100 mA High-Voltage LDO Regulator

1 FEATURES

- **Input Voltage Range: 4.5 V to 60 V**
  - Up to 70 V Transient
- **Output Voltage Range:**
  - Fixed Option: 3.3 V and 5.0 V
- **Low I_Q: 32 µA (TYP)**
- **High PSRR: 70 dB at 100 Hz**
- **Up to 100mA Load Current**
- **Low Dropout Voltage**
- **Low Temperature Coefficient**
- **Short Circuit Protection is Typical 15mA**
- **Output Voltage Accuracy: ±1%**
- **SOT23-3, SOT23-5, and SOT-223 Packages**

2 APPLICATIONS

- **Smart Power Network Equipment**
- **Portable Power Tools**
- **BMS Systems**
- **Motor Control System/Industrial Control System**
- **Power Meter/Instrument**
- **White Goods**
- **Vehicle-Mounted System**
- **Battery-Powered Equipment**
- **Automotive Head Unit**
- **Security Equipment**
- **Communication Equipment**

3 DESCRIPTIONS

The RS3009 devices are high-voltage, low dropout (LDO) regulators, capable of generating 100 mA output current. The input voltage ranges of 4.5V to 60V makes it suitable in 12V to 48V power rails and in high-voltage battery packs.

A low UVLO at shutdown of 3.7V makes it adequate for cold cranking conditions in automotive applications.

The RS3009 comes in two standard fixed output voltage versions: 3.3V and 5.0V. The regulator output is stable with 2.2 µF ceramic capacitors. The device is protected from short-circuit events by the current foldback function and from overheating by means of thermal shutdown protection.

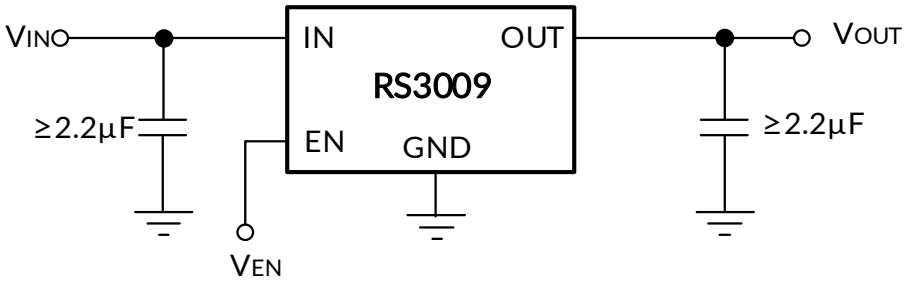
While in shutdown, the quiescent current drops to 2.5 µA (V_{IN}=60V), allowing for lower, overall power consumption. The device itself has a ground current of 120 µA typical, while delivering maximum output current of 100 mA.

Device Information (1)

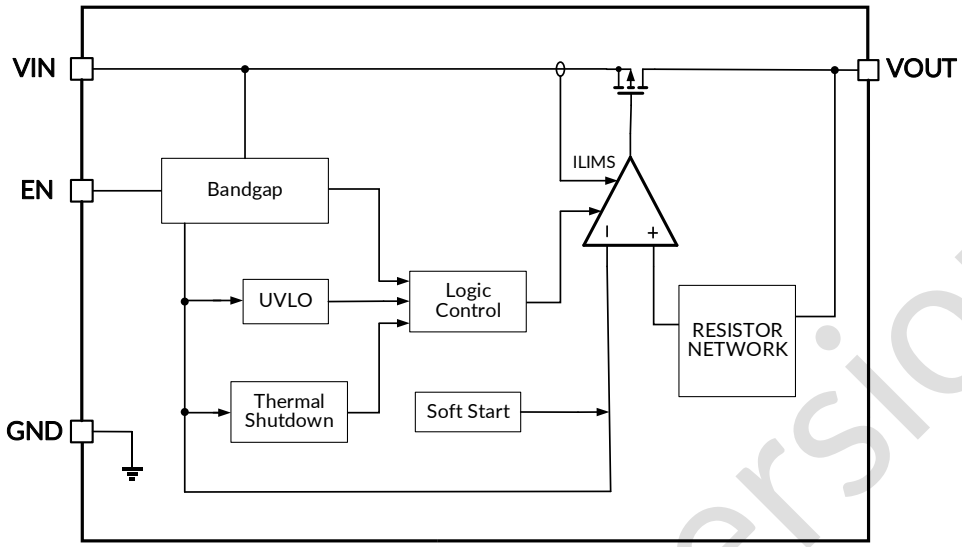
PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS3009	SOT23-3	1.60mm×2.92mm
	SOT23-5	1.60mm×2.92mm
	SOT-223	3.50mm×7.00mm

(1) For all available packages, see the orderable addendum at the next page of the data sheet.

4 TYPICAL APPLICATION SCHEMATIC



5 FUNCTIONAL BLOCK DIAGRAM



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6 REVISION HISTORY

Note: Page numbers for previous revisions may different from page numbers in the current version.

VERSION	Change Date	Change Item
A.0	2024/11/25	Preliminary version completed

7 PACKAGE/ORDERING INFORMATION (1)

PRODUCT	ORDERING NUMBER	V_{OUT}(V)	V_{OUT} Accuracy	PACKAGE LEAD	PACKAGE MARKING (2)	MSL (3)	PACKAGE OPTION
RS3009-3.3	RS3009-3.3XF3-G	3.3	±1%	SOT23-3	SG33	MSL1	Tape and Reel, 3000
	RS3009-3.3XF5-G	3.3	±1%	SOT23-5	SG33	MSL1	Tape and Reel, 3000
	RS3009-3.3XD3-G	3.3	±1%	SOT-223	SG33	MSL1	Tape and Reel, 2500
RS3009-5.0	RS3009-5.0XF3-G	5.0	±1%	SOT23-3	SG50	MSL1	Tape and Reel, 3000
	RS3009-5.0XF5-G	5.0	±1%	SOT23-5	SG50	MSL1	Tape and Reel, 3000
	RS3009-5.0XD3-G	5.0	±1%	SOT-223	SG50	MSL1	Tape and Reel, 2500

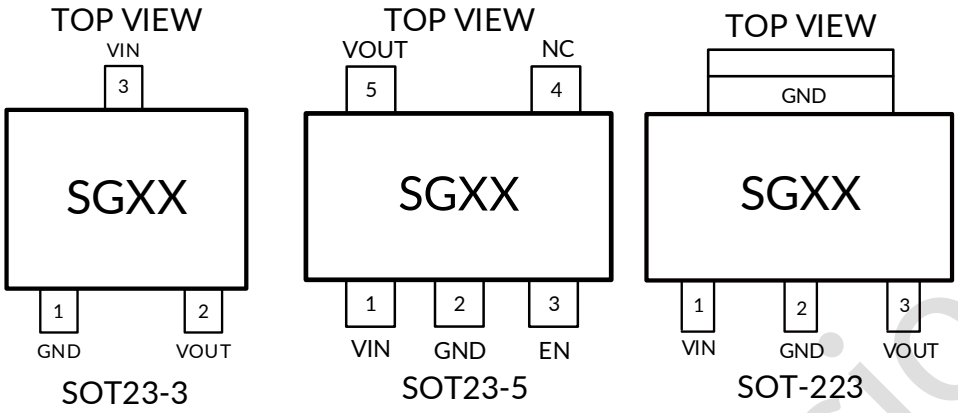
NOTE:

