



YOUSHANG SEMICONDUCTOR

设计研发新型功率器件

各类小信号开关

中低压及高压大电流等场效应管

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Description

The NK-AP2127 Series are positive voltage regulator ICs fabricated by CMOS process.

The NK-AP2127 Series have features of low dropout voltage, low noise, high output voltage accuracy, and low current consumption which make them ideal for use in various battery-powered devices.

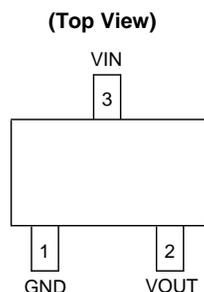
The NK-AP2127 has 1.0V, 1.2V, 1.5V, 1.8V, 2.5V, 2.8V, 3.0V, 3.3V, 4.2V, and 4.75V fixed voltage versions and 0.8V to 5.5V adjustable voltage versions.

The NK-AP2127 Series are available in SOT-23 (for fixed versions only), SOT-23-3 (for fixed versions only), SOT-23-5, SOT-89 (for fixed versions only) packages.

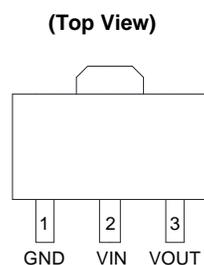
Features

- Wide Operating Voltage: 2.5V to 6V
- High Output Voltage Accuracy: $\pm 2\%$
- High Ripple Rejection:
68dB @ $f = 1\text{kHz}$, 54dB @ $f = 10\text{kHz}$
- Low Standby Current: 0.1 μA
- Low Dropout Voltage: 170mV @ 300mA for $V_{\text{OUT}} = 3.3\text{V}$,
140mV @ 300mA for $V_{\text{OUT}} = 4.75\text{V}$
- Low Quiescent Current: 60 μA Typical
- Low Output Noise: 60 μVRMS @ $V_{\text{OUT}} = 0.8\text{V}$
- Short Current Limit: 50mA
- Over Temperature Protection
- Compatible with Low ESR Ceramic Capacitor:
1 μF for C_{IN} and C_{OUT}
- Excellent Line/Load Regulation
- Soft Start Time: 50 μs
- Auto Discharge Resistance: $R_{\text{DS(ON)}} = 60\Omega$
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

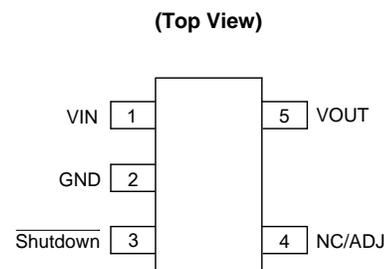
Pin Assignments



SOT-23/SOT-23-3



SOT-89

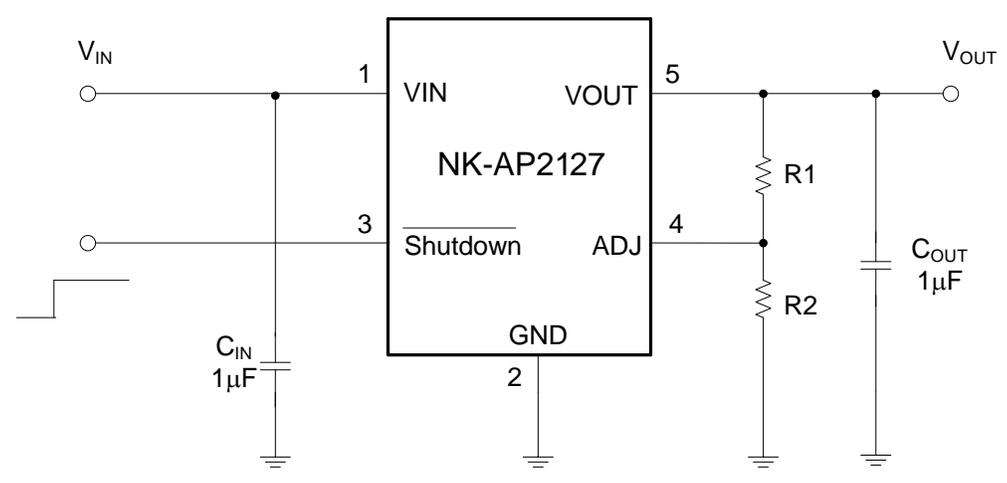


SOT-23-5

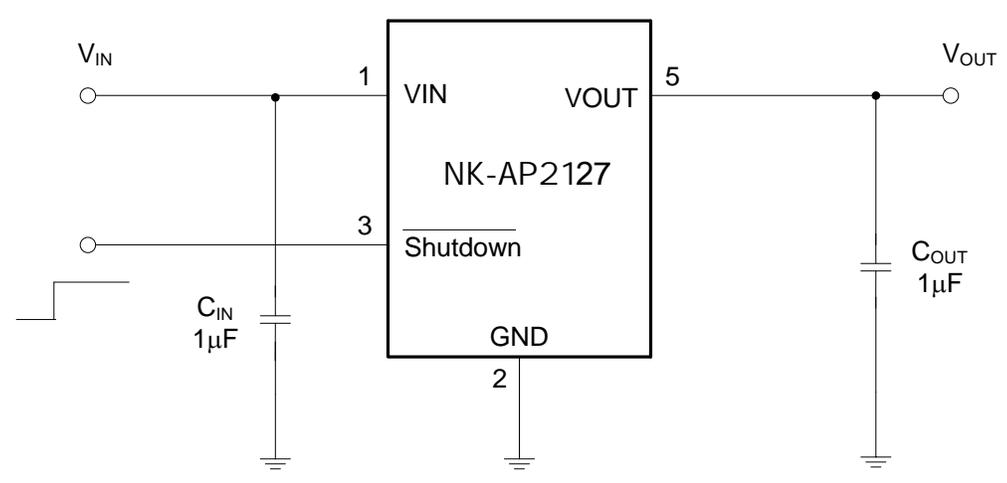
Applications

- Datacom
- Notebook Computers
- Mother Board

Typical Applications Circuit



$$V_{OUT} = 0.8(1 + R1/R2)V$$

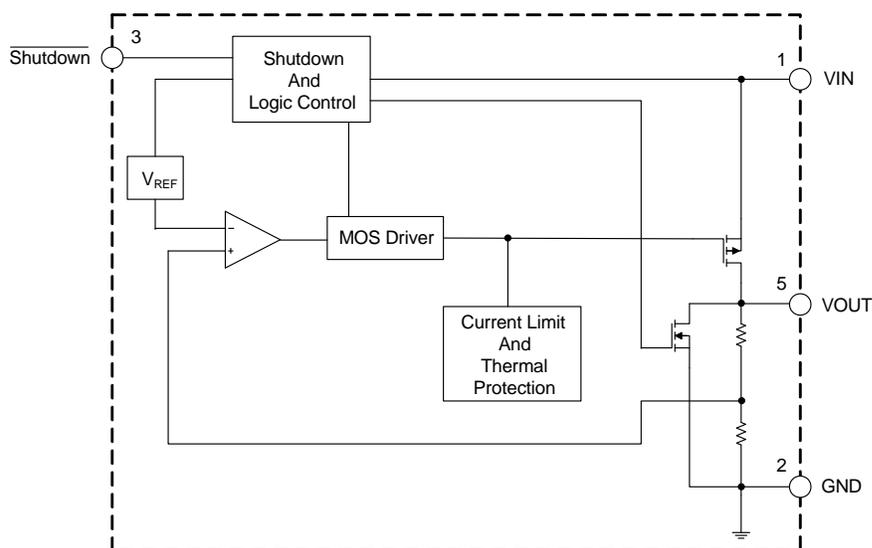


For Fixed Voltage Versions

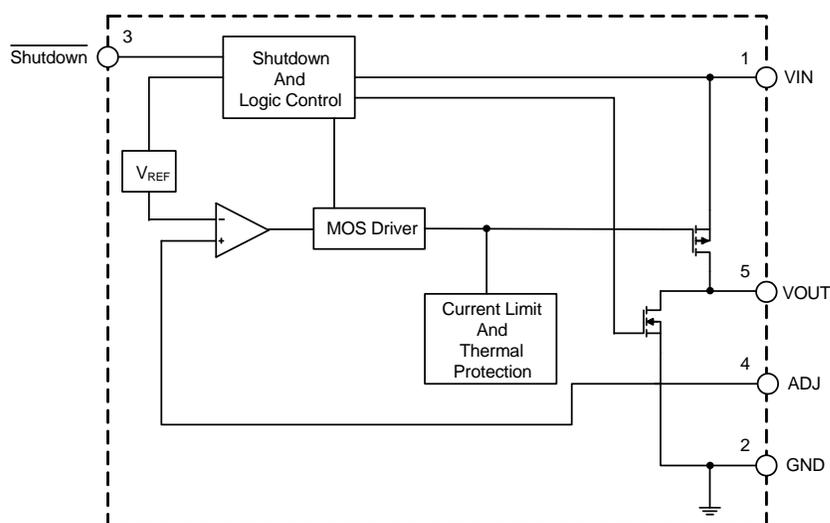
Pin Descriptions

Pin Name	Pin Number			Function
	SOT-23 SOT-23-3	SOT-23-5	SOT-89	
VIN	3	1	2	Power Input
VOUT	2	5	3	Power Output
GND	1	2	1	Ground
NC/ADJ	—	4	—	No Connection / VOUT feedback input, connect resistor divider.
Shutdown	—	3	—	Enable Input.
PAD	—	—	—	Exposed PAD for thermal performance improvement connect to GND

Functional Block Diagram



Fixed Version (SOT-23-5 Package)



Adjustable Version (SOT-23-5 Package)

Absolute Maximum Ratings (Note 4) (@ $T_A = +25^\circ\text{C}$, unless otherwise specified.)

