Description

The TN9650 Series is a low dropout, positive linear regulator with very low quiescent current. It can supply 600mA output current with a input range from 1.7V to 7V, which makes it suitable for all kinds of applications.

TN9650 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 ±2%(Fixed Output); ±1%(Adjustable Output). TN9650 Series provides full fault protection including current limit, short circuit protection and thermal shutdown protection.

Features

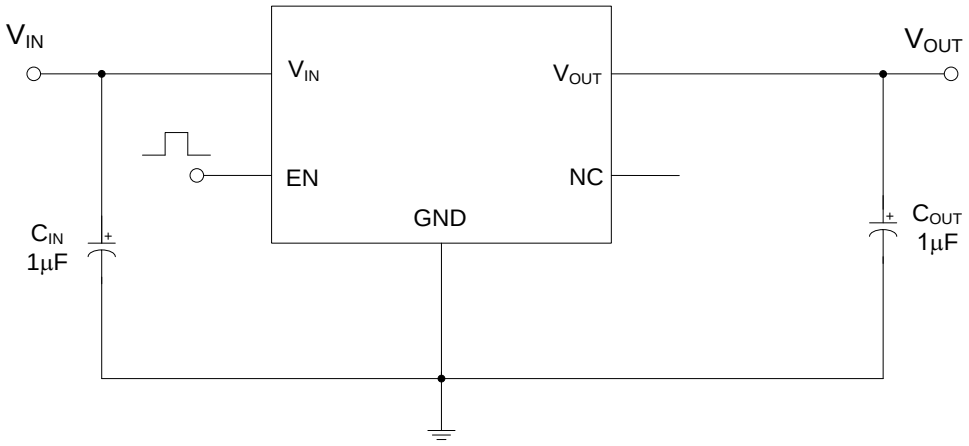
- Fixed Output Voltages:
- 0.7V,1.0V,1.2V,1.5V,1.8V,2.5V,2.8V,3.0V,3.3V,3.6V,Other output can be customized
- Adjustable Output from 0.6V to (VIN-VDROP)
- Maximum Output Current:600mA
- Low Quiescent Current:50uA(Typ.)
- Very low dropout voltage:
  300mV@600mA(Vout=3.3V)
- Highly Accurate:±2%(Fixed Output)
  ±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

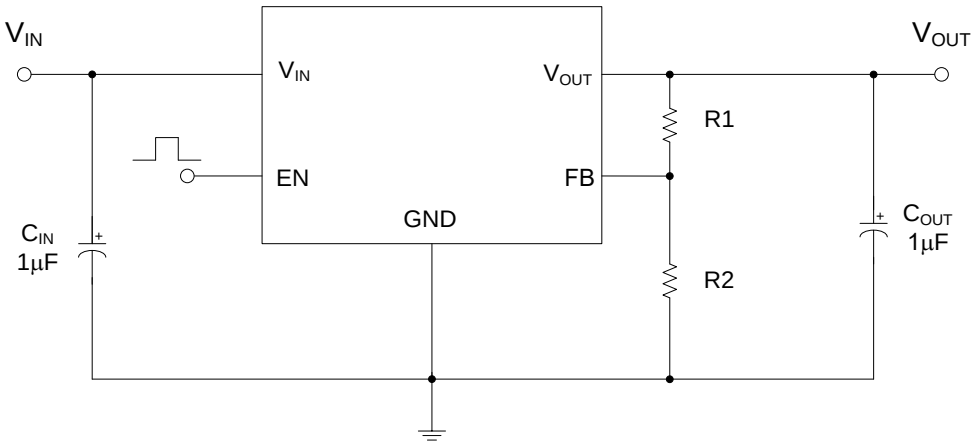
- Battery powered portable devices
- Smart phone, tablet
- Hi resolution camera sensor power
- Wireless modules
- RF,PLL,VCO clock power

Typical Application Circuit (Package in SOT-23-5)

Fixed Output Voltage



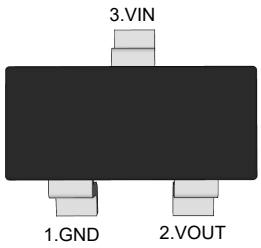
Adjustable Output Voltage



Note:
1. Input capacitor (CIN=1uF) and Output capacitor (COUT=1uF) are recommended in all application circuit.
2. VOUT=VFB x (1+R1/R2),VFB=0.6V.

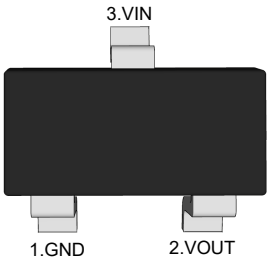
Applicable Packages

SOT-23



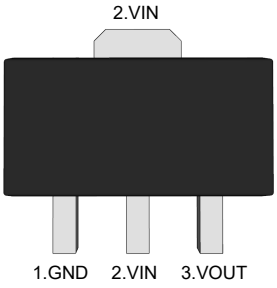
(Top View)

SOT-23-3



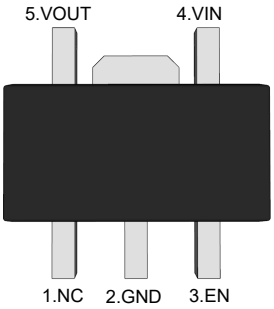
(Top View)

SOT-89



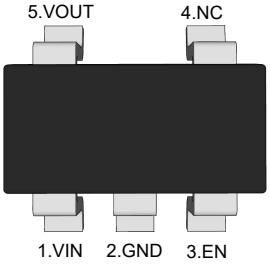
(Top View)

SOT-89-5



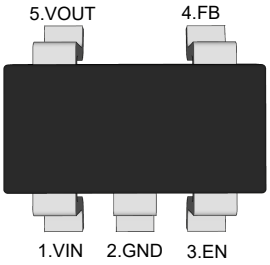
(Top View)

SOT-23-5 (Fixed)



(Top View)

SOT-23-5 (ADJ)

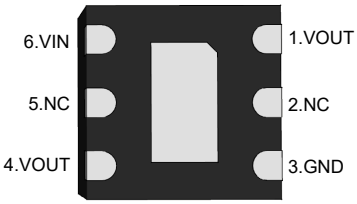


(Top View)

DFN1x1-4L

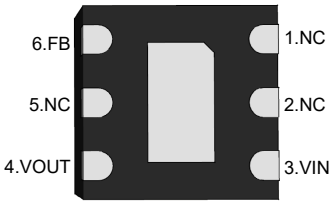
(Bottom View)

DFN2x2C-6L (Fixed)



Bottom View

DFN2x2C-6L (ADJ)



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

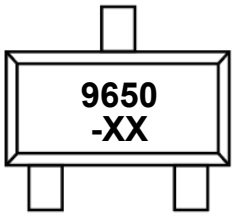
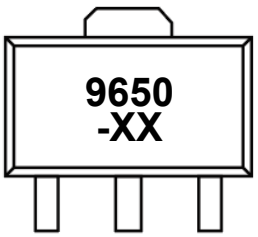
Ordering Information