(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

(2) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

(3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F. Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

8 PIN CONFIGURATION AND FUNCTIONS



NOTE: XX indicate Output Voltage, xx indicate Date Code
For example: SG33 (V_{OUT}=3.3V)

PIN DESCRIPTION

NAME	PIN			FUNCTION
	SOT23-3	SOT23-5	SOT-223	
GND	1	2	2	Ground
VOUT	2	5	3	Regulated output voltage. Connect a minimum 2.2μF low-ESR capacitor to this pin.
VIN	3	1	1	Input voltage supply. Must be closely decoupled to GND with a 2.2μF or greater capacitor.
EN	/	3	/	Enable input. A low voltage (< V_{IL}) on this pin turns the regulator off and discharges the output pin to GND through an internal pulldown resistor. A high voltage (> V_{IH}) on this pin enables the regulator output. Do not leave floating.
NC	/	4	/	No internal connection(should either be left floating or connected to ground)

9 SPECIFICATIONS

9.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1) (2)

			MIN	MAX	UNIT
V_{IN}	Input voltage		-0.3	70	V
V_{EN}	Voltage on EN		-0.3	V_{IN}	V
V_{OUT}	Voltage on V_{OUT}		-0.3	6.6	V
	Output Short-Circuit Duration		Unlimited		
P_D	Continuous Power Dissipation (3)		Internally limited		W
θ_{JA}	Package Thermal Impedance (4)	SOT23-3		TBD	°C/W
		SOT23-5		150	
		SOT-223		68	
T_{stg}	Storage Temperature Range		-55	180	°C
T_J	PN Junction Temperature (5)		-40	165	°C

(1) Stresses beyond 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-rated conditions for extended periods may affect device reliability.
(2) All voltages are with respect to the GND pin.
(3) Internal thermal shutdown circuitry protects the device from permanent damage. The actual chip output current is subject to the input-output voltage difference, ambient temperature and PCB heat dissipation design.
(4) The package thermal impedance is calculated in accordance with JESD-51.
(5) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.

9.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM), ANSI/ESDA/JEDEC JS001-2024	±2000	V
		Charge Device Model (CDM), ANSI/ESDA/JEDEC JS-002-2022	±1000	V

ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_{IN}	Input Voltage Range on V_{IN}	4.5	60	V
V_{OUT}	Output Voltage	3.3	5	V
I_{OUT}	Output Current Range on I_{OUT}	0	100	mA
C_{OUT}	Output Capacitor	2.2	22	μF
T_J	Junction Temperature	-40	150	°C

9.4 Electrical Characteristics

Over operating temperature range (−40°C ≤ T_J ≤ 150°C), V_{IN} = V_{OUT}nom + 1.2V [1], V_{OUT}=5V, I_{OUT}=1mA, C_{IN} = C_{OUT} = 2.2μF, unless otherwise noted. Typical values are at T_A = 25°C.

PARAMETER	SYMBOL	CONDITIONS		MIN[2]	TYP[3]	MAX[2]	UNIT
POWER SUPPLY AND CURRENTS							
Input Voltage [1]	V_{IN}			4.5		60	V
Under Voltage Lockout	UVLO	VIN rising			3.7		V
Hysteresis	V_{HYS}	VIN falling			100		mV
Quiescent Current	I_Q	V_{EN} = 2V, I_{OUT} = 0mA			32		μA
Ground Pin Current	I_{GND}	V_{EN} = 2V, I_{OUT} = 100mA			120		μA
Shutdown Current	I_{SD}	V_{EN} = 0V, V_{IN}=60V			2.5	8	μA
OUTPUT VOLTAGE							
Output Voltage Range	V_{OUT}			3.3		5.0	V
DC Output Accuracy [1]	ΔV_{OUT}	T_J = 25°C, I_{OUT} = 1mA			±1		%
Line Regulation [1]	$\Delta V_{OUT(\Delta VIN)}$	V_{IN} = V_{OUT} + 1.2V to 60V, I_{OUT} = 1mA			0.002		%/V
Load Regulation [1]	$\Delta V_{OUT(\Delta IOUT)}$	V_{IN} =V_{OUT} + 1.2V, I_{OUT} = 1mA to 100mA			2		mV
Output Voltage Temperature Coefficient [4]	$\frac{\Delta V_{OUT}}{\Delta T_A \times V_{OUT}}$	I_{OUT} = 1mA, T_J = -40°C ~ 85°C			40		ppm/°C
		I_{OUT} = 1mA, T_J = -40°C ~ 125°C			30		
		I_{OUT} = 1mA, T_J = -40°C ~ 150°C			50		
Maximum output current [5]	I_{OUTMAX}			100			mA
DROPOUT VOLTAGE							
Dropout Voltage [6]	V_{DO}	I_{OUT} = 100mA	V_{OUT} = 3.3V		TBD		mV
			V_{OUT} = 5.0V		240		
POWER SUPPLY REJECTION RATIO AND NOISE							
Power Supply Rejection Ratio [7]	PSRR	V_{IN}=14V, V_{OUT} = 5V, I_{OUT} = 10mA	f = 100Hz		70		dB
			f = 1KHz		63		dB
			f = 10KHz		50		dB
			f = 100KHz		55		dB
Output Noise Voltage [7]	V_N	BW = 10Hz ~ 100KHz, V_{OUT} = 5V, I_{OUT} = 10mA			400		μV_{RMS}
ENABLE AND STARTUP TIME							
EN Input Logic High Voltage	V_{IH}	V_{IN} = 4.5V to 60V, EN rising		2			V
EN Input Logic Low Voltage	V_{IL}	V_{IN} = 4.5V to 60V, EN falling				0.8	V
EN Input Leakage Current	I_{EN}	V_{IN} = 60V, V_{EN} = 0V				0.1	μA
		V_{IN} = 60V, V_{EN} = 60V				1	μA
Output Discharge FET Rdson	R_{DIS}	V_{IN} = 14V, V_{EN}<V_{IL} (output disable)			65		Ω
Output Voltage Delay Time	T_D	From V_{EN} > V_{IH} to V_{OUT} = 10% of V_{OUT}nom			180		μs
Output Rise Time	T_R	From V_{OUT} = 10% to 90% of V_{OUT}nom			250		μs
PROTECTIONS							
Over Current Limit	I_{LMT}	V_{IN} = 14V, V_{OUT} = 0.8*V_{OUT}nom			255		mA
Short-Circuit Current Limit	I_{SC}	V_{IN} = 14V, V_{OUT} = 0V			15		mA
Thermal Shutdown Threshold [7]	T_{TSD}	T_J rising			165		°C
Thermal shutdown hysteresis [7]	T_{HYS}	T_J falling from shutdown			20		°C

(1) Minimum V_{IN} = V_{OUT} + V_{DO} or 4.5V, whichever is greater.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.
(4) Output voltage temperature coefficient is defined as the worst-case voltage change divided by the total temperature range.
(5) Maximum output current is affected by the PCB layout, size of metal trace, the thermal conduction path between metal layers, ambient temperature and the other environment factors of system. Attention should be paid to the dropout voltage when V_{IN} < V_{OUT} + V_{DROP}.
(6) V_{DROP} FT test method: test the V_{OUT} voltage at V_{SET} +$V_{DROPMAX}$ with output current.
(7) Guaranteed by design and characterization, not a FT item.