Symbol	Parameter	Value		Unit
V_{IN}	Input Voltage	6.5		V
V_{CE}	Shutdown Input Voltage	-0.3 to $V_{IN} + 0.3$		V
I_{OUT}	Output Current	450		mA
T_J	Junction Temperature	+150		$^\circ\text{C}$
T_{STG}	Storage Temperature Range	-65 to +150		$^\circ\text{C}$
T_{LEAD}	Lead Temperature (Soldering, 10sec)	+260		$^\circ\text{C}$
θ_{JA}	Thermal Resistance (Junction to Ambient)	SOT-23	180	$^\circ\text{C/W}$
		SOT-23-3	250	
		SOT-23-5	250	
		SOT-89	100	
ESD	ESD (Human Body Model)	6000		V
ESD	ESD (Machine Model)	200		V

Note: 4. Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "Recommended Operating Conditions" is not implied. Exposure to "Absolute Maximum Ratings" for extended periods may affect device reliability.

Recommended Operating Conditions (@ $T_A = +25^\circ\text{C}$, unless otherwise specified.)

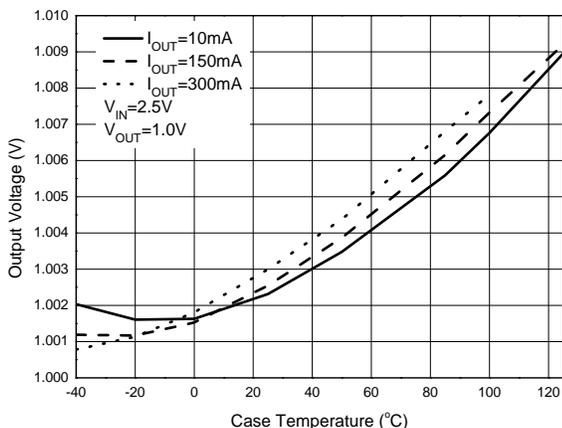
Symbol	Parameter	Min	Max	Unit
V_{IN}	Input Voltage	2.5	6	V
T_A	Operating Ambient Temperature Range	-40	+85	$^\circ\text{C}$

Electrical Characteristics ($V_{IN} = 2.5V$ (for 0.8V to 1.8V voltage versions), $V_{IN} = V_{OUT} + 1V$ (for 2.5V to 4.75V voltage versions), $V_{IN} = 6V @ V_{OUT} = 4.75V$, $T_A = +25^\circ C$, $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, **Bold** typeface applies over $-40^\circ C \leq T_A \leq +85^\circ C$, unless otherwise specified.)

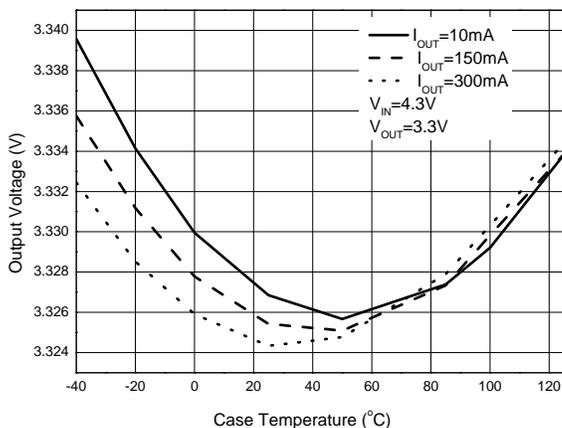
Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
V_{REF}	Reference Voltage	$V_{IN} = V_{OUT} + 1V$ $1mA \leq I_{OUT} \leq 300mA$	0.784	0.8	0.816	V	
V_{OUT}	Output Voltage	$V_{IN} = V_{OUT} + 1V$ $1mA \leq I_{OUT} \leq 300mA$	98% x V_{OUT}	—	102% x V_{OUT}	V	
V_{IN}	Input Voltage	—	2.5	—	6	V	
$I_{OUT(MAX)}$	Maximum Output Current	$V_{IN} - V_{OUT} = 1V$ $V_{OUT} = 0.98 \times V_{OUT}$	300	400	—	mA	
ΔV_{OUT}	Load Regulation	$V_{IN} - V_{OUT} = 1V$ $1mA \leq I_{OUT} \leq 300mA$	—	4	10	mV	
ΔV_{OUT}	Line Regulation	$V_{OUT} + 0.5V \leq V_{IN} \leq 6V$ $I_{OUT} = 30mA$	—	0.5	5	mV	
V_{DROP}	Dropout Voltage	$V_{OUT} = 1.0V, I_{OUT} = 300mA$	—	1400	1500	mV	
		$V_{OUT} = 1.2V, I_{OUT} = 300mA$	—	1200	1300		
		$V_{OUT} = 1.5V, I_{OUT} = 300mA$	—	900	1000		
		$V_{OUT} = 1.8V, I_{OUT} = 300mA$	—	600	700		
		$V_{OUT} = 2.5V, 2.8V, 3.0V, 3.3V, 4.2V,$ $I_{OUT} = 300mA$	—	170	300		
		$V_{OUT} = 4.75V,$ $I_{OUT} = 300mA$	—	140	300		
I_Q	Quiescent Current	$V_{IN} = V_{OUT} + 1V, I_{OUT} = 0mA$	—	60	90	μA	
I_{STD}	Standby Current	$V_{IN} = V_{OUT} + 1V$ $V_{SHUTDOWN}$ in off mode	—	0.1	1.0	μA	
PSRR	Power Supply Rejection Ration	AP2127-1.0V to 4.2V, Ripple 1V _{P-P} $V_{IN} = V_{OUT} + 1V$	f = 100Hz	—	68	—	dB
			f = 1kHz	—	68	—	dB
			f = 10kHz	—	54	—	dB
		AP2127-4.75V, Ripple 0.5V _{P-P} $V_{IN} = V_{OUT} + 1V$	f = 100Hz	—	63	—	dB
			f = 10kHz	—	45	—	dB
$\Delta V_{OUT}/V_{OUT} / \Delta T$	Output Voltage Temperature Coefficient	$I_{OUT} = 30mA, -40^\circ C \leq T_A \leq +85^\circ C$	—	± 100	—	ppm/ $^\circ C$	
I_{SHORT}	Short Current Limit	$V_{OUT} = 0V$	—	50	—	mA	
t_{SS}	Soft Start Time	—	—	50	—	μs	
V_{NOISE}	RMS Output Noise	$T_A = +25^\circ C, 10Hz \leq f \leq 100kHz,$ $V_{OUT} = 0.8V$	—	60	—	μV_{RMS}	
—	Shutdown High Voltage	Shutdown Input Voltage High	1.5	—	—	V	
—	Shutdown Low Voltage	Shutdown Input Voltage Low	—	—	0.5	V	
—	V_{OUT} Discharge MOSFET $R_{DS(ON)}$	Shutdown Input Voltage Low	—	60	—	Ω	
—	Shutdown Pull Down Resistance	—	—	3	—	M Ω	
—	Thermal Shutdown	—	—	+165	—	$^\circ C$	
—	Thermal Shutdown Hysteresis	—	—	+30	—	$^\circ C$	
θ_{JC}	Thermal Resistance	SOT-23	—	100	—	$^\circ C/W$	
		SOT-23-3	—	150	—		
		SOT-23-5	—	150	—		
		SOT-89	—	75	—		

Performance Characteristics (Note 5)

