$$

## Current Limit and Thermal Shutdown Protection

In order to prevent overloading or thermal condition from damaging the device, SL9650 Series has internal thermal and current limiting functions designed to protect the device. It will rapidly shut off PMOS pass element during overloading or over temperature condition.

## Thermal Considerations

The SL9650 Series can deliver a current of up to 300mA over the full operating junction temperature range. However, the maximum output current must be controlled at higher ambient temperature to ensure the junction temperature does not exceed 150°C. 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.

$$PD = (VIN - VOUT) \times IOUT$$

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

$$PD (max) = (Tj (max) - Ta) / R\theta JA$$

Where Tj (max) is the maximum junction temperature of the die (150°C) and Ta is the maximum ambient temperature.

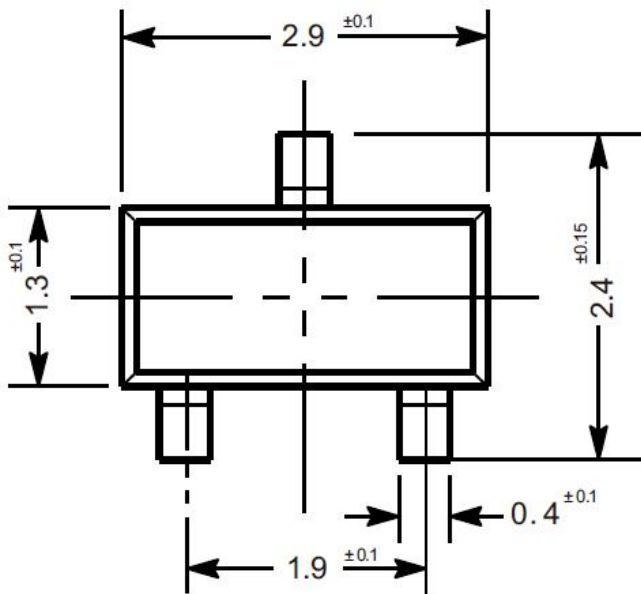
## PCB Layout

An input capacitance of  $\approx 1 \mu$ F is required between the SL9650 Series input pin and ground (the amount of the capacitance may be increased without limit), this capacitor must be located a distance of not more than 1cm from the input and return to a clean analog ground. Input capacitor can filter out the input voltage spikes caused by the surge current due to the inductive effect of the package pin and the printed circuit board's routing wire. Otherwise, the actual voltage at the Vin pin may exceed the absolute maximum rating. The output capacitor also must be located a distance of not more than 1cm from output to a clean analog ground. Because it can filter out the output spike caused by the surge current due to the inductive effect of the package pin and the printed circuit board's routing wire.

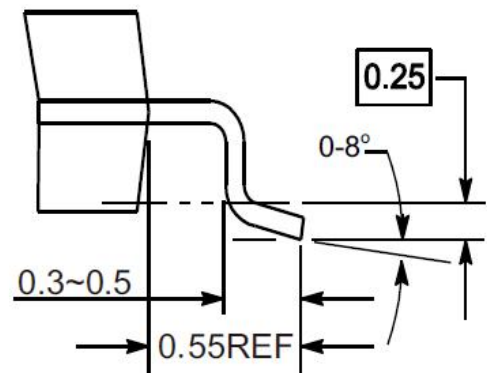
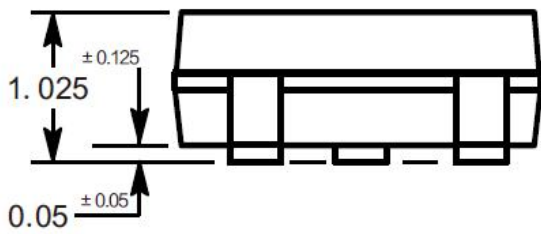
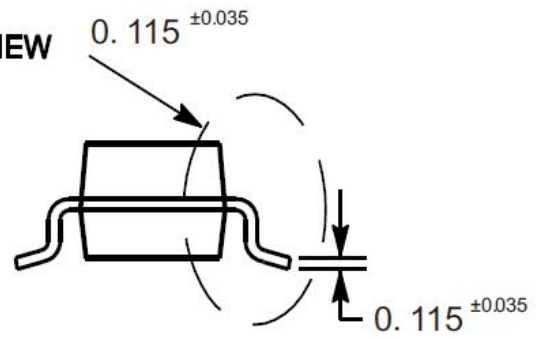
## Package Outline