9.5 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

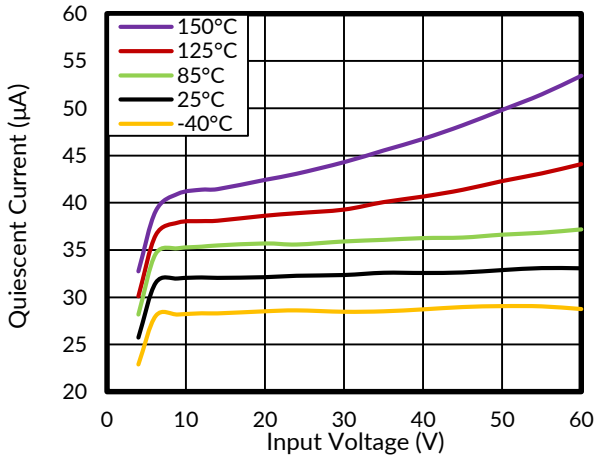


Figure 1. Quiescent Current vs Input Voltage

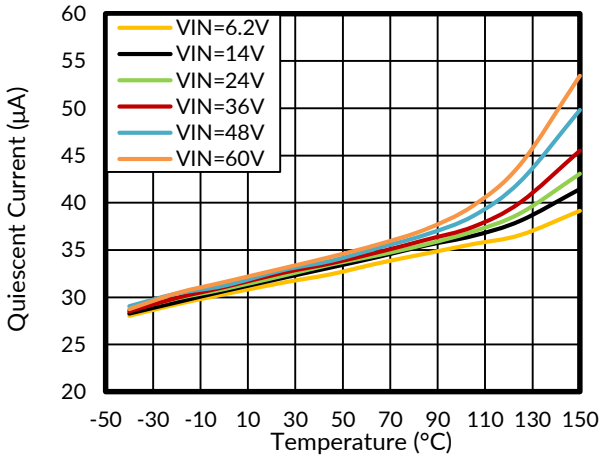


Figure 2. Quiescent Current vs Temperature

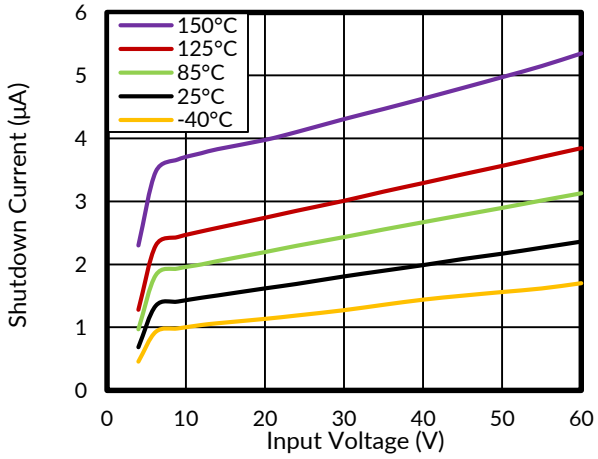


Figure 3. Shutdown Current vs Input Voltage

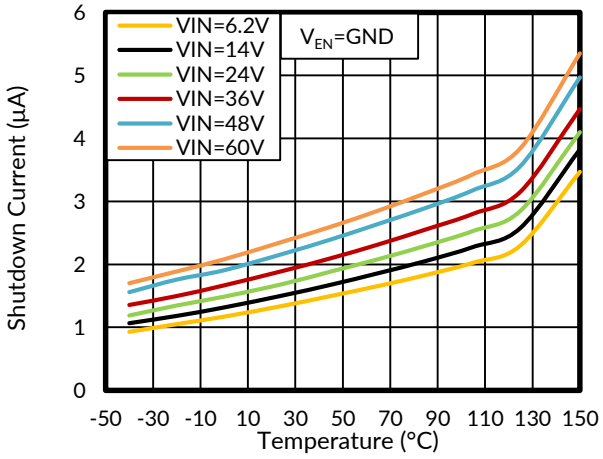


Figure 4. Shutdown Current vs Junction Temperature

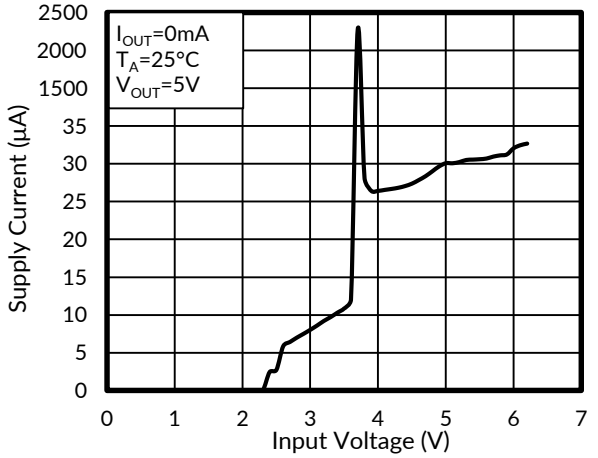


Figure 5. Supply Current vs Input Voltage

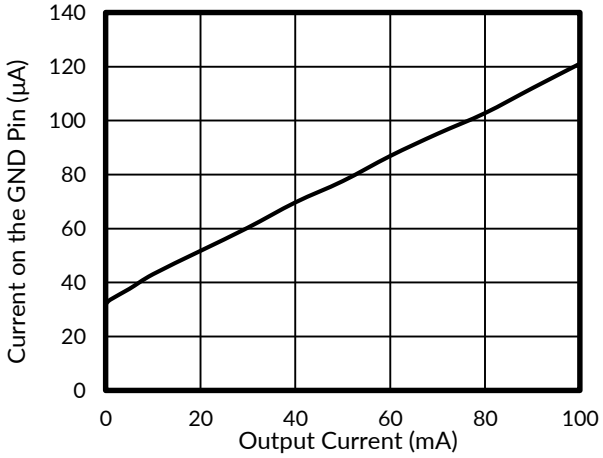


Figure 6. Ground Pin Current vs Output Current

Typical Characteristics

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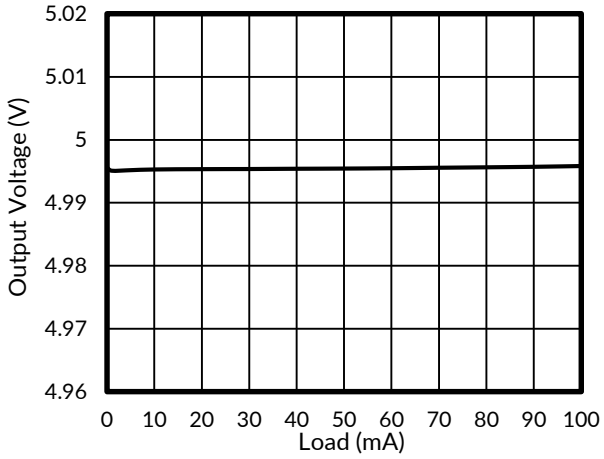