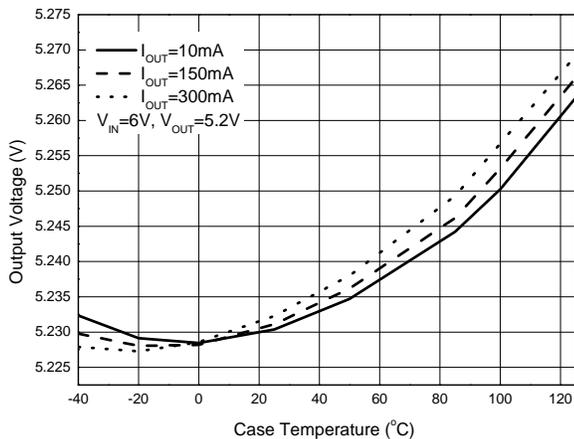
Output Voltage vs. Case Temperature



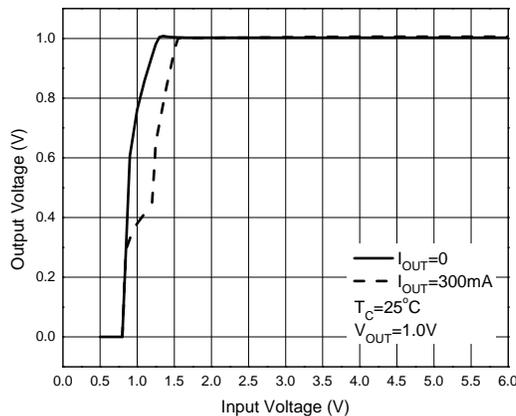
Output Voltage vs. Case Temperature



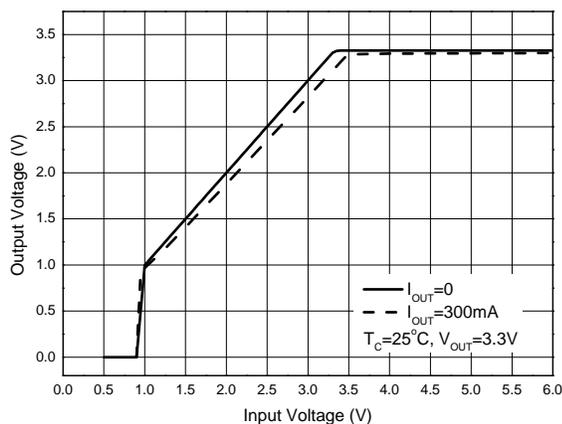
Output Voltage vs. Case Temperature



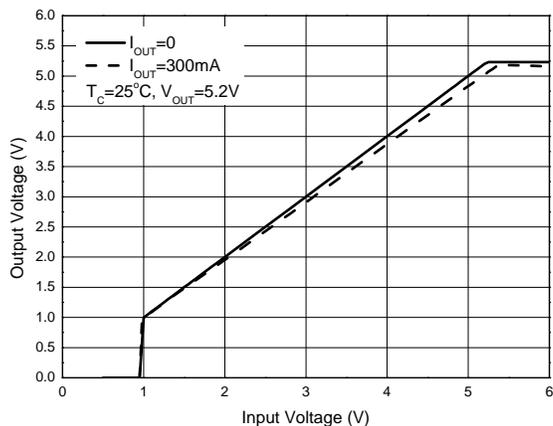
Output Voltage vs. Input Voltage



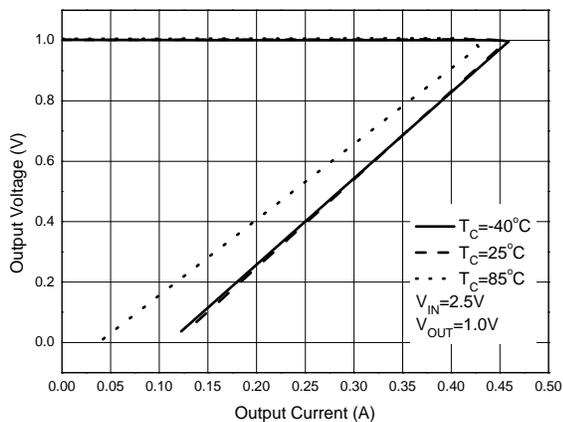
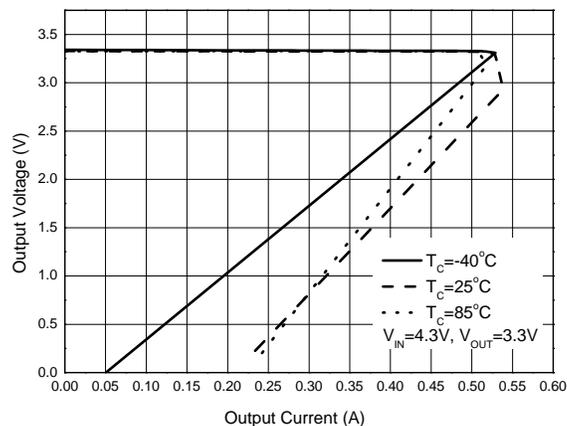
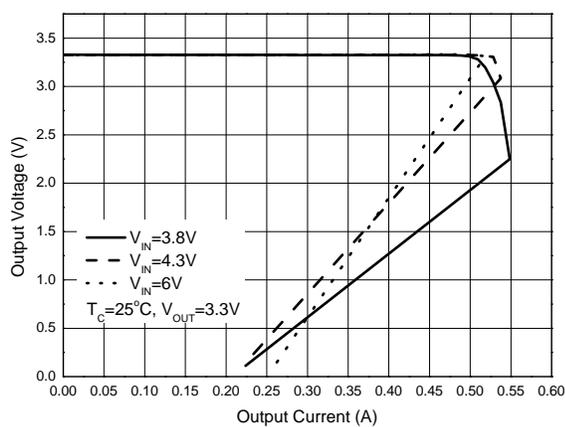
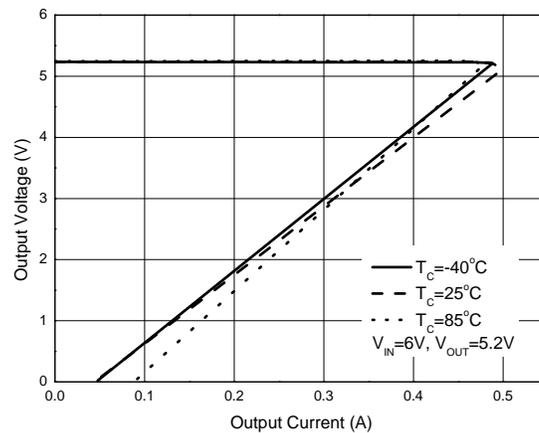
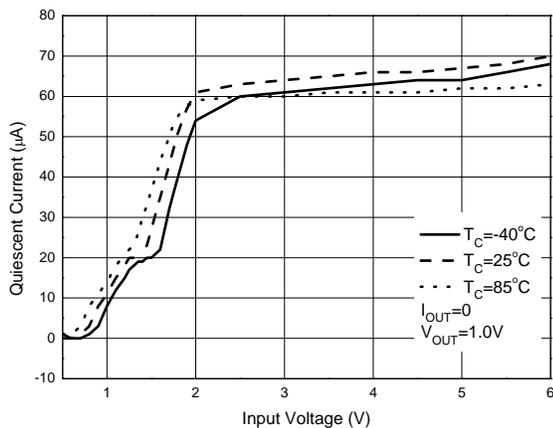
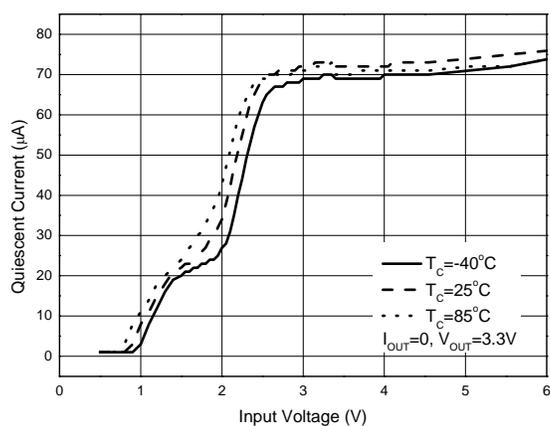
Output Voltage vs. Input Voltage



Output Voltage vs. Input Voltage



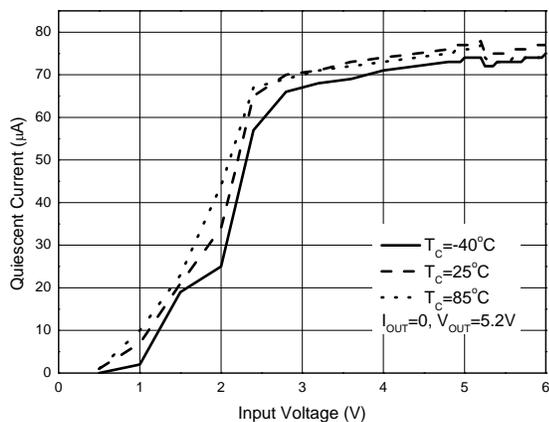
Note 5: Maximum output of 4.75V passed qualification test. Performance Characteristics for 5.2V are for reference only.