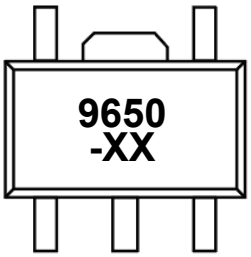
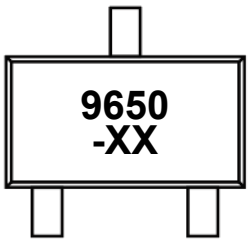
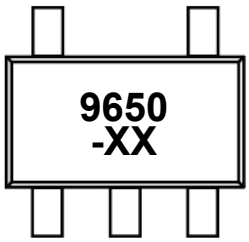
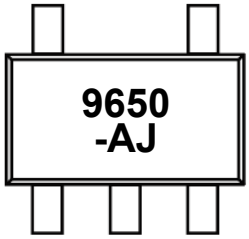
TN9650 □□□□

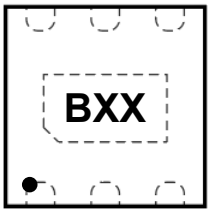
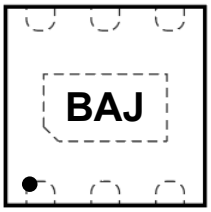
Package Type
SA:SOT-23 SC:SOT-23-3
SQ:SOT-89 SR:SOT-89-5
SE:SOT-23-5 DE:DFN1x1-4L
DFC:DFN2x2C-6L

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

Orderable Device	Package	Reel (inch)	Package Qty (PCS)	Eco Plan Note	MSL Level	Marking Code
TN9650M10SA	SOT-23	7	3000	RoHS & Green	MSL1	 XX:Output Voltage e.g. 3.0:3.0V
TN9650M12SA						
TN9650M15SA						
TN9650M18SA						
TN9650M25SA						
TN9650M28SA						
TN9650M30SA						
TN9650M33SA						
TN9650M36SA						
TN9650M10SQ	SOT-89	7/13	1000/3000	RoHS & Green	MSL1	 XX:Output Voltage e.g. 3.0:3.0V
TN9650M12SQ						
TN9650M15SQ						
TN9650M18SQ						
TN9650M25SQ						
TN9650M28SQ						
TN9650M30SQ						
TN9650M33SQ						
TN9650M36SQ						

TN9650M10SR	SOT-89-5	7/13	1000/3000	RoHS & Green	MSL1	 XX:Output Voltage e.g. 3.0:3.0V
TN9650M12SR						
TN9650M15SR						
TN9650M18SR						
TN9650M25SR						
TN9650M28SR						
TN9650M30SR						
TN9650M33SR						
TN9650M36SR						
TN9650M10SC	SOT-23-3	7	3000	RoHS & Green	MSL3	 XX:Output Voltage e.g. 3.0:3.0V
TN9650M12SC						
TN9650M15SC						
TN9650M18SC						
TN9650M25SC						
TN9650M28SC						
TN9650M30SC						
TN9650M33SC						
TN9650M36SC						
TN9650M10SE	SOT-23-5	7	3000	RoHS & Green	MSL3	 XX:Output Voltage e.g. 3.0:3.0V
TN9650M12SE						
TN9650M15SE						
TN9650M18SE						
TN9650M25SE						
TN9650M28SE						
TN9650M30SE						
TN9650M33SE						
TN9650M36SE						
TN9650MADJSE	SOT-23-5	7	3000	RoHS & Green	MSL3	

TN9650M10DE	DFN1x1-4L	7	10000	RoHS & Green	MSL1	 XX:Output Voltage e.g. 18:18V
TN9650M12DE						
TN9650M15DE						
TN9650M18DE						
TN9650M25DE						
TN9650M28DE						
TN9650M30DE						
TN9650M33DE						
TN9650M36DE						
TN9650M10DFC	DFN2x2C-6L	7	3000	RoHS & Green	MSL1	 XX:Output Voltage e.g. 30:30V
TN9650M12DFC						
TN9650M15DFC						
TN9650M18DFC						
TN9650M25DFC						
TN9650M28DFC						
TN9650M30DFC						
TN9650M33DFC						
TN9650M36DFC						
TN9650MADJDFC	DFN2x2C-6L	7	3000	RoHS & Green	MSL1	

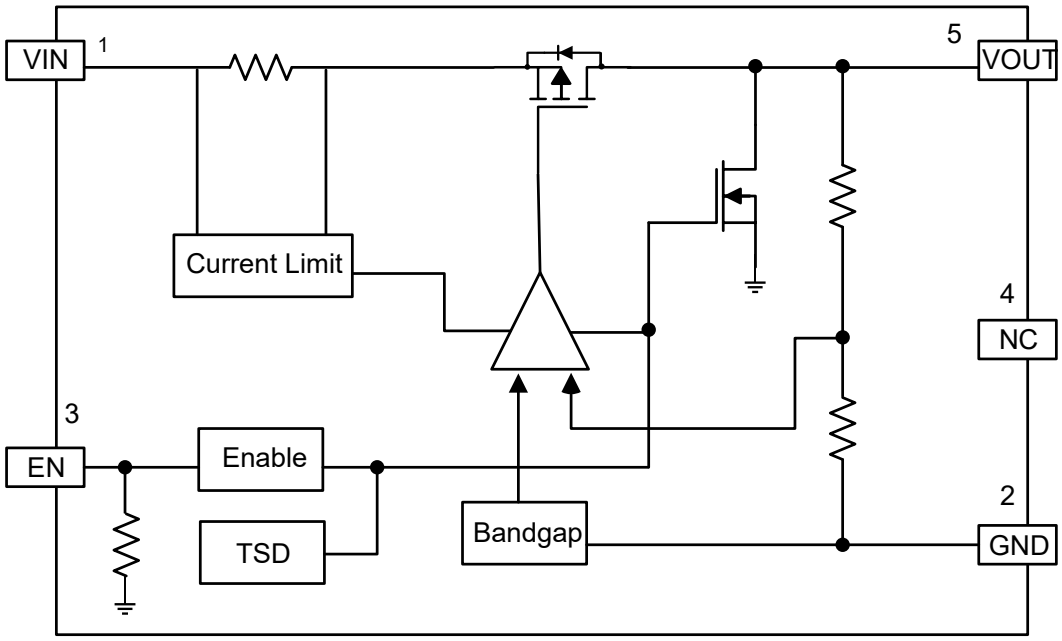
Note:

RoHS：TN defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials.

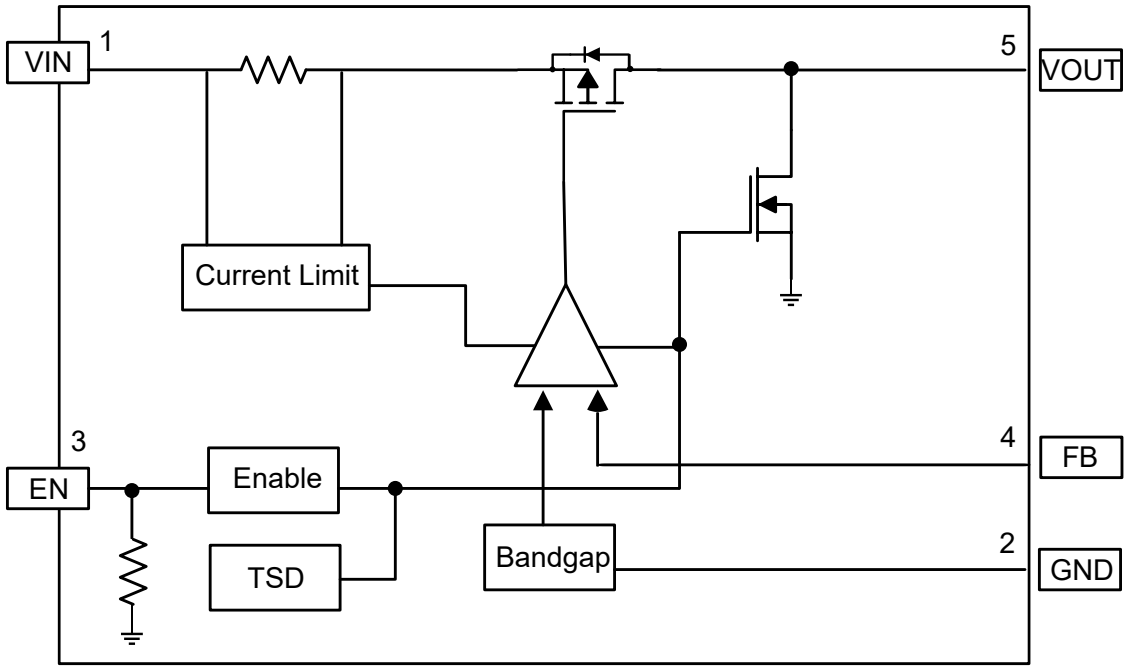
Green：TN defines "Green" to mean Halogen-Free and Antimony-Free.