Figure 7. Load Regulation

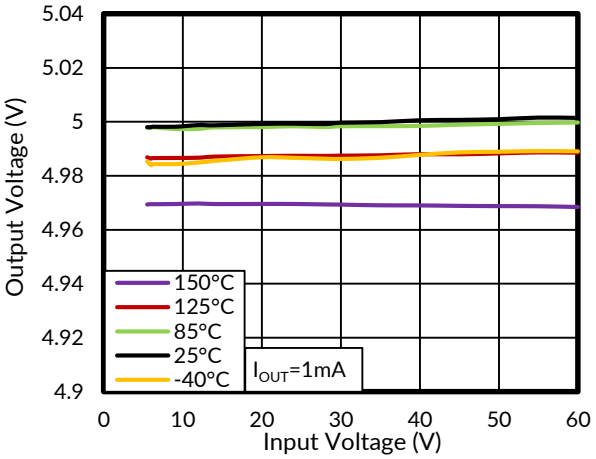

Figure 8. Line Regulation

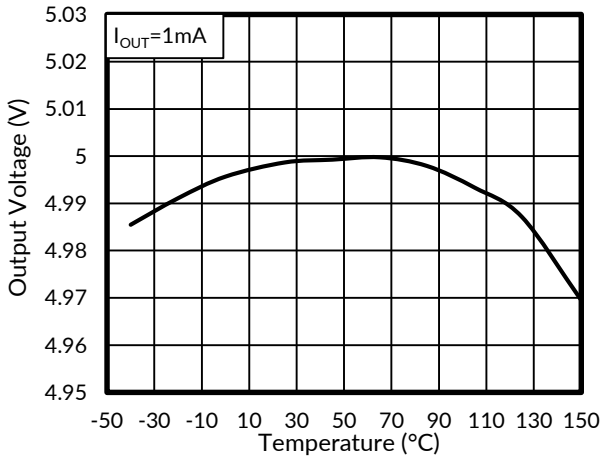

Figure 9. Output Voltage vs Junction Temperature

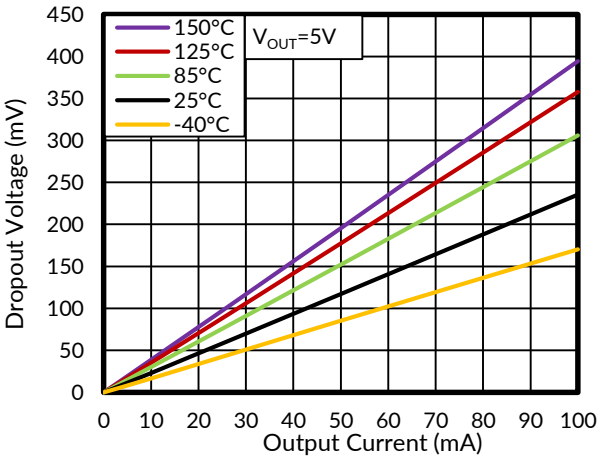

Figure 10. Dropout Voltage vs Output Current

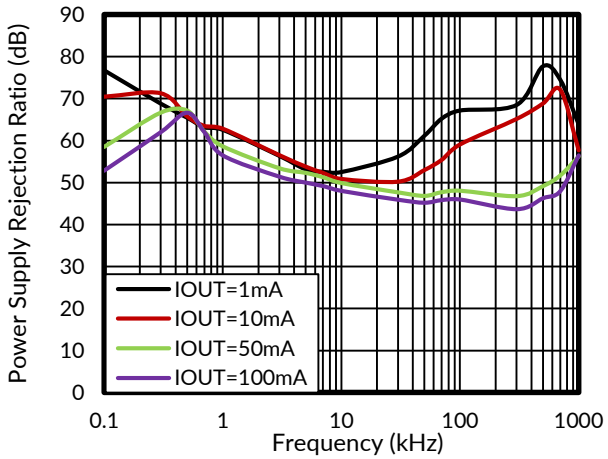

Figure 11. Power Supply Rejection Ratio vs Frequency

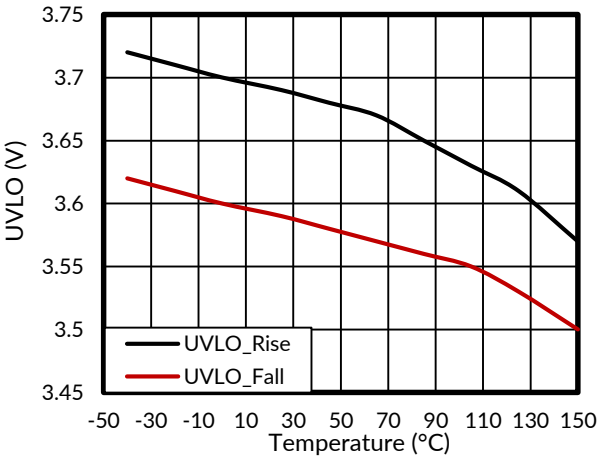

Figure 12. UVLO vs Junction Temperature

Typical Characteristics

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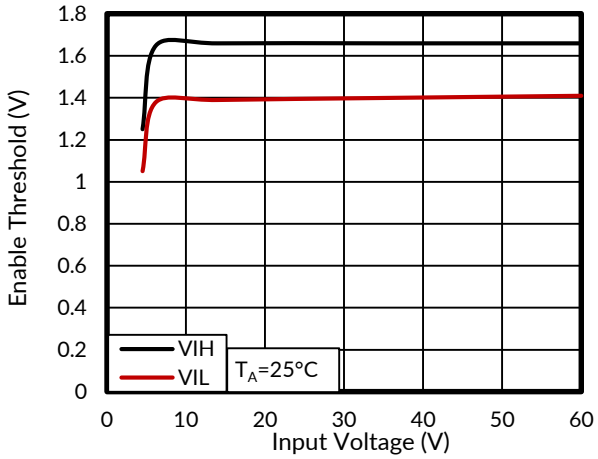