Performance Characteristics (Cont.) (Note 5)
Output Voltage vs. Output Current

Output Voltage vs. Output Current

Output Voltage vs. Output Current

Output Voltage vs. Output Current

Quiescent Current vs. Input Voltage

Quiescent Current vs. Input Voltage


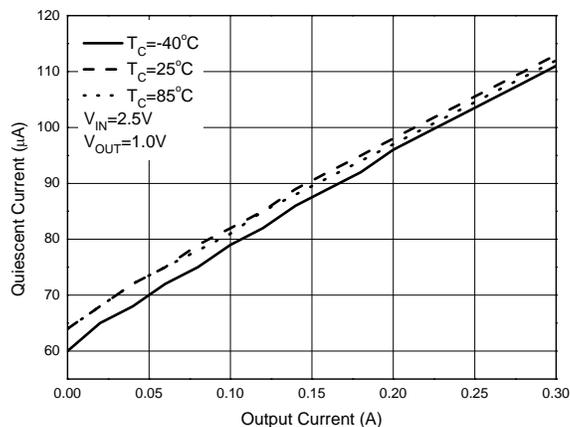
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Performance Characteristics (Cont.) (Note 5)

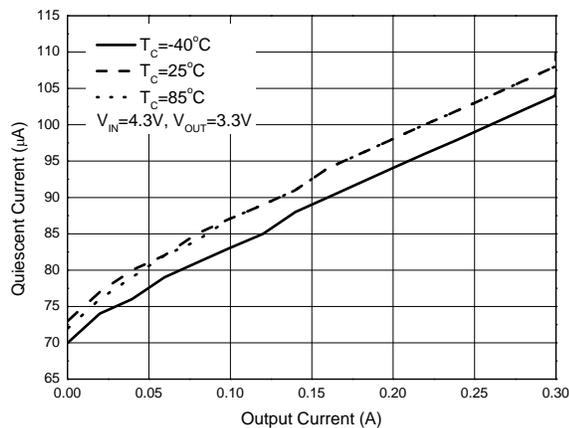
Quiescent Current vs. Input Voltage



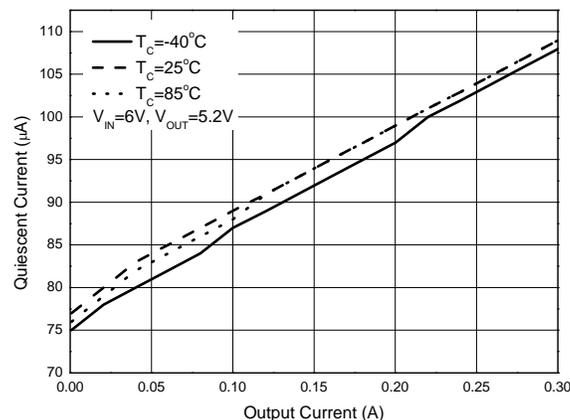
Quiescent Current vs. Output Current



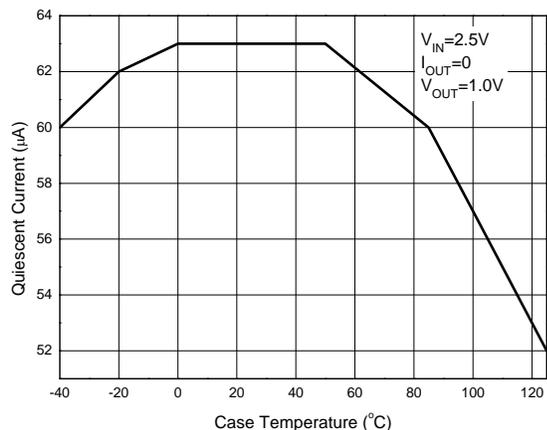
Quiescent Current vs. Output Current



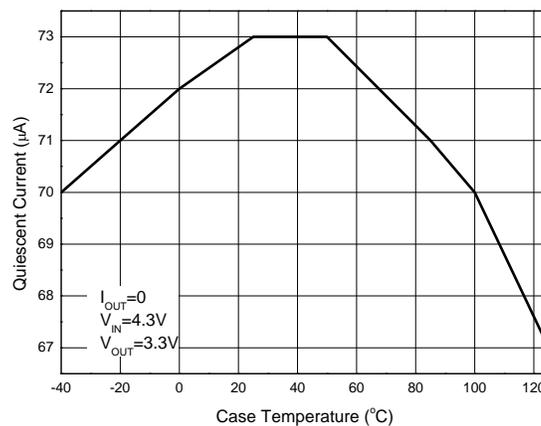
Quiescent Current vs. Output Current



Quiescent Current vs. Case Temperature



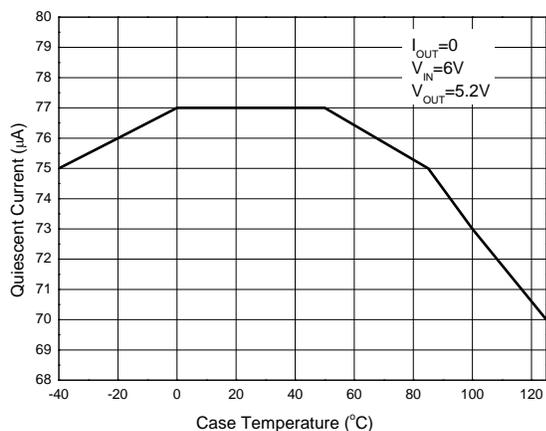
Quiescent Current vs. Case Temperature



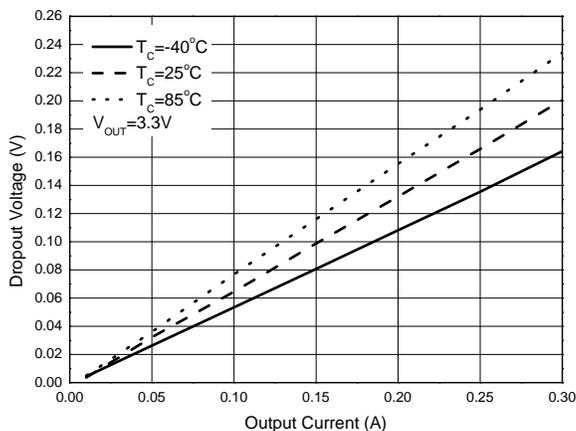
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Performance Characteristics (Cont.) (Note 5)