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

Fixed Output Voltage



Adjustable Output Voltage



Absolute Maximum Ratings

Ratings at 25℃ ambient temperature unless otherwise specified.

Parameter		Value	Unit
Max 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
	DFN2x2C-6L	1000	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
	DFN2x2C-6L	100	°C/W
Junction Temperature		150	°C
Operating Ambient Temperature		-40 ~ +125	°C
Storage Temperature Range		-40~ +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

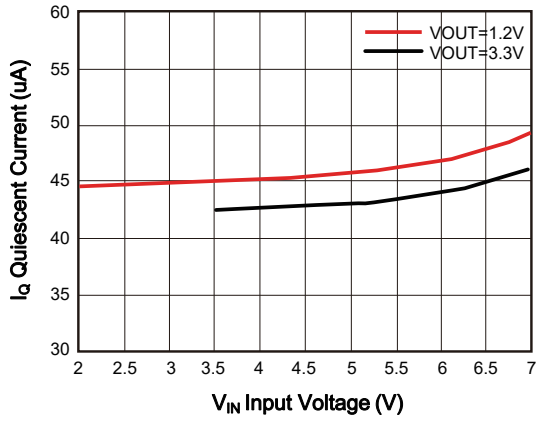
(C_{IN}=1μF, C_{OUT}=1μF, T_A=25℃ , unless otherwise noted.)

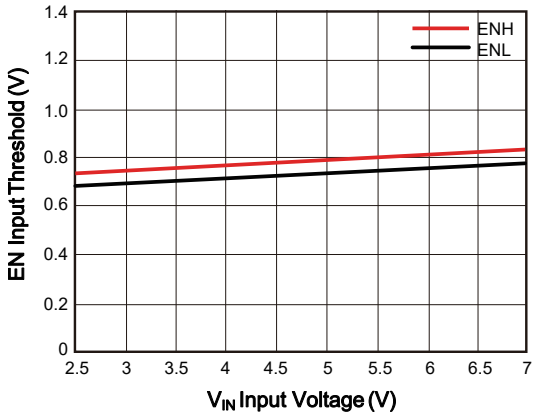
Parameter		Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Input Voltage		V_{IN}		1.7	--	7	V
Output Voltage Range		V_{OUT}	V_{IN}=V_{OUT}+1V 1mA<I_{OUT}<30mA	V_{OUT} ×0.98	--	V_{OUT} ×1.02	V
Feedback Voltage		V_{FB}	Adjustable Output Version	--	0.6	--	V
Output Voltage Accuracy		ΔV_{OUT}	Fixed Output Version	-2	--	+2	%
			Adjustable Output Version	-1	--	+1	%
Quiescent Current		I_Q	I_{OUT}=0mA	--	50	75	μA
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		ΔV_{LINE}	I_{OUT}=1mA	--	0.02	0.1	%/V
Load Regulation		ΔV_{LOAD}	0mA≤I_{OUT}≤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	μA
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, f=1KHz,I_{OUT}=10mA	--	75	--	dB
Startup Time		t_{start}		--	80	--	μS
Output Voltage Temperature Coefficient		TC_{VOUT}		-100	--	100	ppm/°C
OTP				130	150	170	°C
OTP Hysteresis				--	40	--	°C

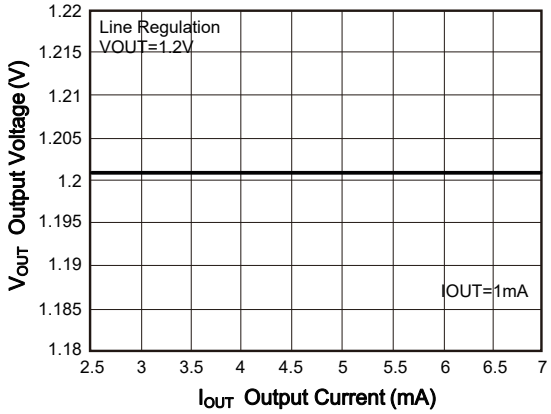
Note: All test are conducted under ambient temperature 25°C and within a short period of time 20ms.

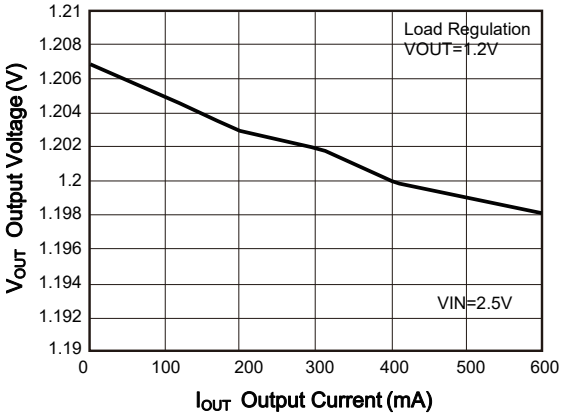
Typical Electrical Curves

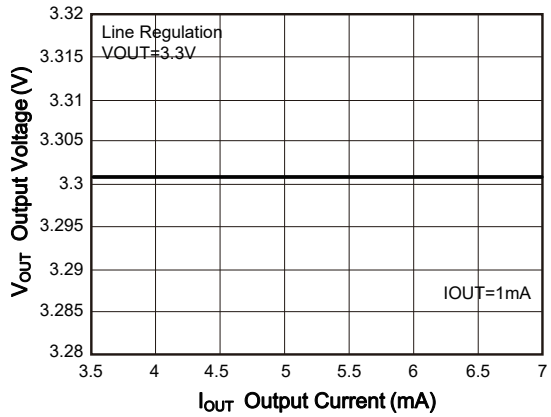
Test conditions: $V_{EN}=V_{IN}$, $C_{IN}=C_{OUT}=1uF$, all typical values are at $T_A=25℃$(unless otherwise noted)