Figure 13. Enable Threshold vs Input Voltage

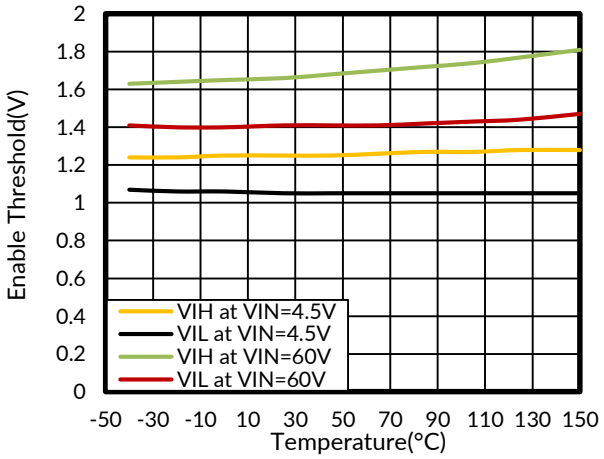


Figure 14. Enable Threshold vs Junction Temperature

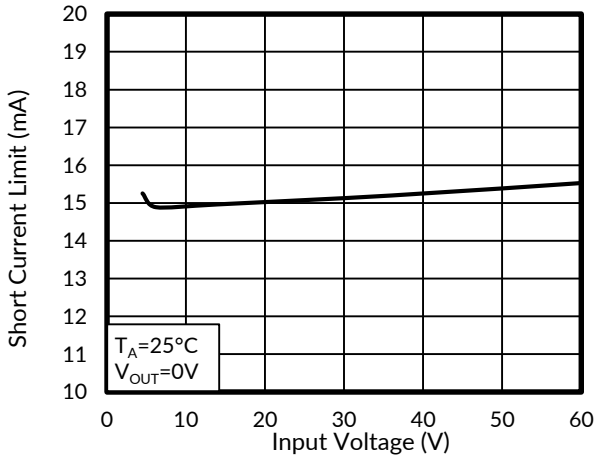


Figure 15. Short Current Limit vs Input Voltage

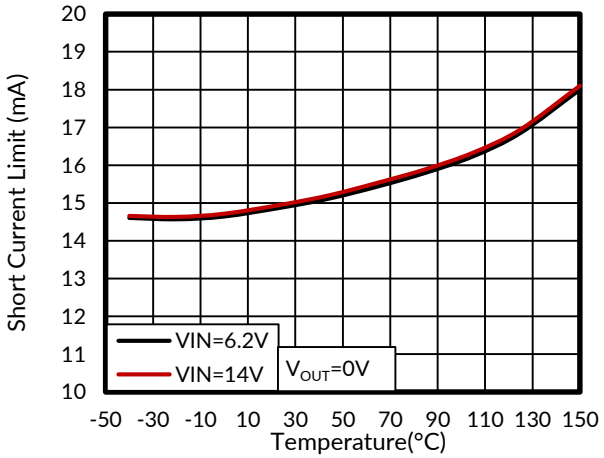


Figure 16. Short Current Limit vs Temperature

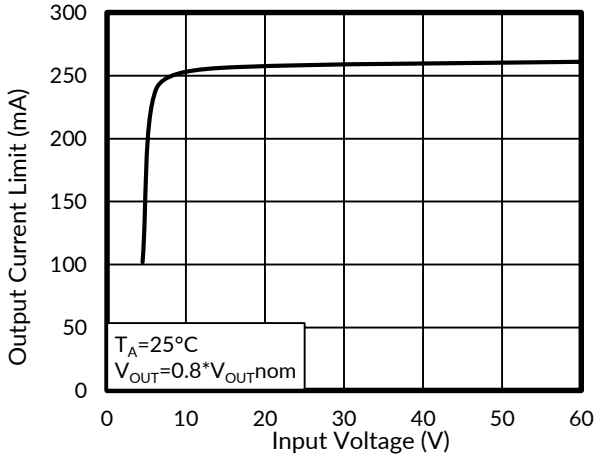


Figure 17. Output Current Limit vs Input Voltage

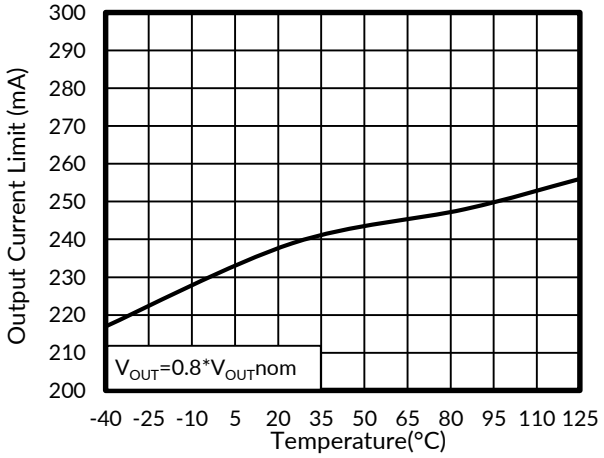


Figure 18. Output Current Limit vs Temperature

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

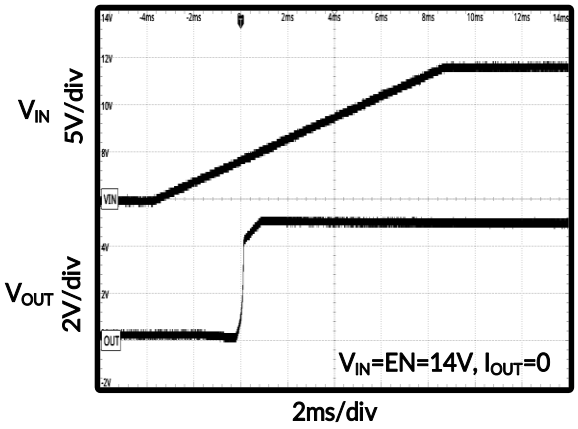


Figure 19. Power On

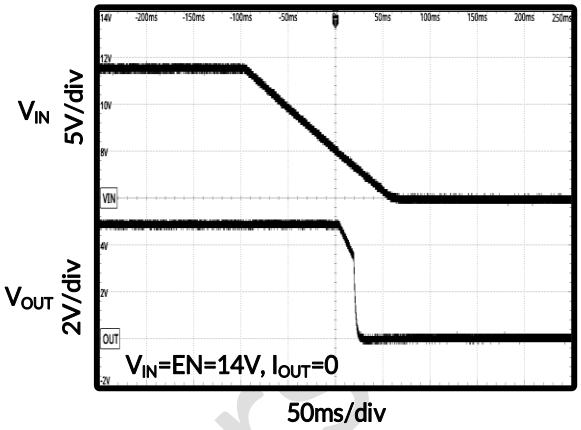


Figure 20. Power Off

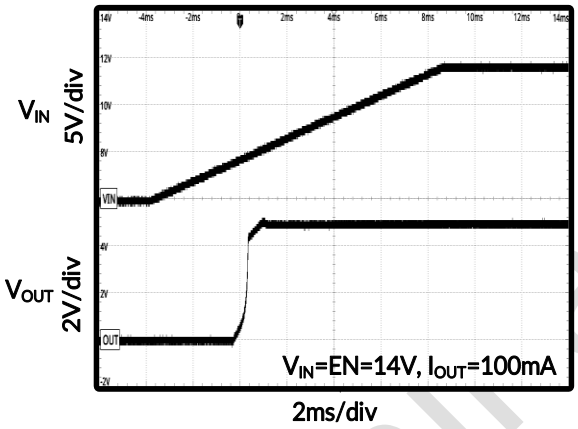


Figure 21. Power On

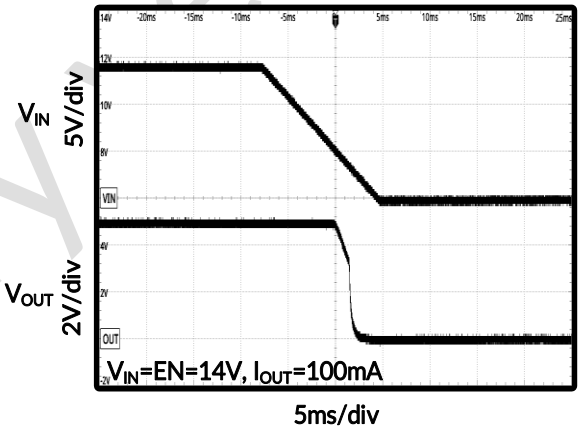


Figure 22. Power Off

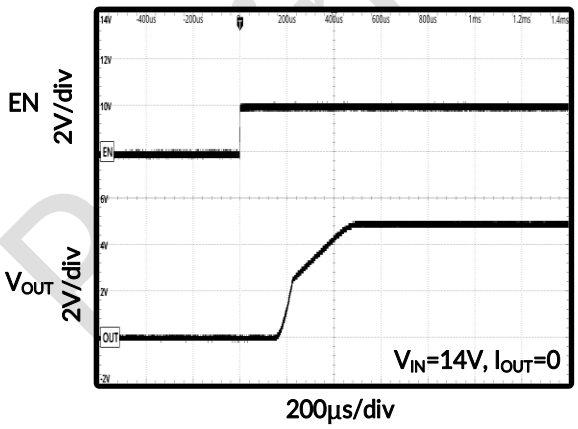