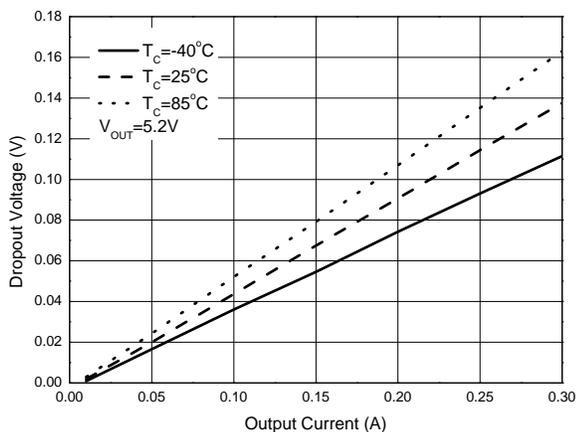
Quiescent Current vs. Case Temperature



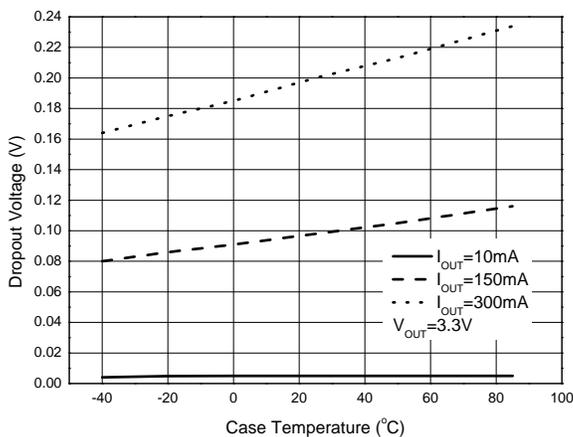
Dropout Voltage vs. Output Current



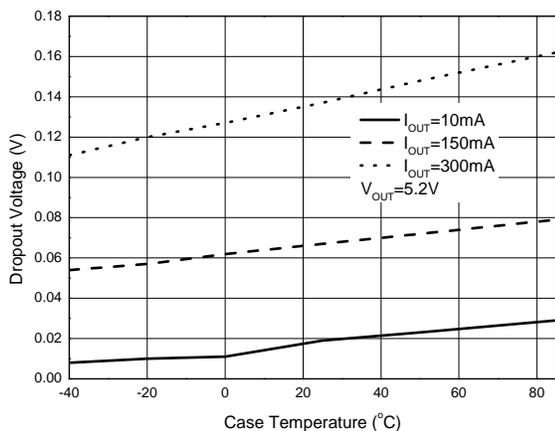
Dropout Voltage vs. Output Current



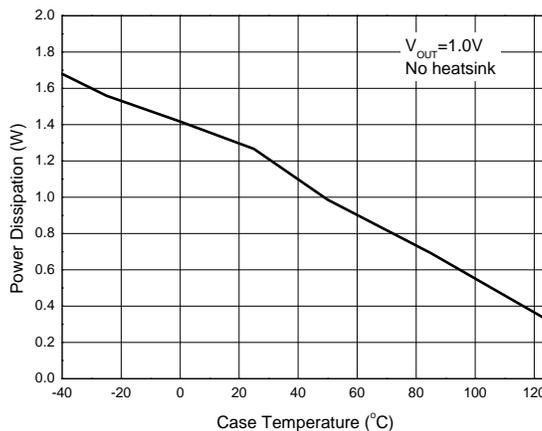
Dropout Voltage vs. Case Temperature



Dropout Voltage vs. Case Temperature



Power Dissipation vs. Case Temperature

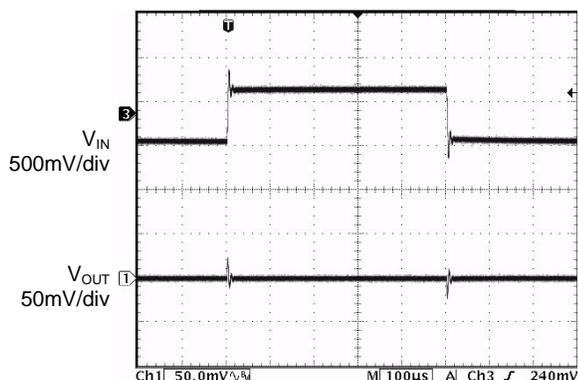


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Performance Characteristics (Cont.) (Note 5)

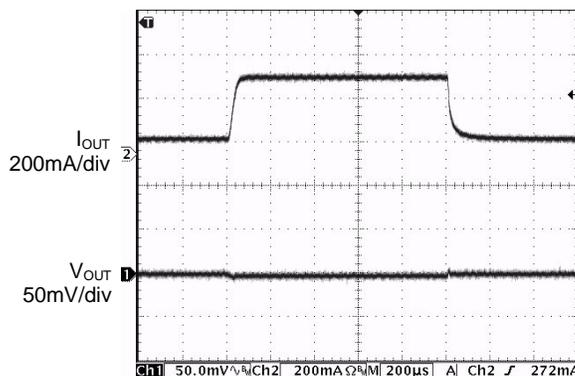
Line Transient

(Condition: $C_{IN}=C_{OUT}=1\mu F$, $I_{OUT}=10mA$, $V_{IN}=2.5V$ to $3.3V$, $V_{OUT}=1V$)



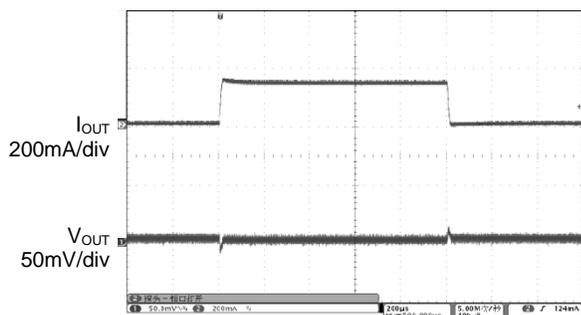
Load Transient

(Condition: $C_{IN}=C_{OUT}=1\mu F$, Slew Rate= $20mA/\mu s$, $V_{IN}=2.5V$, $V_{OUT}=1V$, $I_{OUT}=10mA$ to $300mA$)



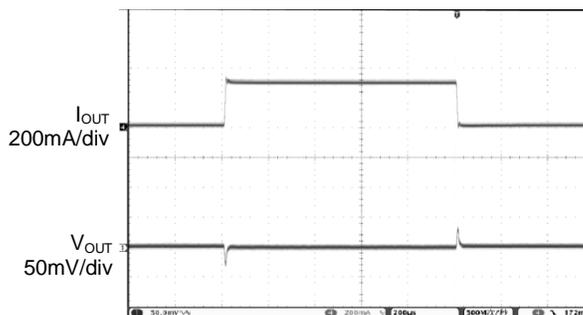
Load Transient

(Condition: $C_{IN}=C_{OUT}=1\mu F$, $I_{OUT}=10mA$ to $300mA$, $V_{IN}=4.3V$, $V_{OUT}=3.3V$)



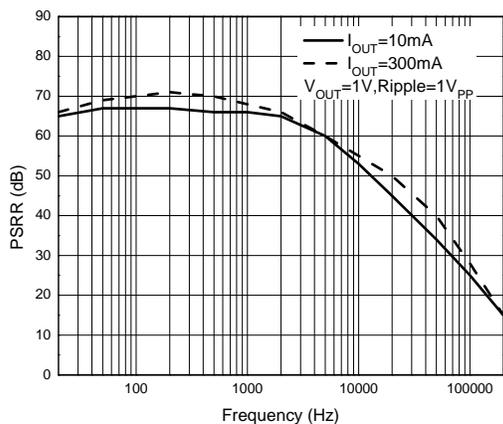
Load Transient

(Condition: $C_{IN}=C_{OUT}=1\mu F$, Slew Rate= $20mA/\mu s$, $V_{IN}=6V$, $V_{OUT}=5.2V$, $I_{OUT}=10mA$ to $300mA$)



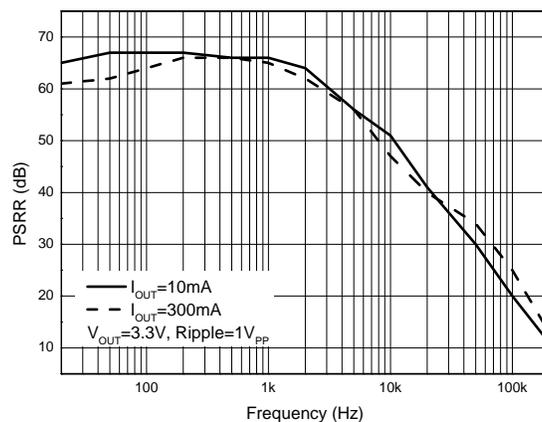
PSRR vs. Frequency

(Condition: $C_{IN}=C_{OUT}=1\mu F$, $V_{IN}=2.5V$, $V_{OUT}=1V$, Ripple= $1V_{PP}$)



PSRR vs. Frequency

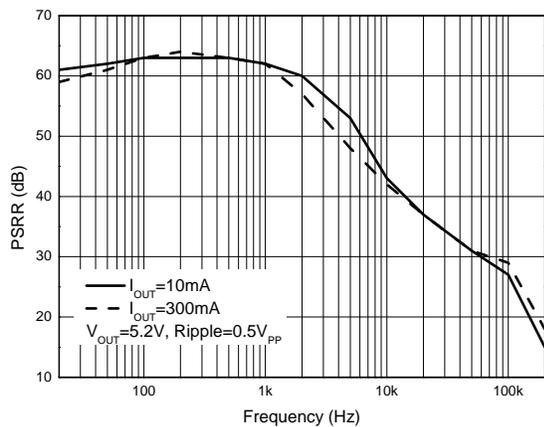
(Condition: $C_{IN}=C_{OUT}=1\mu F$, $V_{IN}=4.3V$, $V_{OUT}=3.3V$, Ripple= $1V_{PP}$)



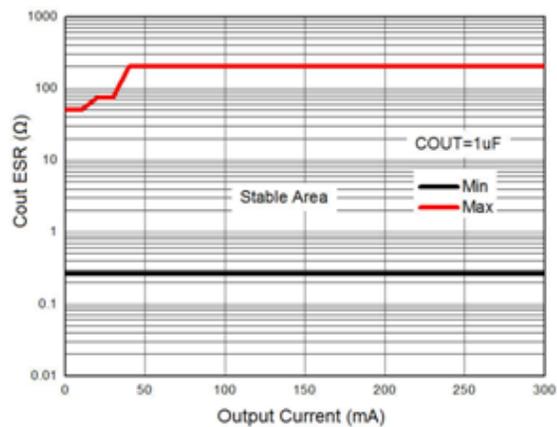
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Performance Characteristics (Cont.) (Note 5)