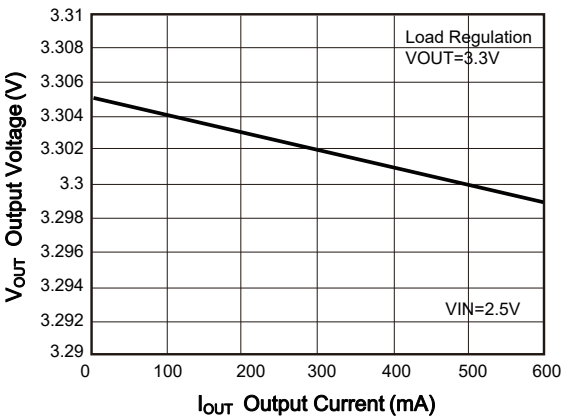






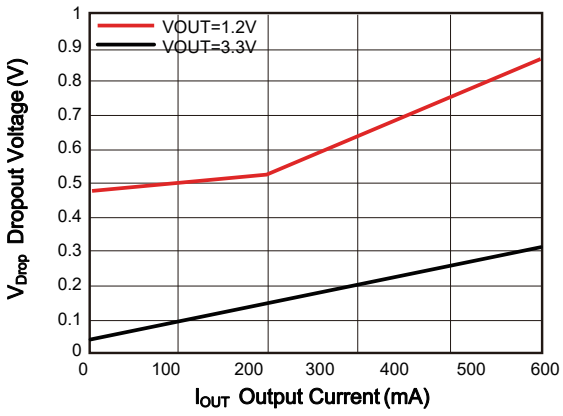


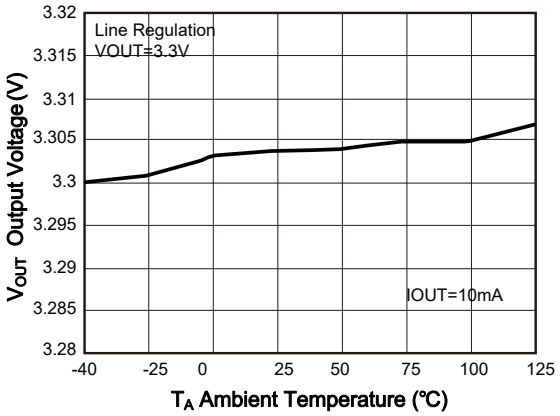


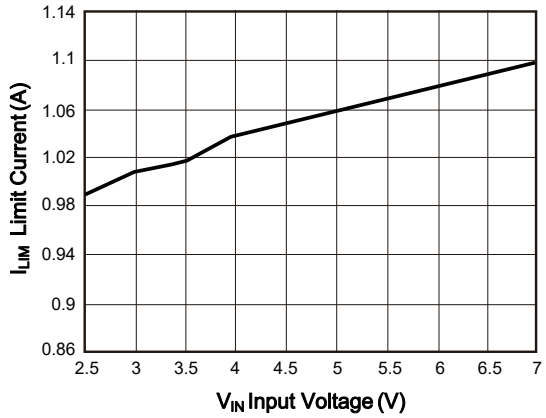


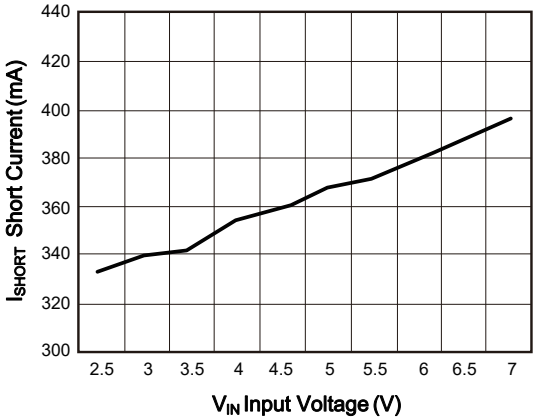
Typical Electrical Curves

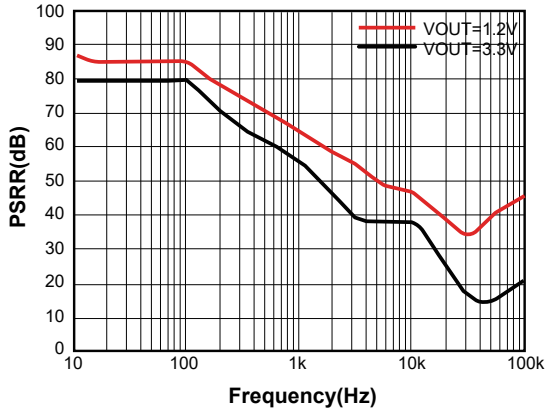
Test conditions: V_{EN}=V_{IN}, C_{IN}=C_{OUT}=1uF， all typical values are at T_A=25℃(unless otherwise noted)

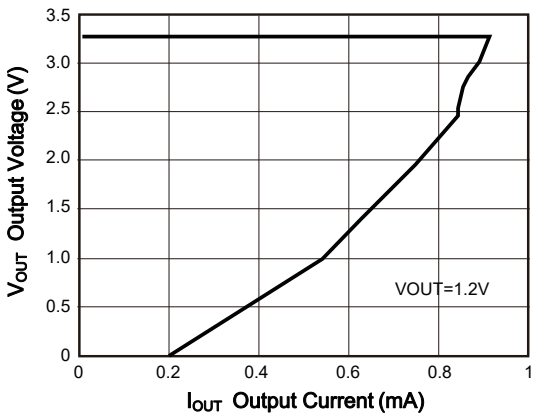


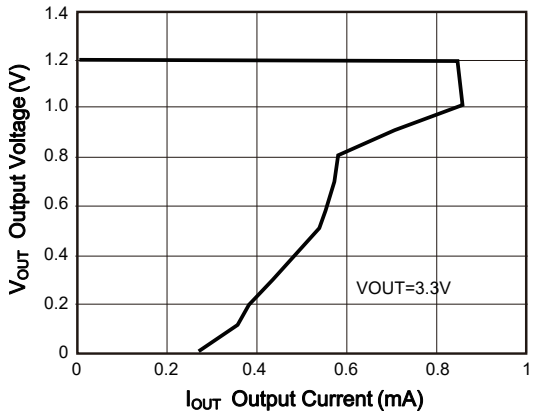






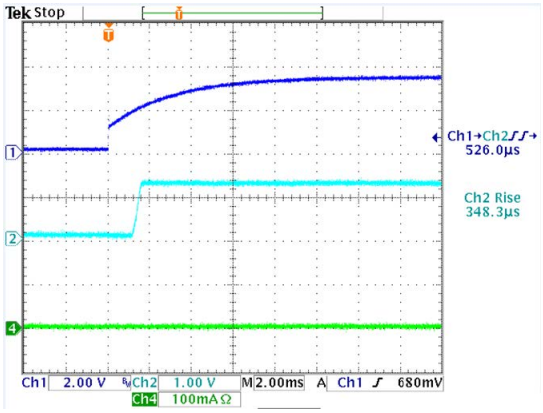




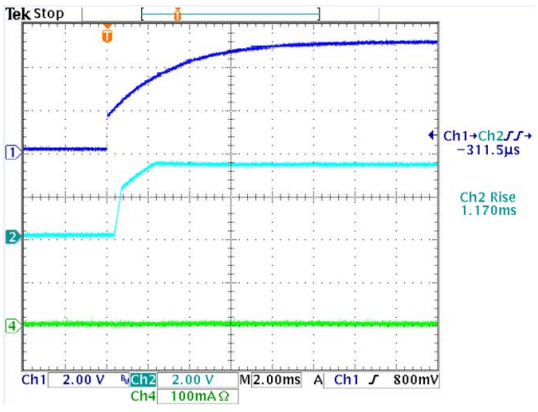


Typical Electrical Curves

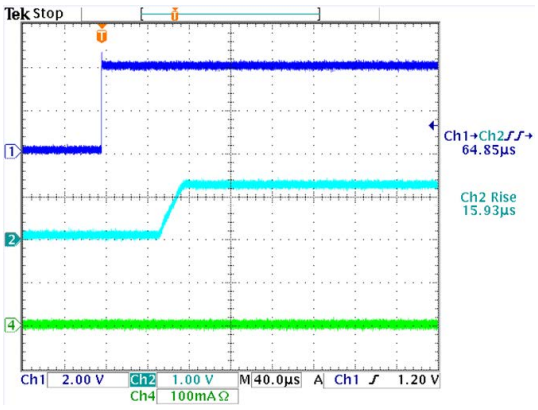
Test conditions: $V_{EN}=V_{IN}$, $C_{IN}=C_{OUT}=1uF$， all typical values are at $T_A=25℃$(unless otherwise noted)