SOT-23

Dimensions in mm



SEE VIEW

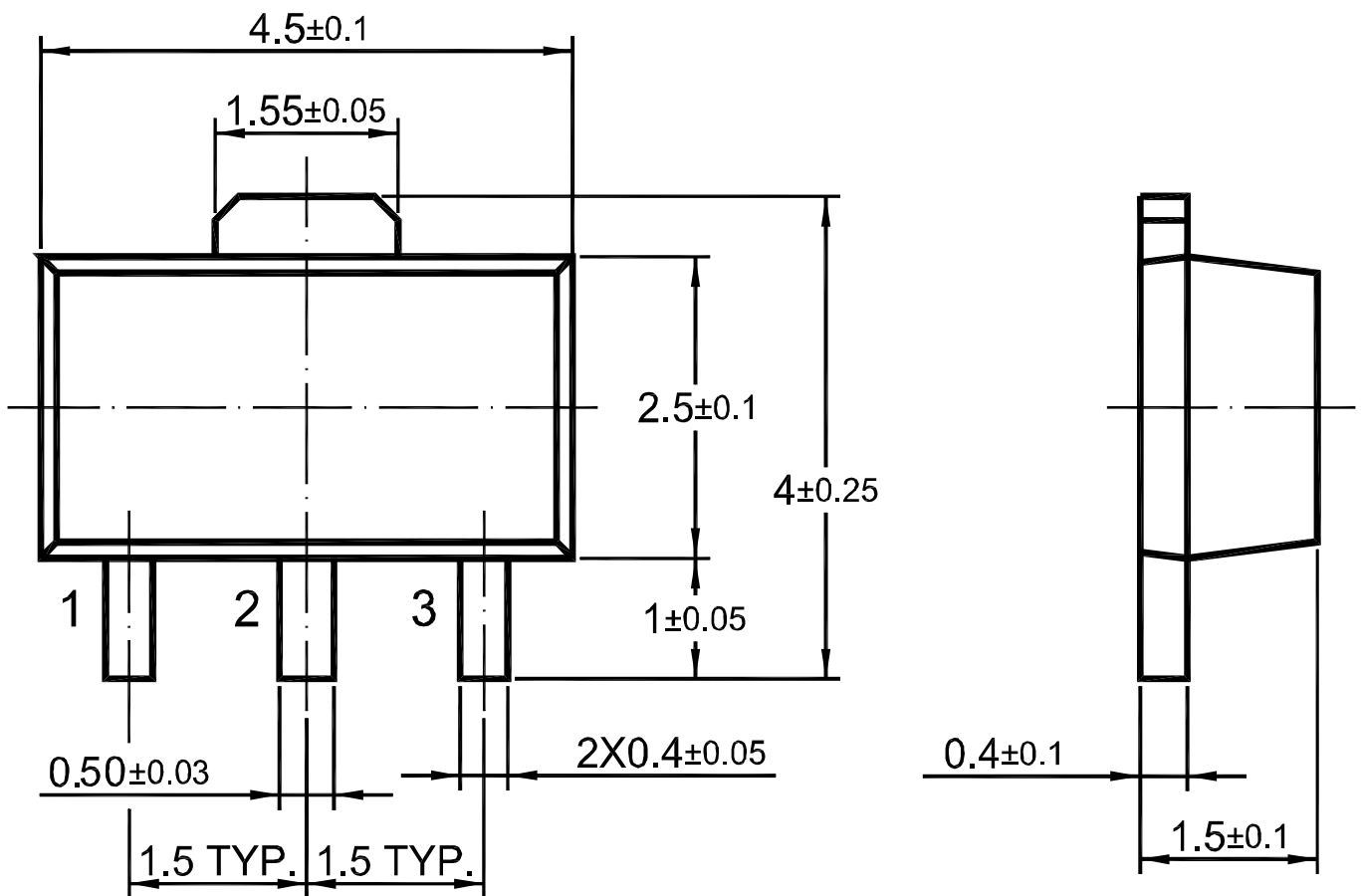


VIEW C

## Package Outline

SOT-89

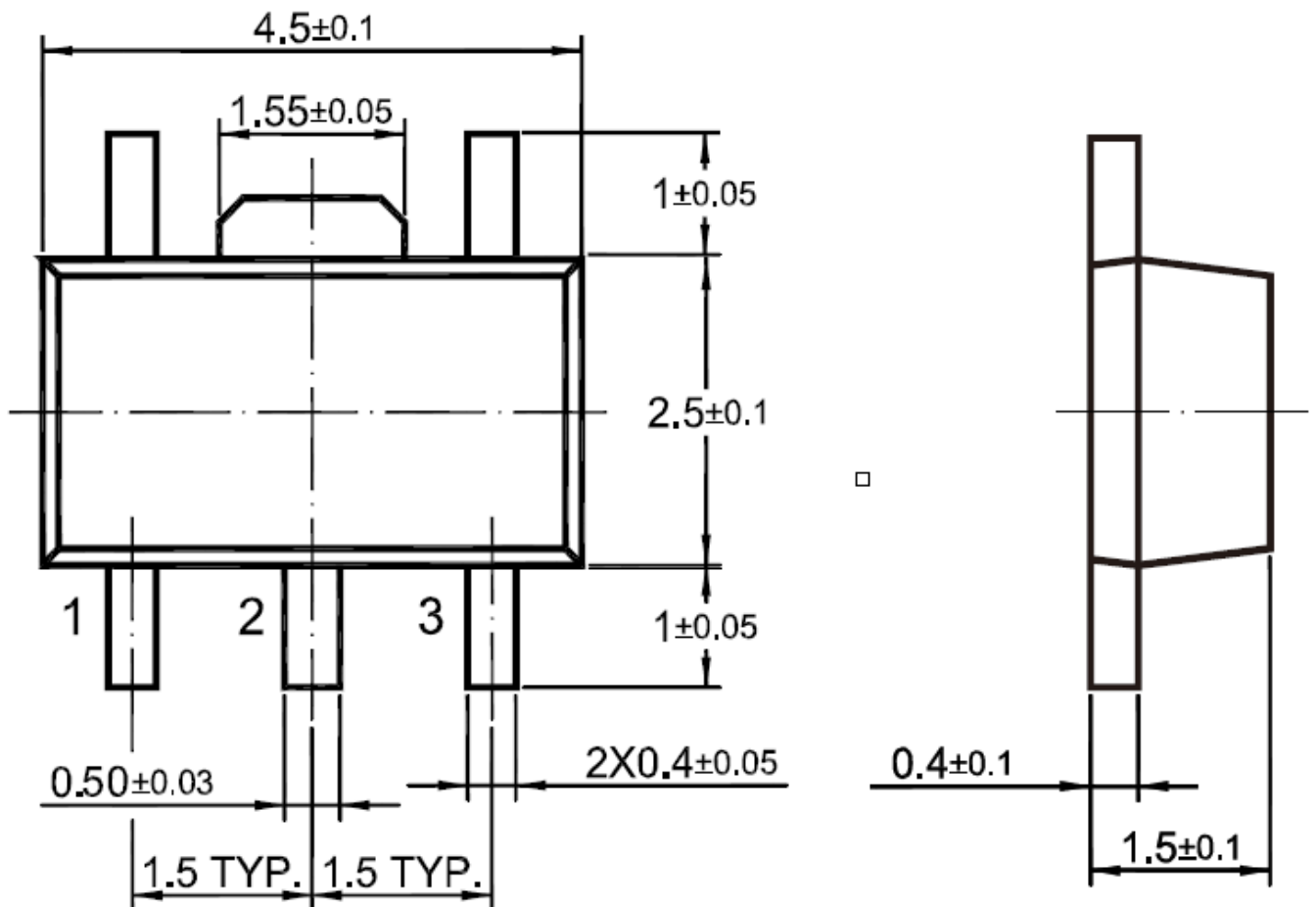
Dimensions in mm