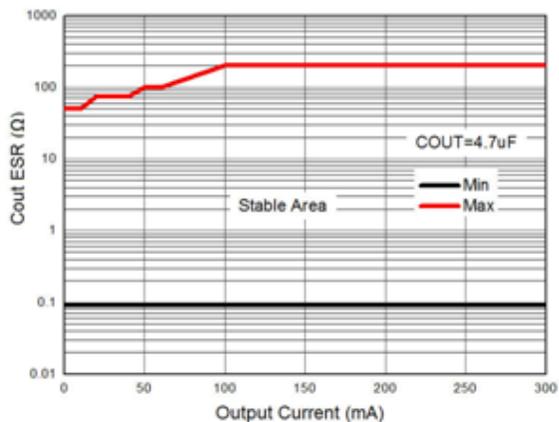
PSRR vs. Frequency
(Condition: $C_{IN}=C_{OUT}=1\mu F$, $V_{IN}=6V$, $V_{OUT}=5.2V$,
Ripple=0.5V_{PP})



Region of Stable C_{OUT} ESR vs. Output Current (C_{OUT} = 1μF)



Region of Stable C_{OUT} ESR vs. Output Current (C_{OUT} = 4.7μF)



Note 5: Maximum output of 4.75V passed qualification test. Performance Characteristics for 5.2V are for reference only.

Application Notes

Input Capacitor

A 1 μ F ceramic capacitor is recommended to connect between VIN and GND pins to decouple input power supply glitch and noise. The amount of the capacitance may be increased without limit. This input capacitor must be located as close as possible to the device to assure input stability and less noise. For PCB layout, a wide copper trace is required for both VIN and GND.

Output Capacitor

The output capacitor is required to stabilize and help transient response for LDO. The NK-AP2127 is stable with very small ceramic output capacitor with a low ESR 1 μ F or higher of X7R or X5R MLCC capacitor, which will be sufficient at full temperature ranges. Additional capacitance helps to reduce undershoot and overshoot during transient. Place output capacitor as close as possible to VOUT and GND pins, and keep the leads as short as possible.

Adjustable Operation

For adjustable version, the output voltage is calculated by:

$$V_{OUT} = V_{REF} \left(1 + \frac{R_1}{R_2} \right)$$

Where $V_{REF} = 0.8V$ (the internal reference voltage)

Rearranging the equation will give the following that is used for adjusting the output to a particular voltage:

$$R_1 = R_2 \left(\frac{V_{OUT}}{V_{REF}} - 1 \right)$$

For NK-AP2127, the resistor at the low side (R_2) can be selected from 5k Ω to 200k Ω .

In order to improve the stability and to decrease the noise level of the adjustable version, a feed-forward capacitor is suggested to be placed between VOUT and ADJ pins (Figure 1). It's recommended that this feed-forward capacitor value can be calculated as:

$$0.7kHz \leq \frac{1}{2\pi \times R_1 \times C_{ff}} \leq 15kHz$$

The recommended value of the feed-forward capacitor for different resistor divider ratios is shown in the table below.

Output Voltage	R1	R2	C _{ff}
1.2V	7.5k Ω	15k Ω	2.7nF
1.6V	7.5k Ω	7.5k Ω	2.7nF
1.8V	22.5k Ω	18k Ω	1nF
1.9V	7.5k Ω	5.49k Ω	2.7nF
2.5V	38.3k Ω	18k Ω	560pF
3.3V	56.2k Ω	18k Ω	390pF
4.0V	120k Ω	30.1k Ω	180pF

Table 1. Output Voltage Setting Guide

Application Notes (Cont.)

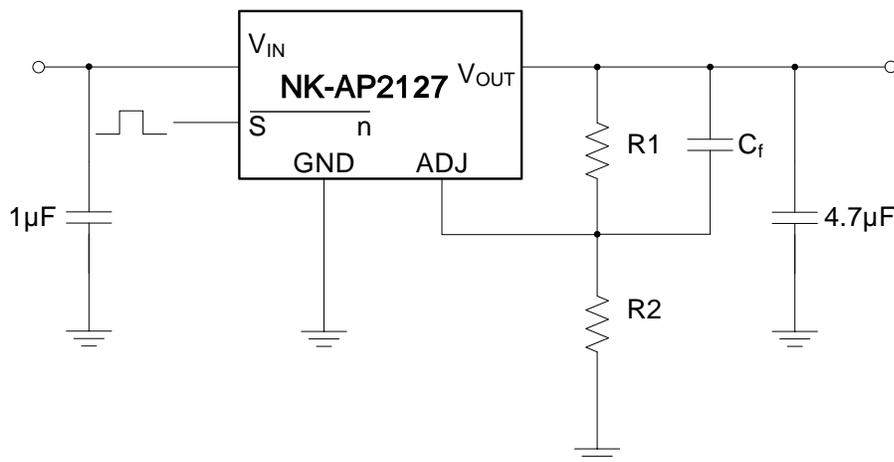


Figure 1. Application Circuit with Feed-forward Capacitor

Current Limit Protection

When output current at VOUT pin is higher than current limit threshold, the current limit protection will be triggered and clamp the output current to prevent over-current and to protect the regulator and load from damaged due to overheating.

Short Circuit Protection

When VOUT pin is shorted to GND, short circuit protection will be triggered and clamp the output current to approximately 50mA.

Auto discharge with Shutdown Version

For shutdown version, an auto discharge MOSFET with $R_{DS(ON)}$ of 60Ω typical is integrated between VOUT and GND pins, which can discharge the charge of the output capacitors quickly when turning off NK-AP2127 with Shutdown pin.

Thermal Consideration

Internal thermal protection circuitry of NK-AP2127 is used to protect device during overload conditions. For continuous operation, ensure not to exceed the operating junction temperature range of +125°C.

The power dissipation definition in the device is:

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

The maximum power dissipation depends on the thermal resistance of IC package, PCB layout and the surrounding airflow. The maximum power dissipation can also be calculated as:

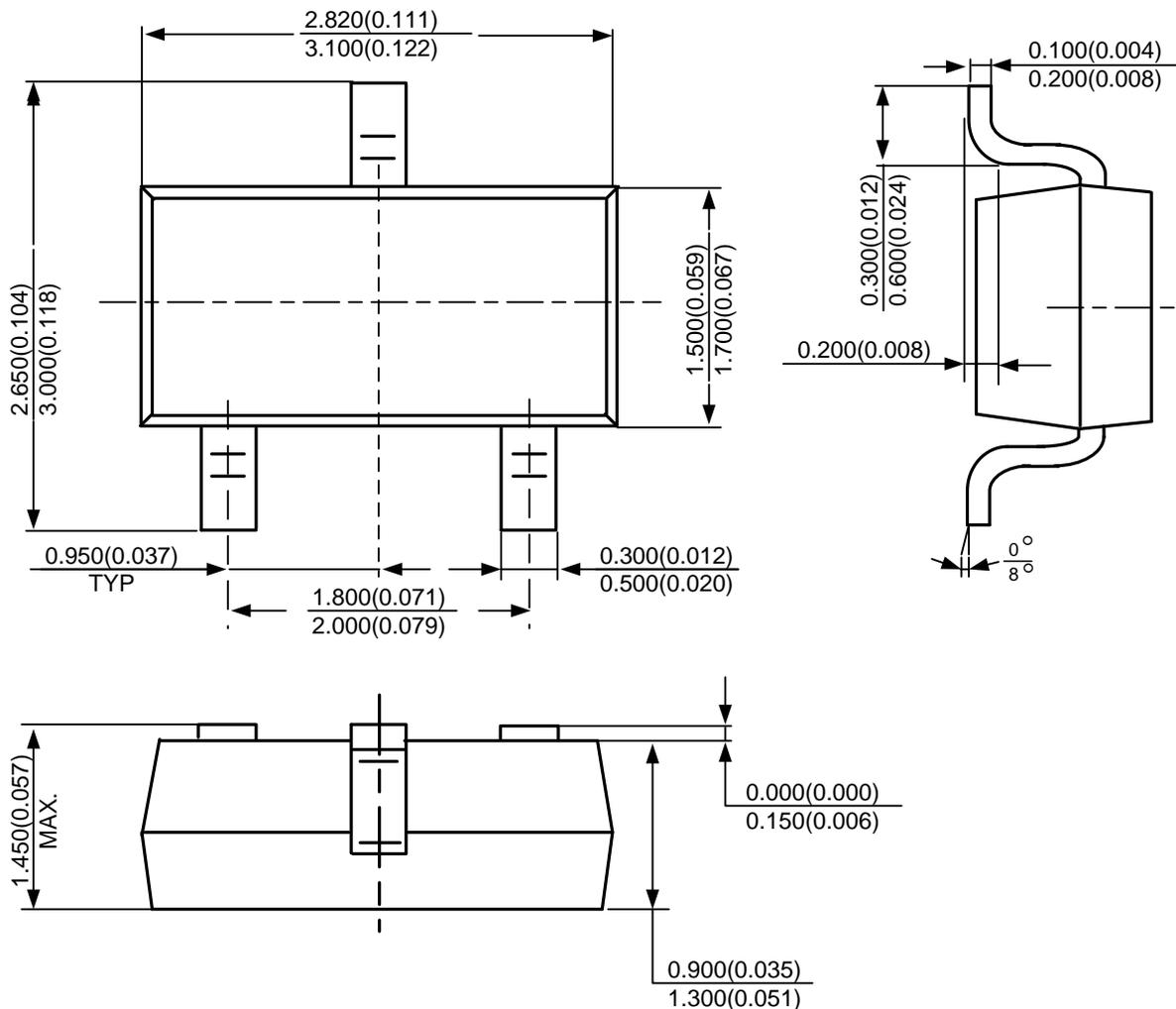
$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