Figure 23. Turn On

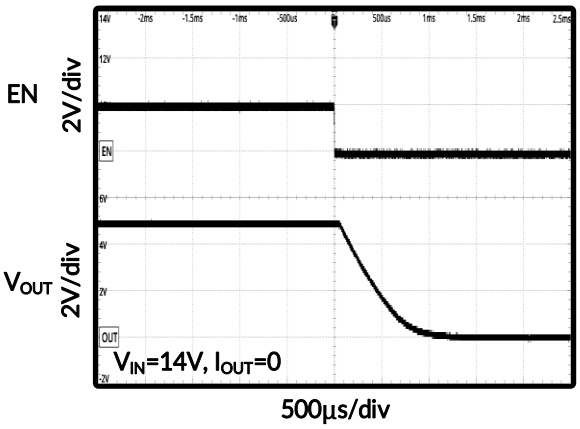


Figure 24. Turn Off

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

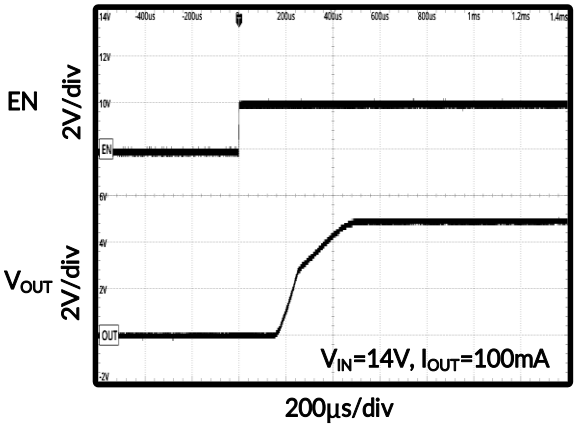


Figure 25. Turn On

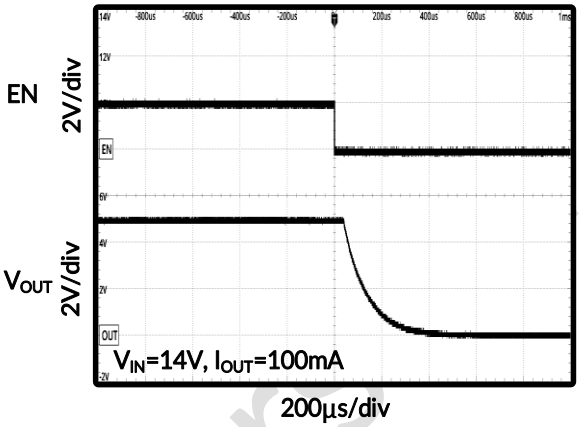


Figure 26. Turn Off

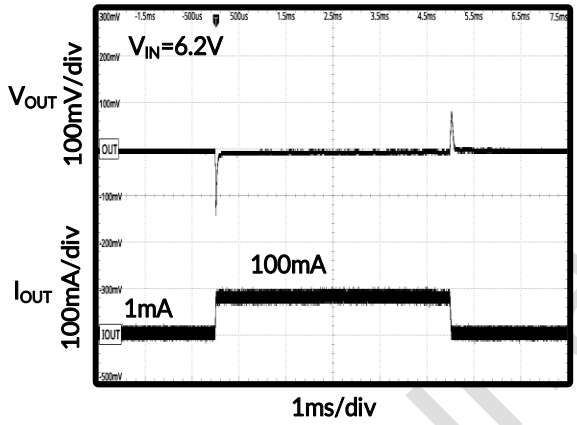


Figure 27. Load Transient Response

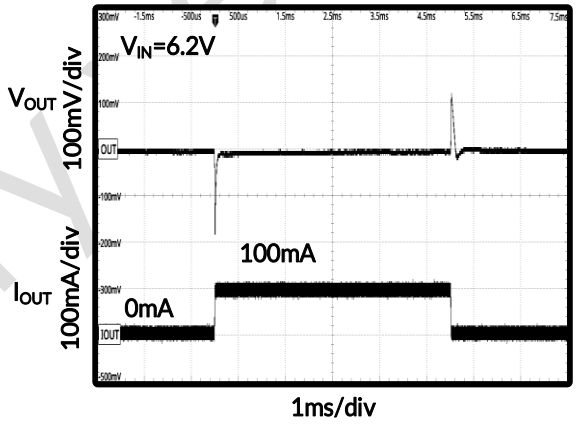


Figure 28. Load Transient Response

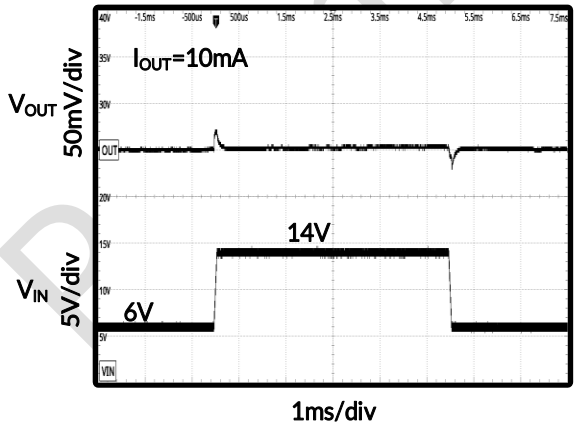


Figure 29. Line Transient Response

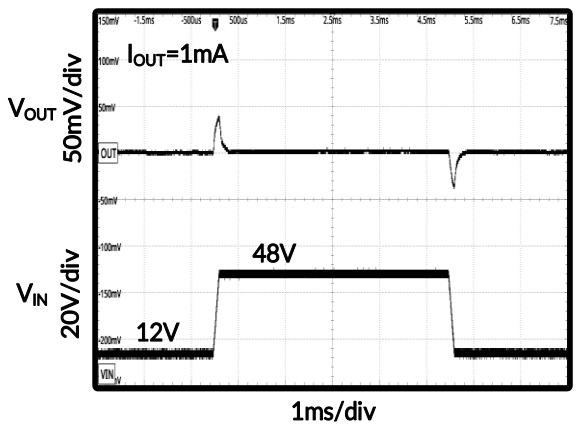


Figure 30. Line Transient Response

10 DETAILED DESCRIPTION

10.1 Overview

The RS3009 devices are high-voltage, low dropout (LDO) regulators, capable of generating 100 mA output current. The input voltage ranges of 4.5V to 60V makes it suitable in 12V to 48V power rails and in high-voltage battery packs.