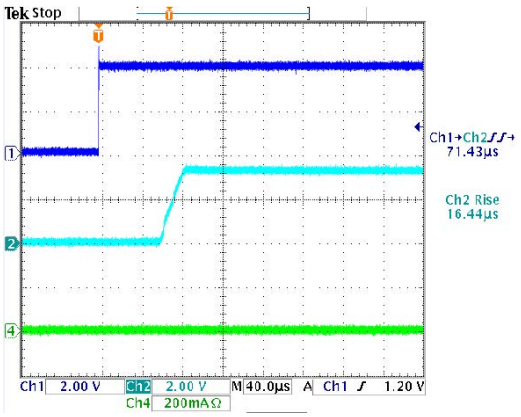
Power ON(VOUT=1.2V)



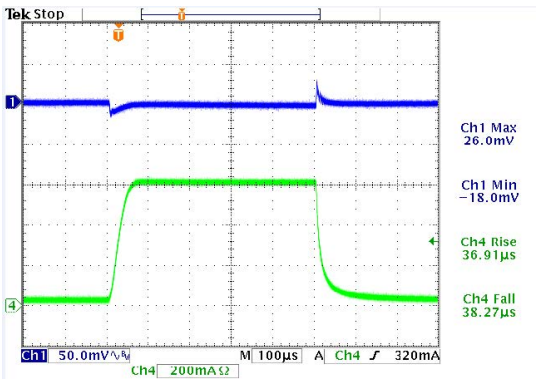
Power ON(VOUT=3.3V)



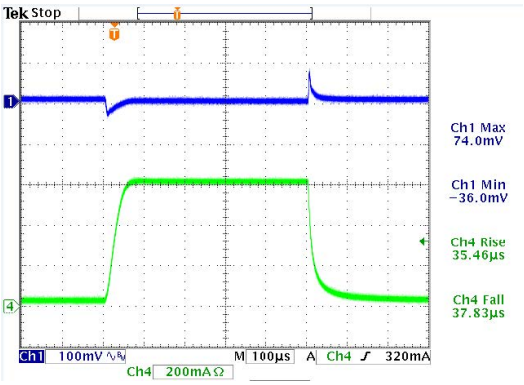
EN ON(VOUT=1.2V)



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 1uF capacitor must be connected from Vout to ground to insure stability. Input capacitor of 1uF 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

TN9650 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 1μF capacitor on the input and a 1μFcapacitor on the output of the TN9650 Series. Larger input capacitor values and lower ESR (X5R, X7R) provide better supply noise rejection and transient response. A higher value output capacitor (2.2μF) 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, TN9650 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 TN9650 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:

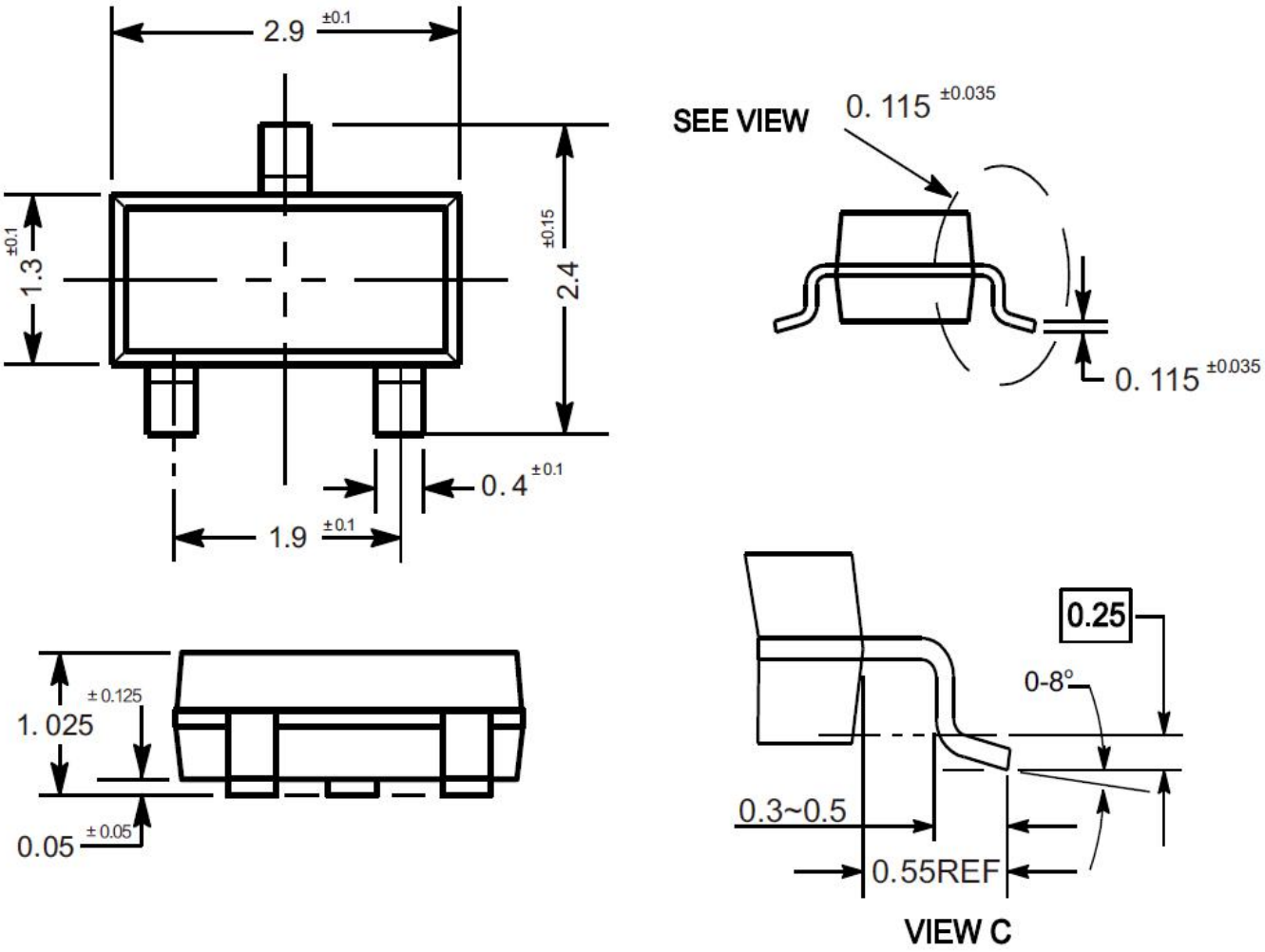
$$PD(max) = (Tj(max) - Ta) / R\theta JA$$

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 ≅1 μF is required between the TN9650 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.