The maximum power dissipation for SOT-23-5 package (least copper size) at $T_A = +25^\circ\text{C}$ can be calculated as:

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (250^\circ\text{C/W}) = 0.4\text{W}$$

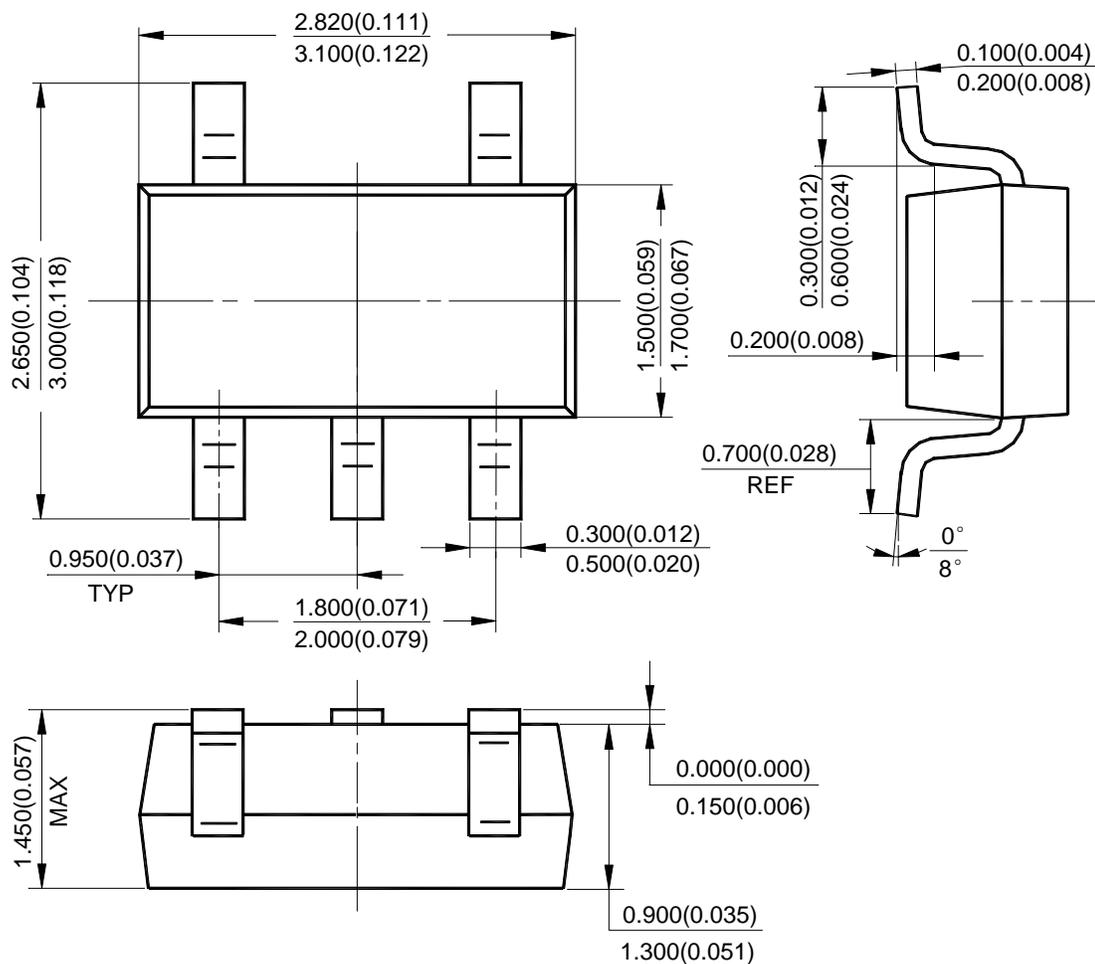
Package Outline Dimensions (Cont.) (All dimensions in mm.)

(2) Package Type: SOT-23-3



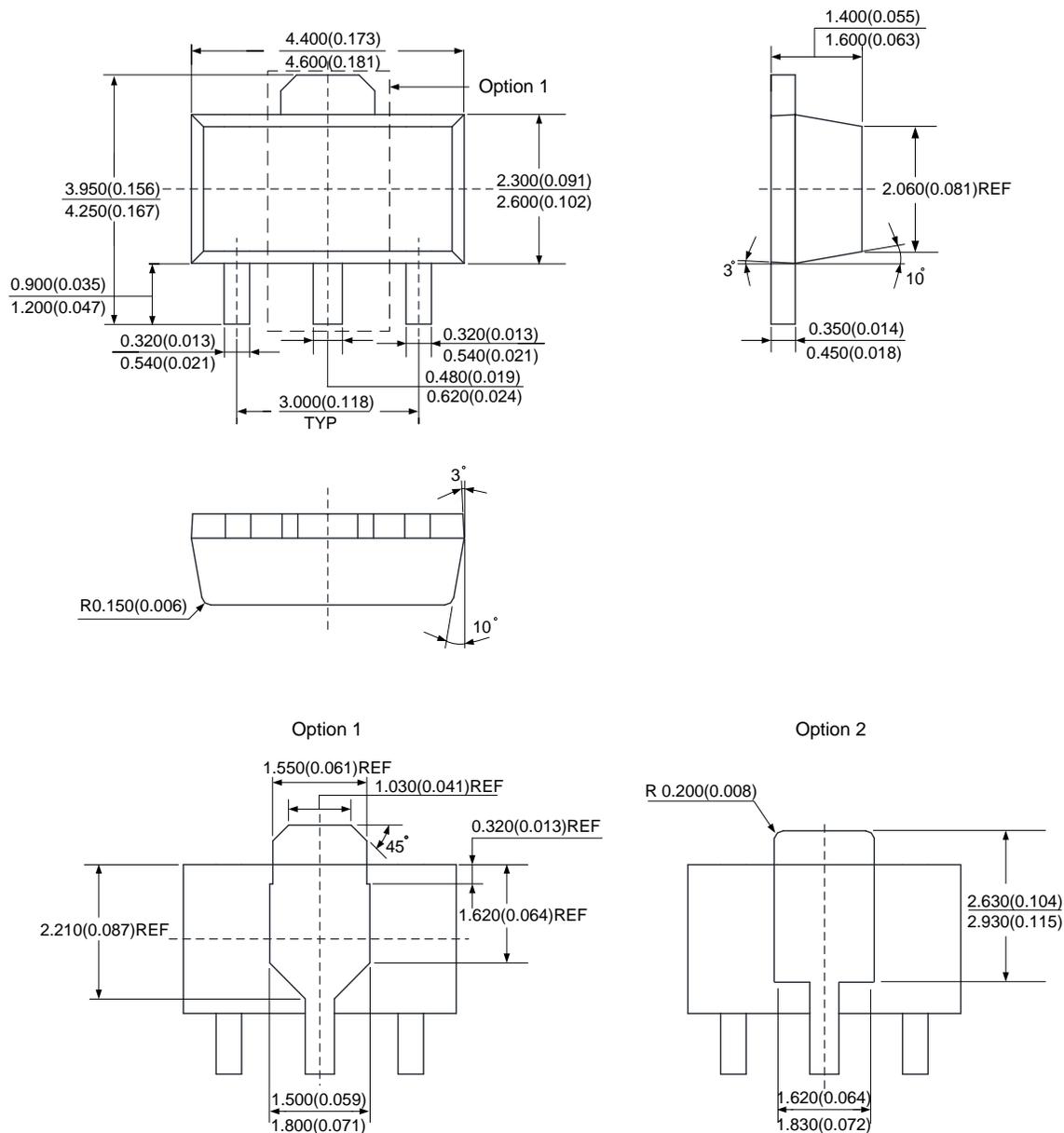
Package Outline Dimensions (Cont.) (All dimensions in mm.)