## Package Outline

SOT-89-5

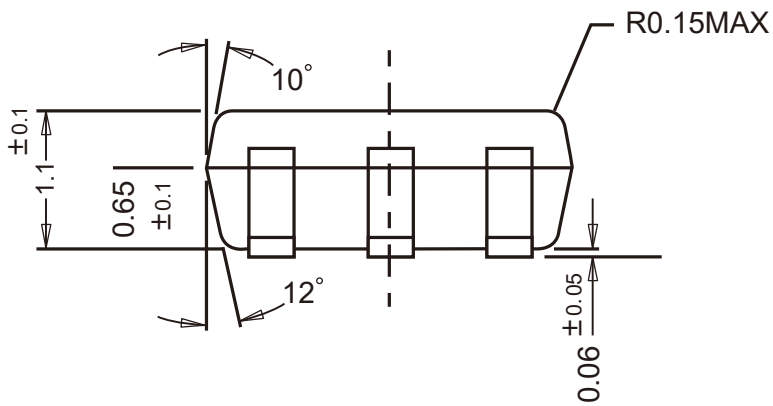
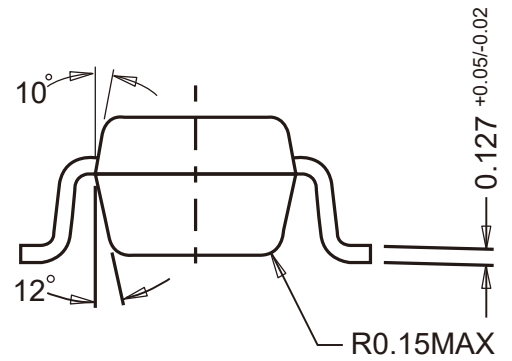
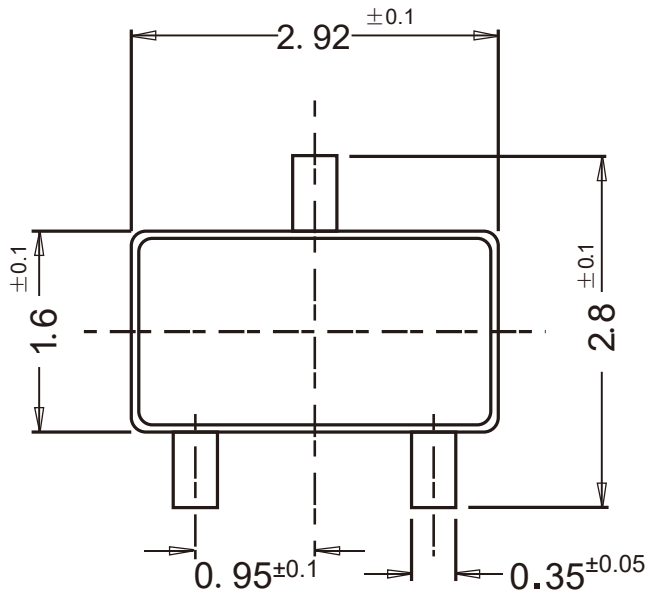
Dimensions in mm