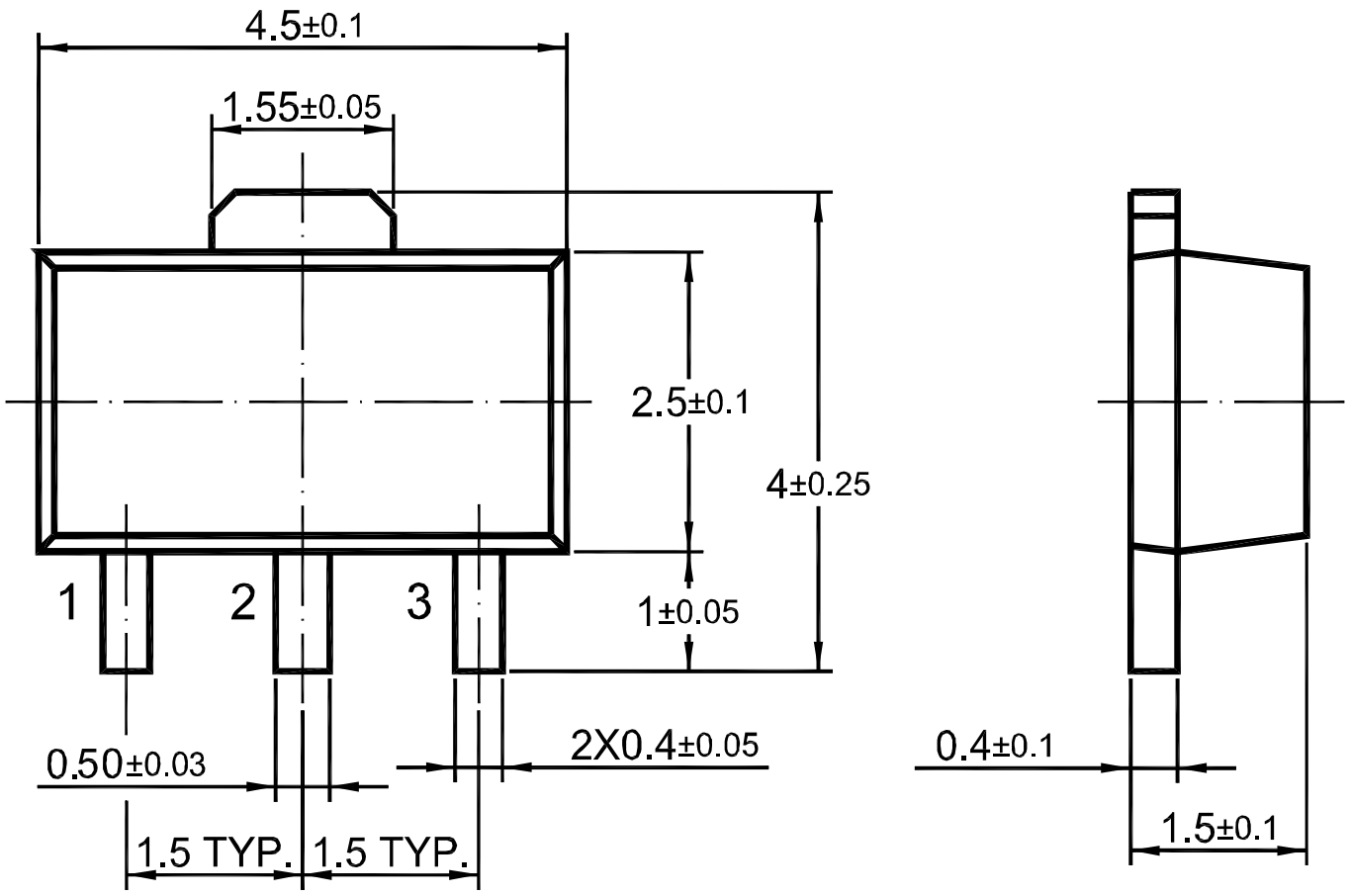
Package Outline
SOT-23
Dimensions in mm



Package Outline

SOT-89

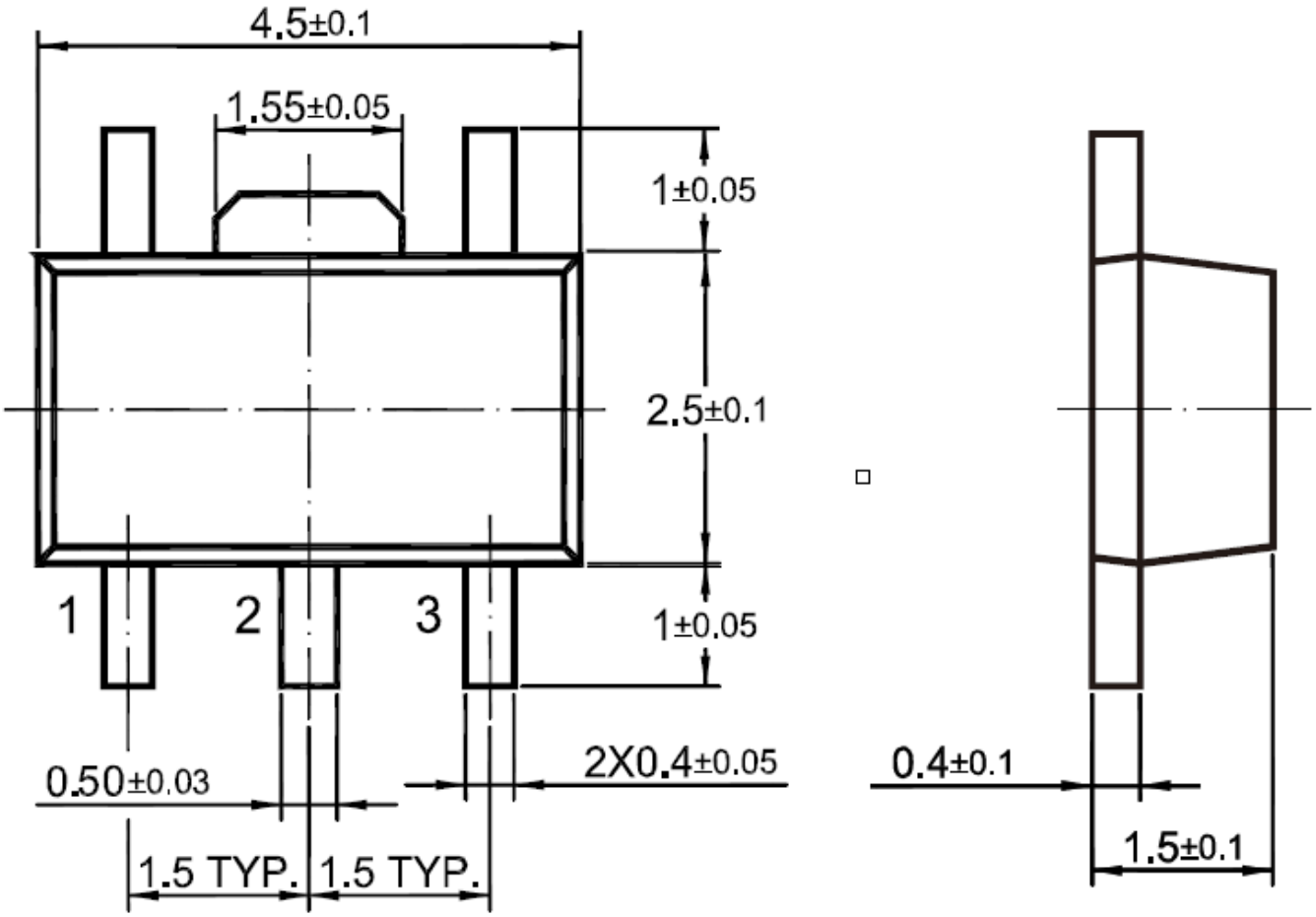
Dimensions in mm



Package Outline

SOT-89-5

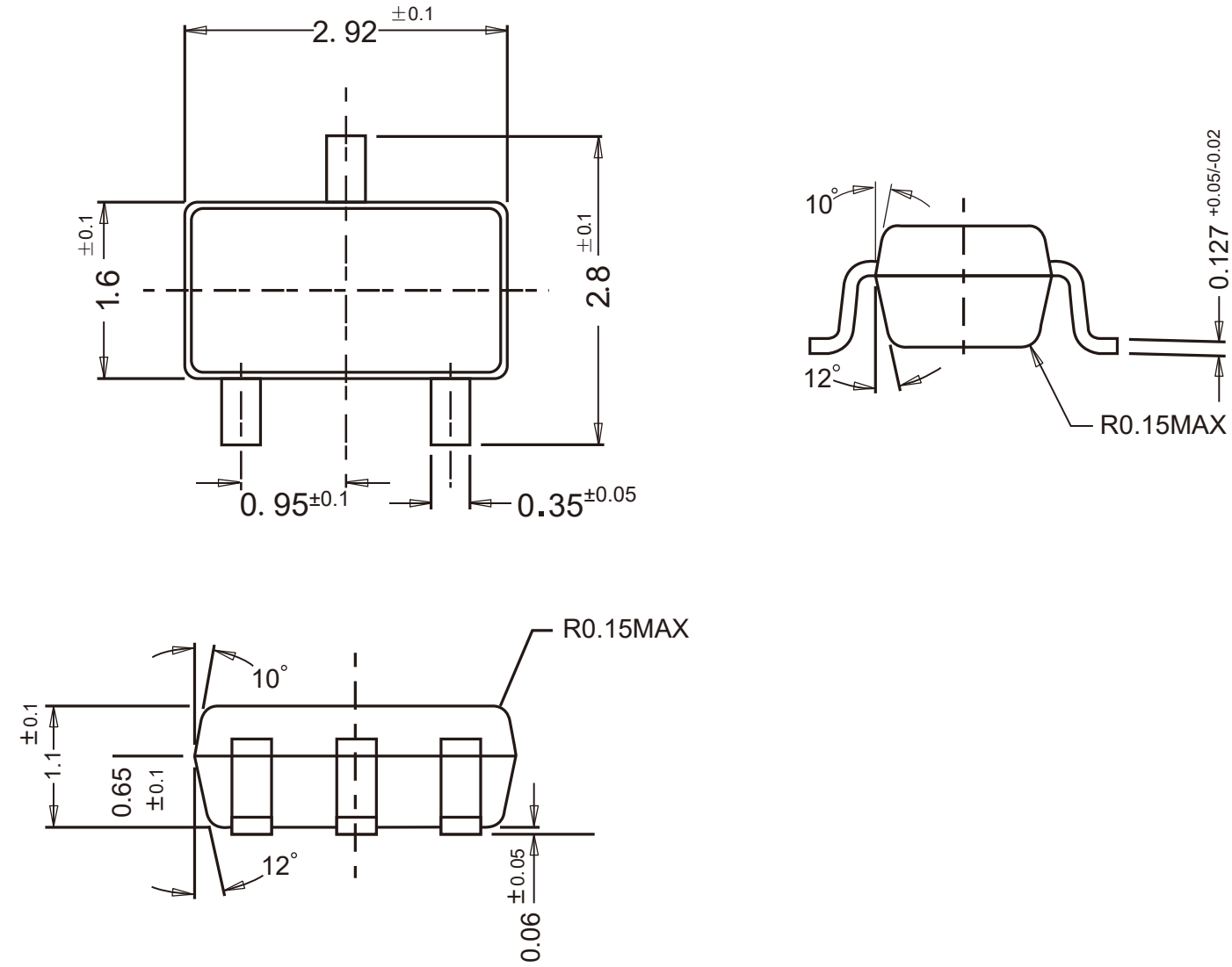
Dimensions in mm



Package Outline

SOT-23-3