A low UVLO at shutdown of 3.7V makes it adequate for cold cranking conditions in automotive applications.

The RS3009 comes in two standard fixed output voltage versions: 3.3V and 5.0V. The regulator output is stable with 2.2 µF ceramic capacitors. The device is protected from short-circuit events by the current foldback function and from overheating by means of thermal shutdown protection.

While in shutdown, the quiescent current drops to 2.5 µA (VIN=60V), allowing for lower, overall power consumption. The device itself has a ground current of 120 µA typical, while delivering maximum output current of 100 mA.

10.2 Under Voltage Lockout (UVLO)

The RS3009 family of devices uses an under voltage lockout circuit to keep the output shut off until the internal circuitry is operating properly.

10.3 Shutdown

Enable input. A low voltage (< V_{IL}) on this pin turns the regulator off and discharges the output pin to GND through an internal pulldown resistor. A high voltage (> V_{IH}) on this pin enables the regulator output. The EN pin can be connected to the VIN pin if not used. Do not leave floating.

10.4 Output Automatic Discharge

The RS3009 output employs an internal 65Ω (typical) pulldown resistance to discharge the output when the EN pin is low, and the device is disabled.

10.5 Thermal Overload Protection (T_{SD})

Thermal shutdown disables the output when the junction temperature rises to approximately 165°C which allows the device to cool. When the junction temperature cools to approximately 145°C, the output circuitry enables.

Based on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This thermal cycling limits the dissipation of the regulator and protects it from damage as a result of overheating.

The thermal shutdown circuitry of the RS3009 has been designed to protect against temporary thermal overload conditions. The T_{SD} circuitry was not intended to replace proper heat-sinking. Continuously running the RS3009 device into thermal shutdown may degrade device reliability.

10.6 Disabled

The device is disabled under the following conditions:

- The input voltage is less than the UVLO threshold minus V_{HYS}, or has not yet exceeded the UVLO threshold.
- The enable voltage is less than the enable falling threshold voltage or has not yet exceeded the enable rising threshold.
- The device junction temperature is greater than the thermal shutdown temperature.

10.7 Current-Limit Protection

The RS3009 monitors the current flowing through the output PMOS and limits the maximum current to prevent load and RS3009 from damages during current overload conditions.

10.8 Short Current-Limit Protection

The short current-limit function reduces the current-limit level down to 15mA(typical) during short circuit conditions.

10.9 Input and Output Capacitor Requirements

Although an input capacitor is not required for stability, connecting a 2.2μF low-equivalent series resistance (ESR) capacitor across the input supply near the regulator is good analog design practice. This capacitor counteracts reactive input sources and improves transient response and ripple rejection. A higher value capacitor can be necessary if large, fast, rise-time load transients are anticipated or if the device is located several inches from the power source.

The RS3009 family of devices is designed to be stable with standard ceramic output capacitors of values 2.2μF or larger. X5R- and X7R-type capacitors are best because they have minimal variation in value and ESR over temperature.

11 POWER SUPPLY RECOMMENDATIONS

The device is designed to operate from an input voltage supply range between 4.5V and 60V. The input voltage range must provide adequate headroom in order for the device to have a regulated output. This input supply must be well regulated. If the input supply is noisy, additional input capacitors with low ESR can help improve output noise.

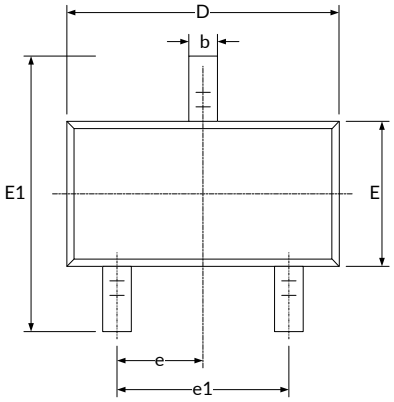
12 LAYOUT

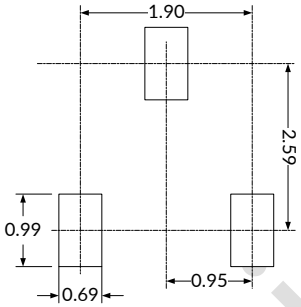
For best overall performance, place all circuit components on the same side of the circuit board and as near as practical to the respective LDO pin connections. Place ground return connections to the input and output capacitor, and to the LDO ground pin as close to each other as possible, connected by a wide, component-side, copper surface. The use of vias and long traces to create LDO component connections is strongly discouraged and negatively affects system performance. This grounding and layout scheme minimizes inductive parasitics, and thereby reduces load-current transients, minimizes noise, and increases circuit stability. A ground reference plane is also recommended and is either embedded in the printed circuit board (PCB) itself or located on the bottom side of the PCB opposite the components. This reference plane serves to assure accuracy of the output voltage, shields the LDO from noise, and behaves similar to a thermal plane to spread (or sink) heat from the LDO device when connected to the exposed thermal pad. In most applications, this ground plane is necessary to meet thermal requirements.

To improve ac performance (such as PSRR, output noise, and transient response), designing the board with separate ground planes for V_{IN} and V_{OUT} is recommended, with each ground plane connected only at the GND pin of the device. In addition, the ground connection for the bypass capacitor must connect directly to the GND pin of the device.