(3) Package Type: SOT-23-5



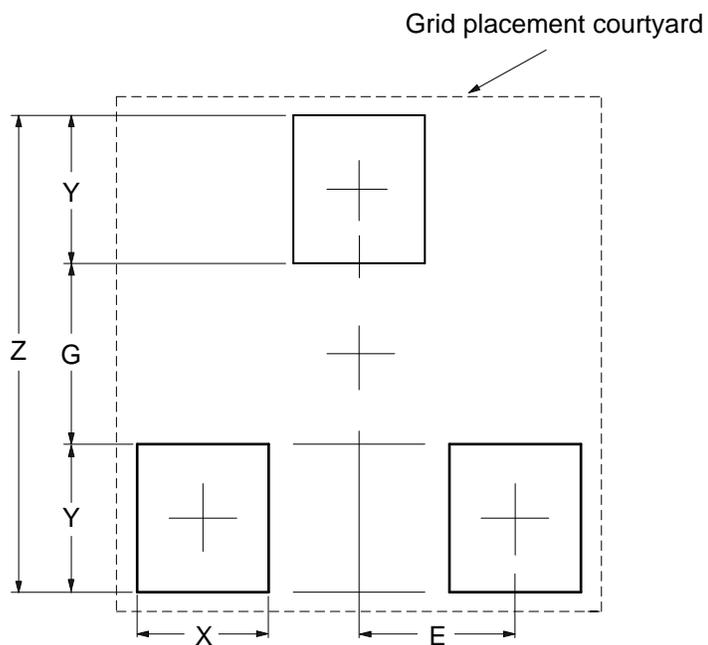
Package Outline Dimensions (Cont.) (All dimensions in mm.)

(4) Package Type: SOT-89



Suggested Pad Layout

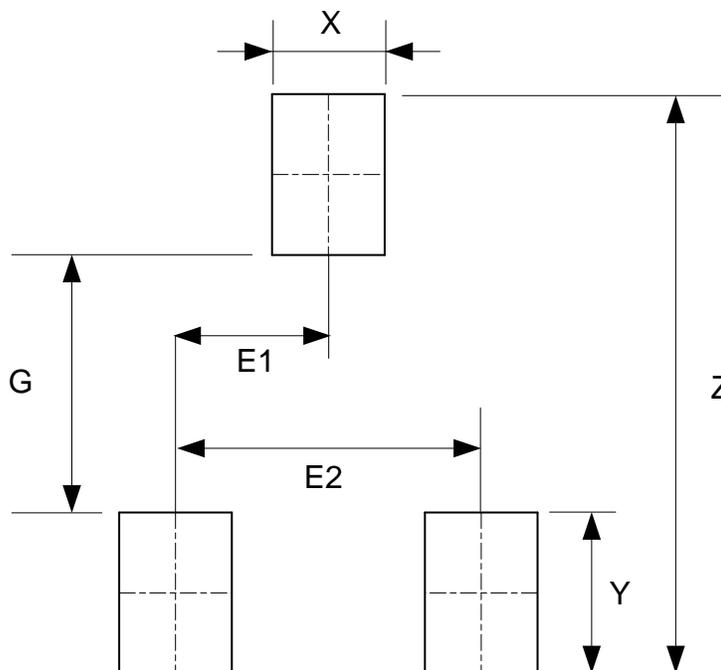
(1) Package Type: SOT-23



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)
Value	2.900/0.114	1.100/0.043	0.800/0.031	0.900/0.035	0.950/0.037

Suggested Pad Layout (Cont.)

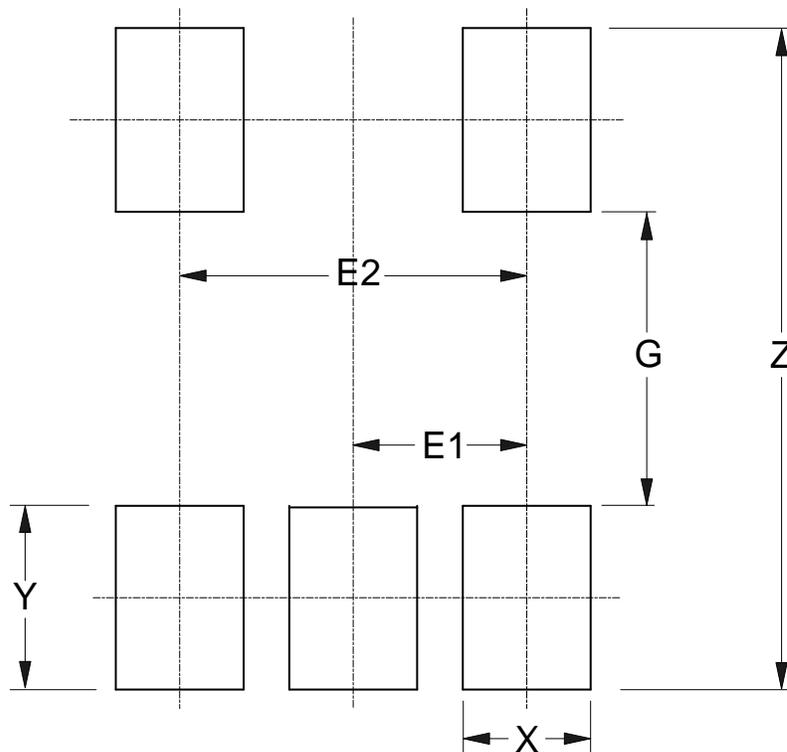
(2) Package Type: SOT-23-3



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E1 (mm)/(inch)	E2 (mm)/(inch)
Value	3.600/0.142	1.600/0.063	0.700/0.028	1.000/0.039	0.950/0.037	1.900/0.075

Suggested Pad Layout (Cont.)

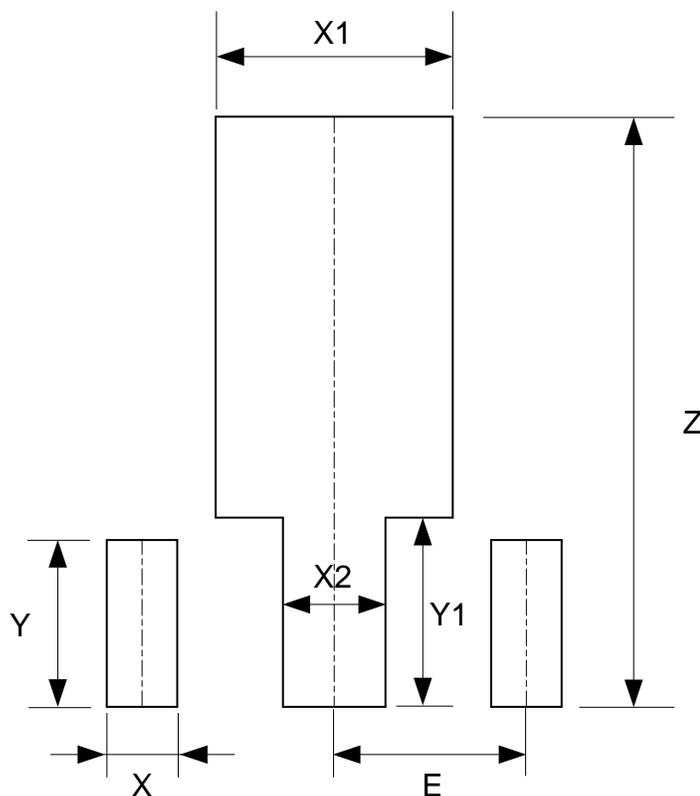
(3) Package Type: SOT-23-5



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E1 (mm)/(inch)	E2 (mm)/(inch)
Value	3.600/0.142	1.600/0.063	0.700/0.028	1.000/0.039	0.950/0.037	1.900/0.075

Suggested Pad Layout (Cont.)

(4) Package Type: SOT-89



Dimensions	Z (mm)/(inch)	X (mm)/(inch)	X1 (mm)/(inch)	X2 (mm)/(inch)	Y (mm)/(inch)	Y1 (mm)/(inch)	E (mm)/(inch)
Value	4.600/0.181	0.550/0.022	1.850/0.073	0.800/0.031	1.300/0.051	1.475/0.058	1.500/0.059