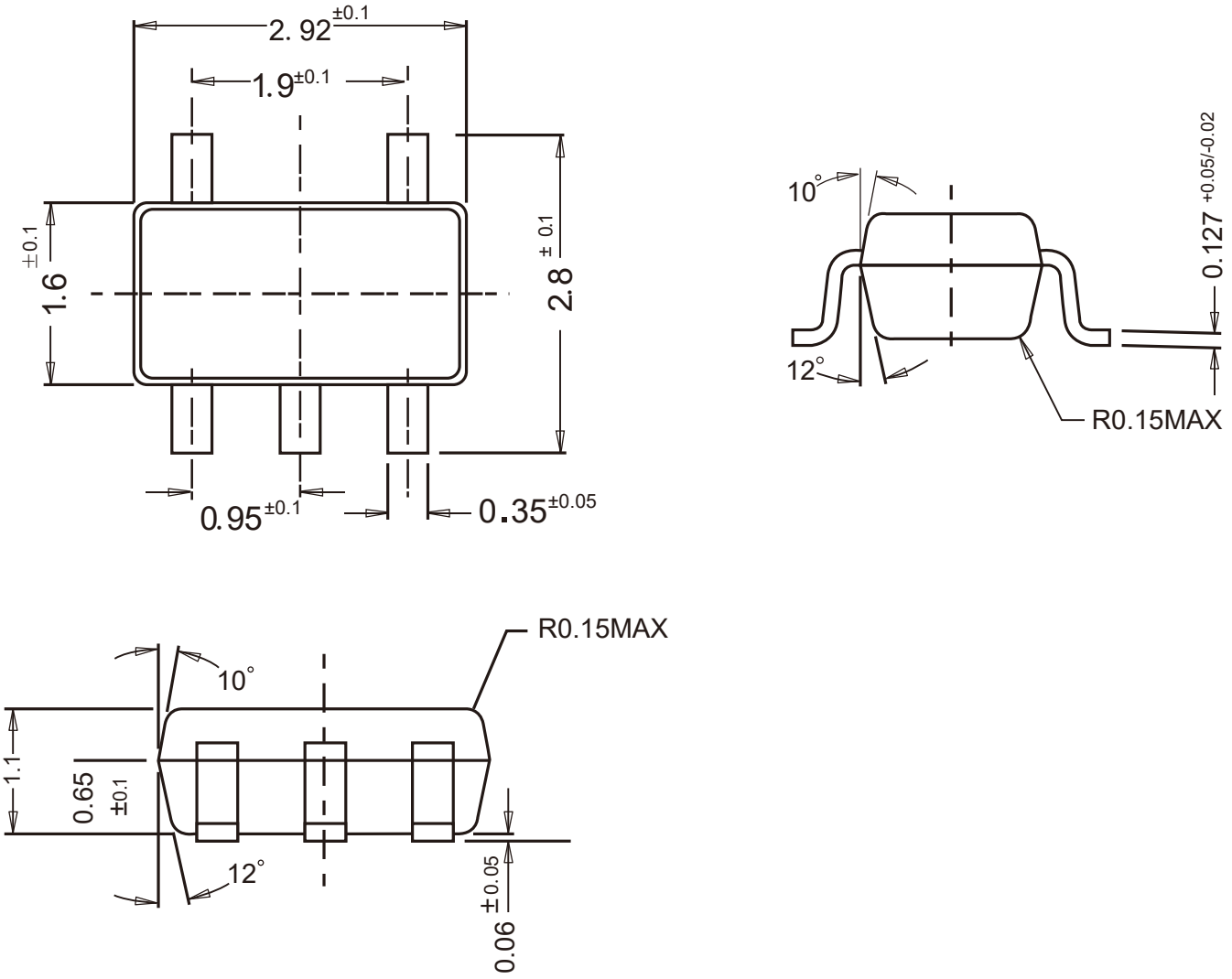
Dimensions in mm



Package Outline

SOT-23-5

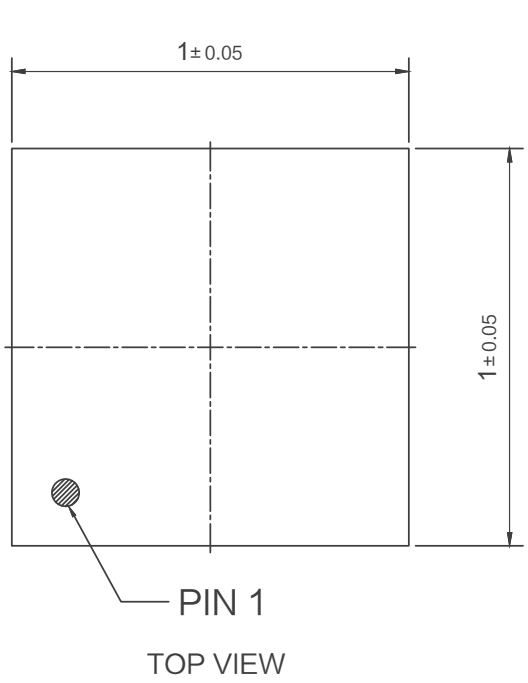
Dimensions in mm



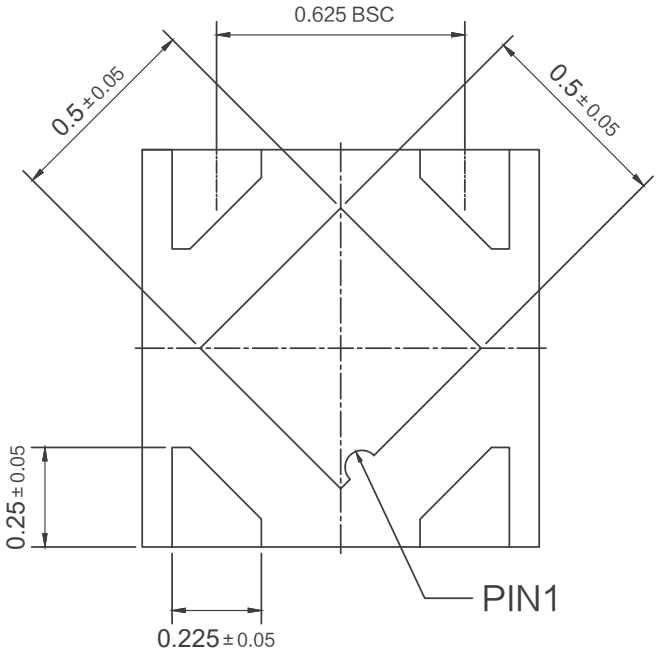
Package Outline

DFN1x1-4L

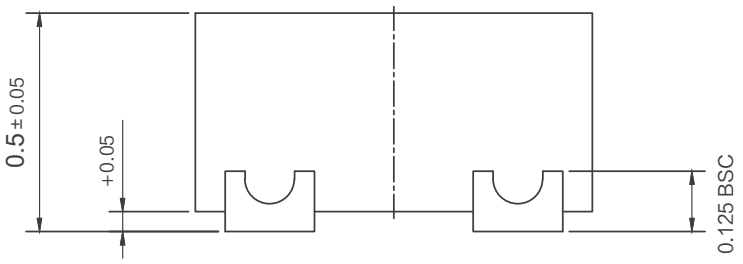
Dimensions in mm



TOP VIEW