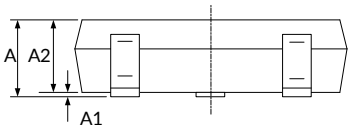
13 PACKAGE OUTLINE DIMENSIONS

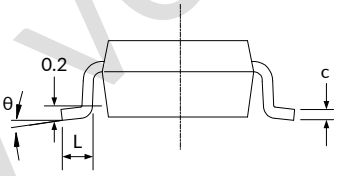
SOT23-3 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



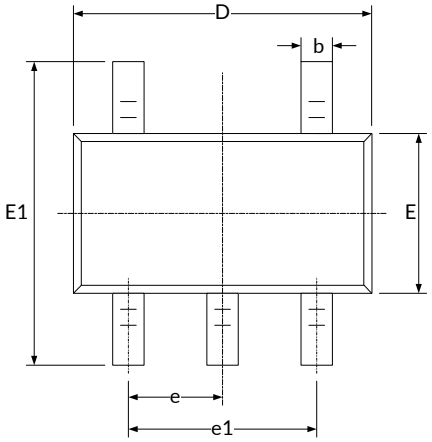


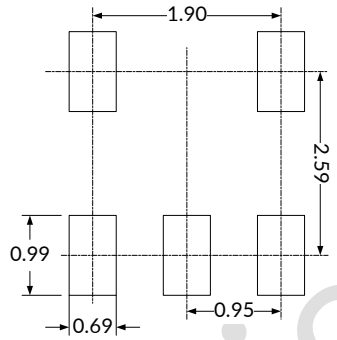
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D (1)	2.820	3.020	0.111	0.119
E (1)	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC) (2)		0.037(BSC) (2)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

NOTE:

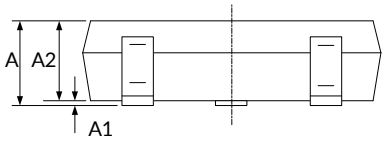
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

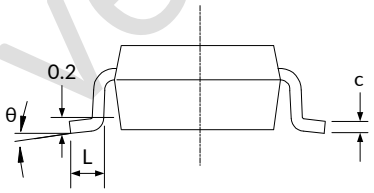
SOT23-5 (3)





RECOMMENDED LAND PATTERN (Unit: mm)



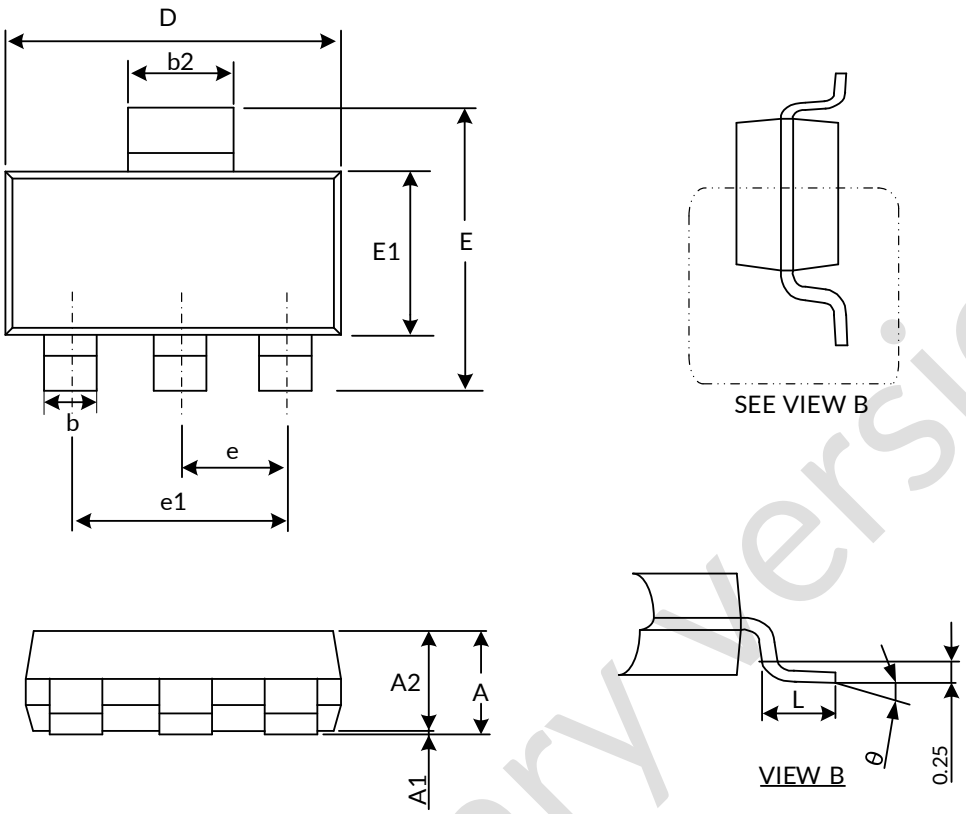


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D (1)	2.820	3.020	0.111	0.119
E (1)	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC) (2)		0.037(BSC) (2)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

NOTE:

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

SOT-223 (3)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	-	1.800	-	0.071
A1	0.02	0.10	0.001	0.004
A2	1.55	1.65	0.061	0.065
b	0.66	0.84	0.026	0.033
b2	2.90	3.10	0.114	0.122
D (1)	6.30	6.70	0.248	0.263
E	6.70	7.30	0.263	0.287
E1 (1)	3.30	3.70	0.130	0.145
e	2.30 BSC (2)		0.090 BSC (2)	
e1	4.60 BSC (2)		0.181 BSC (2)	
L	0.90	-	0.035	-

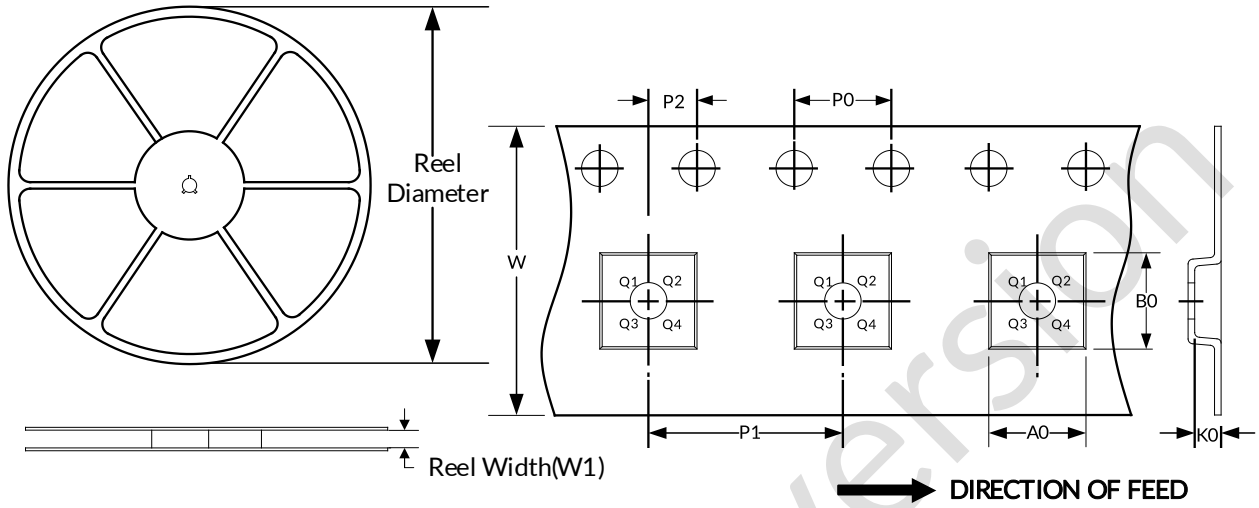
NOTE:

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

14 TAPE AND REEL INFORMATION

REEL DIMENSIONS

TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT23-3	7”	9.0	3.20	3.30	1.30	4.0	4.0	2.0	8.0	Q3
SOT23-5	7”	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOT-223	13”	12.4	6.765	7.335	1.88	4.0	8.0	2.0	12.0	Q3

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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