## Package Outline

SOT-23-3

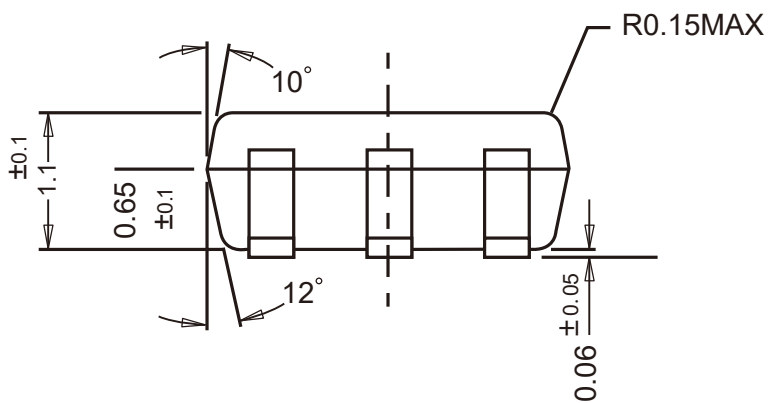
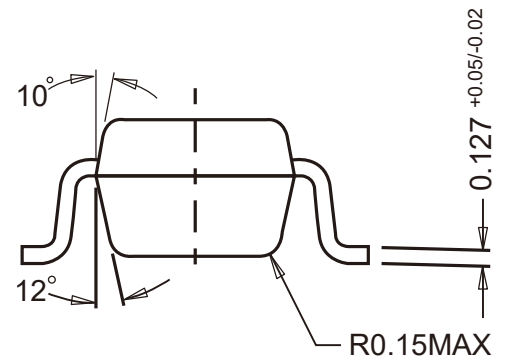
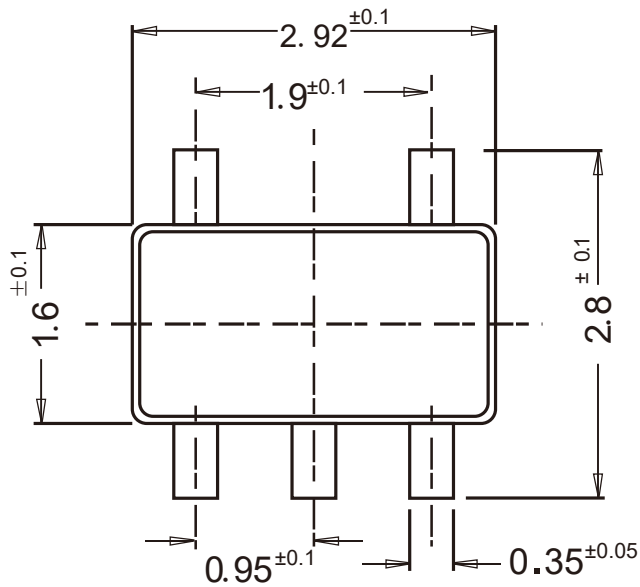
Dimensions in mm