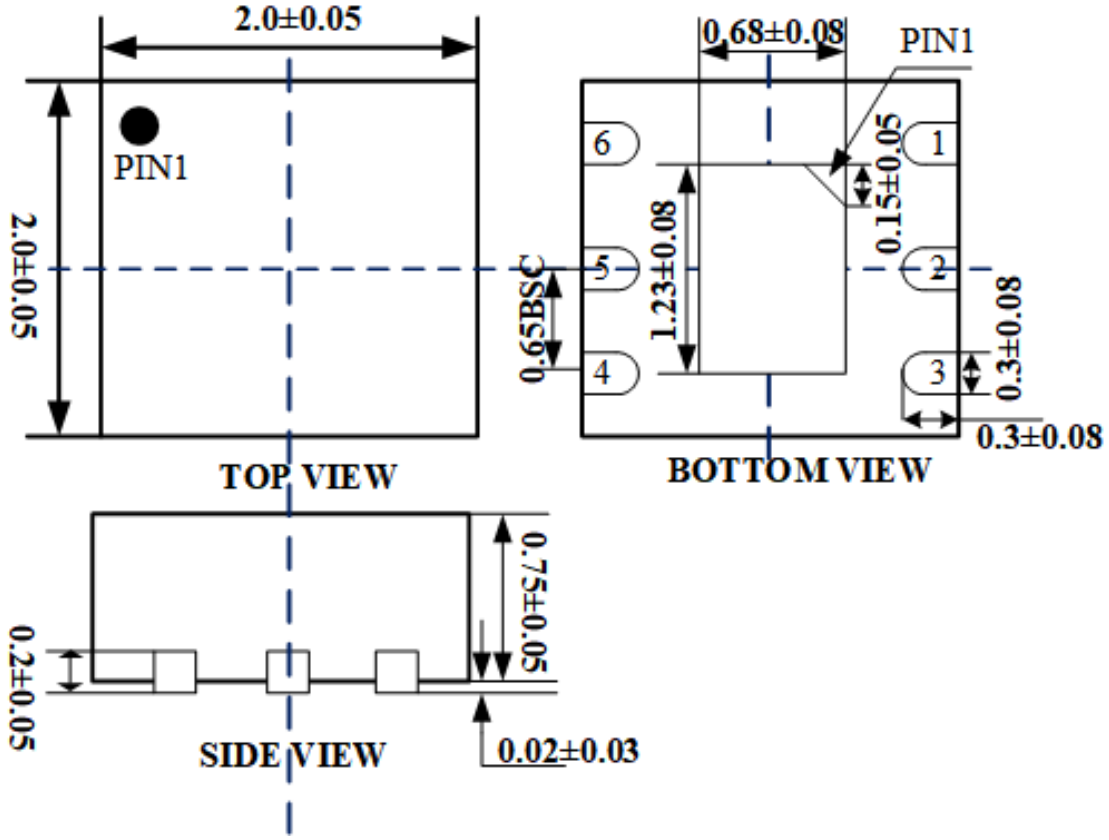
BOTTOM VIEW



SIDE VIEW

Package Outline

DFN2x2-6L-0006 Dimensions in mm



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For additional information, please contact your local Sales Representative.

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