## Package Outline

SOT-23-5

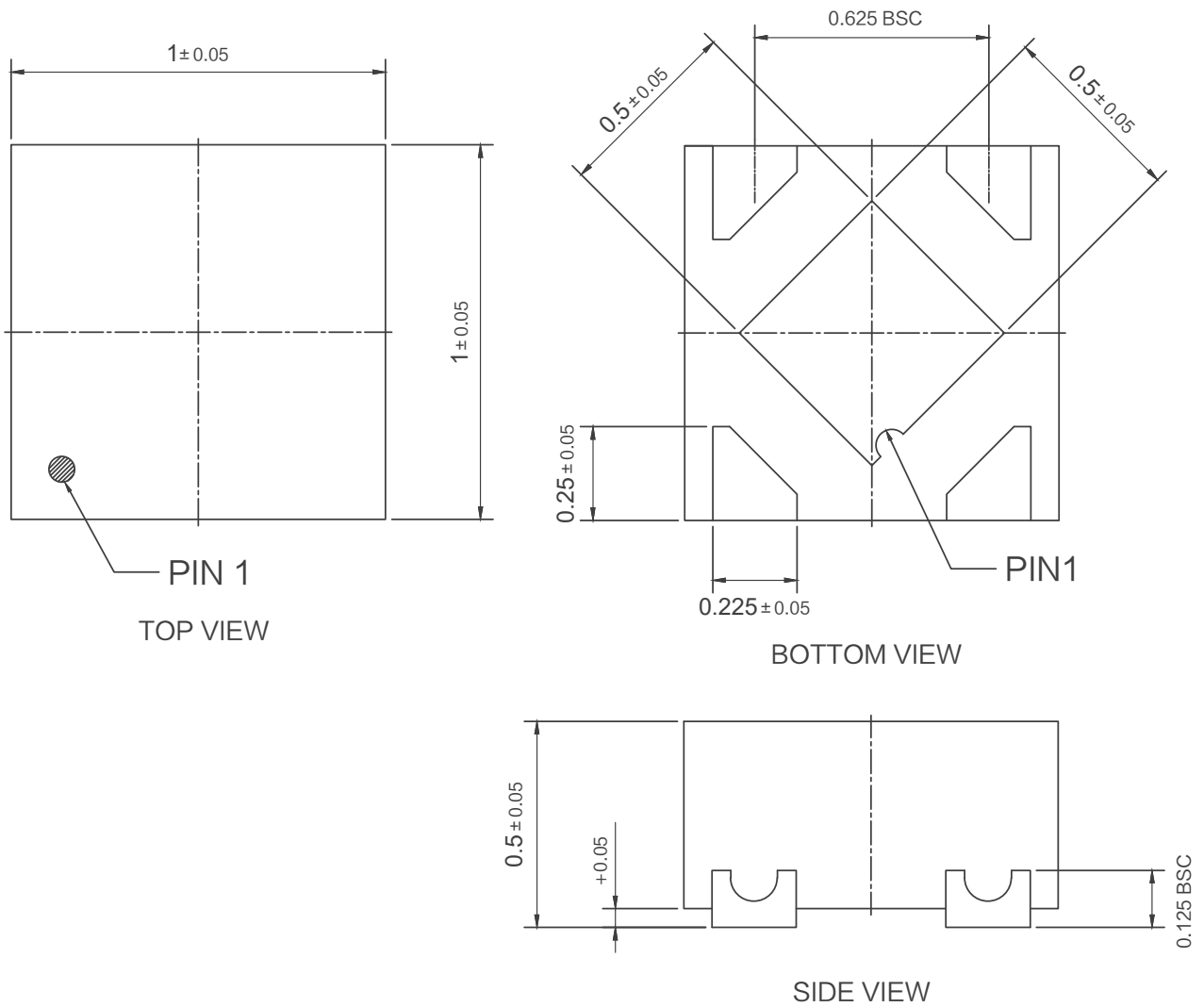
Dimensions in mm



## Package Outline

DFN1x1-4L

Dimensions in mm

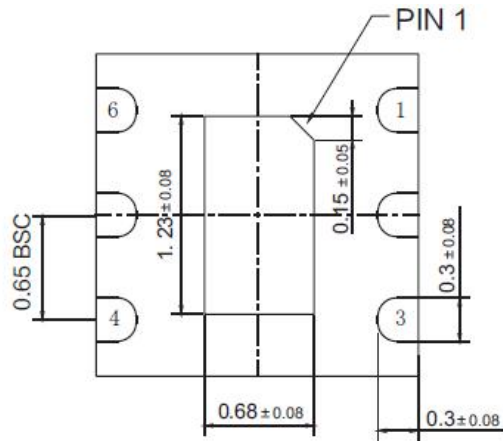




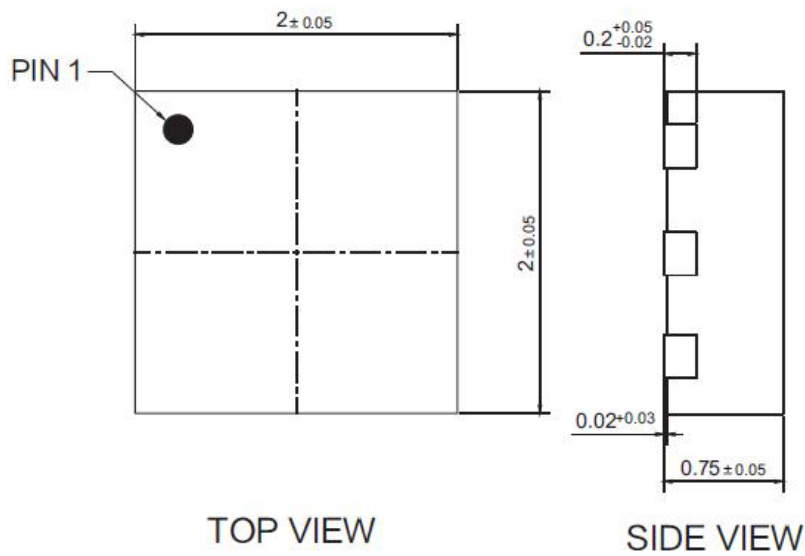
## Package Outline

DFN2x2-6L-0006

Dimensions in mm



BOTTOM VIEW



TOP VIEW

SIDE VIEW

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[NCV78M05ABDTRKG](#) [LV5680P-E](#) [L79M05T-E](#) [L78LR05D-MA-E](#) [NCV317MBTG](#) [NTE7227](#) [MP2018GZD-33-P](#) [MP2018GZD-5-P](#)  
[LV5680NPVC-XH](#) [ZTS6538SE](#) [UA78L09CLP](#) [UA78L09CLPR](#) [CAT6221-PPTD-GT3](#) [MC78M09CDTRK](#) [NCV51190MNTAG](#)  
[BL1118CS8TR1833](#) [BL8077CKETR33](#) [BL9153-33CC3TR](#) [BL9161G-28BADRN](#) [BRCO7530MMC](#) [CJ7815B-TFN-ARG](#) [LM317C](#)  
[GM7333K](#) [GM7350K](#) [XC6206P332MR](#) [HT7533](#) [LM7912S/TR](#) [LT1764S/TR](#) [LM7805T](#) [LM338T](#) [LM1117IMP-3.3/TR](#) [HT1117AM-3.3](#)  
[HT7550S](#) [AMS1117-3.3](#) [HT7150S](#) [78L12](#) [HT7550](#) [HT7533-1](#) [HXY6206I-2.5](#) [HT7133](#) [HT7533S](#) [662K](#)