

Product Overview

NSR31 series is 150 mA low-dropout linear regulator designed for battery-direct-connection automotive applications. Wide supply voltage range from 3 V to 40 V makes NSR31 series a good fit for severe operating conditions including load dump, cold cranking and start-stop.

With 5 μ A quiescent current at light loads, NSR31 series is quite suitable for always-on automotive applications where standby power consumption is strictly restricted.

With integrated compensation implementation, NSR31 series can be stable with low-ESR (1 m Ω to 3 Ω) ceramic output capacitor, ranging from 2.2 μ F to 100 μ F.

The device features integrated short-circuit-to-GND and thermal shutdown protections. This device operates in ambient temperatures from -40 $^{\circ}$ C to 125 $^{\circ}$ C.

Key Features

- AEC-Q100 Qualified (Grade 1) for Automotive Applications
- 3 V to 40 V Wide Supply Voltage Range
- Output Current Range: Up to 150 mA
- Low Quiescent Current:
 - 5 μ A (Typ.) at No Load
- Low Dropout Voltage: 620 mV @ 150 mA / 5 V Vout
- Low ESR Ceramic Output Stability Capacitor (2.2 μ F – 100 μ F)
- Integrated Fault Protection:
 - Short-Circuit-to-GND protection
 - Thermal Shutdown
- RoHs & REACH compliance

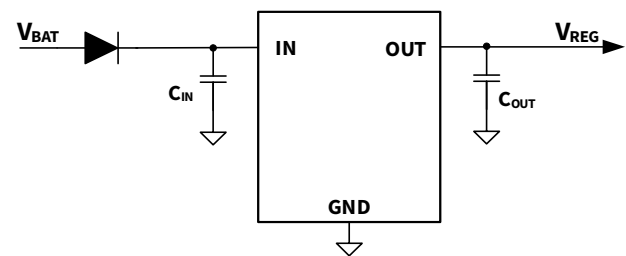
Applications

- Infotainment
- Power Train
- Cluster
- Body Control Module
- Battery Connected Always-On System

Device Information

Part Number	Output Voltage	Package
NSR31025-Q1	2.5 V	SOT-223, SOT-23-5L, DFN-8
NSR31033-Q1	3.3 V	SOT-223, SOT-23-5L, DFN-8
NSR31050-Q1	5 V	SOT-223, SOT-23-5L, DFN-8
NSR31133-Q1	3.3 V	SOT-23-5L
NSR31150-Q1	5 V	SOT-23-5L

Typical Application



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1. Pin Configuration and Functions

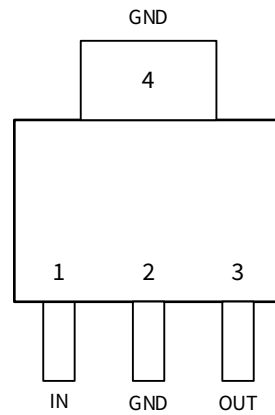


Figure 1 SOT-223 Pin-out (Top View)

PIN NO.	SYMBOL	FUNCTION
1	IN	Power supply pin.
2, 4	GND	Ground reference.
3	OUT	Regulated output voltage pin.

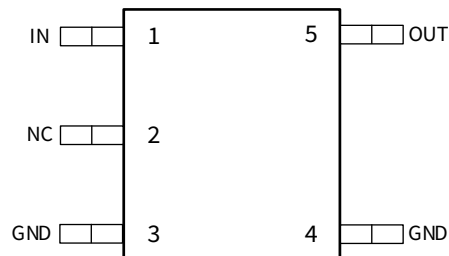


Figure 2 SOT-23-5L (NSR310 Version) Pin-out (Top View)

PIN NO.	SYMBOL	FUNCTION
1	IN	Power supply pin.
2	NC	Connect to GND or floating only.
3, 4	GND	Ground reference.
5	OUT	Regulated output voltage pin.

NSR31 series

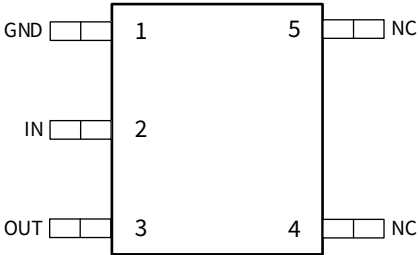


Figure 3 SOT-23-5L (NSR311 Version) Pin-out (Top View)

PIN NO.	SYMBOL	FUNCTION
1	GND	Ground reference.
2	IN	Power supply pin.
3	OUT	Regulated output voltage pin.
4, 5	NC	Not connected.

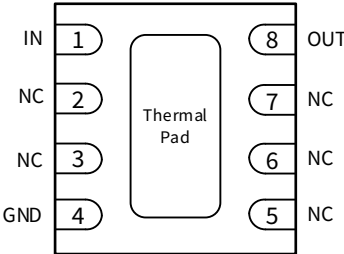


Figure 4 DFN-8 Pin-out (Top View)

PIN NO.	SYMBOL	FUNCTION
1	IN	Power supply pin.
2,3,5,6,7	NC	Not connected.
4	GND	Ground reference.
8	OUT	Regulated output voltage pin.

2. Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit
Input Voltage of IN	V_{IN}	-0.3		42	V
Regulated Output Voltage	V_{OUT}	-0.3		7	V
Junction Temperature	T_J	-40		150	°C
Storage Temperature	T_{stg}	-65		150	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.

(2) All voltage values are with respect to the GND terminal.

3. ESD Ratings

Parameters	Symbol	Value	Unit
V(ESD) Electrostatic discharge	Human-body model (HBM), per AEC-Q100-002-RevD	±2000	V
	Charged device model (CDM), per AEC-Q100-011-RevB	±750	V

4. Recommended Operating Conditions

Parameters	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	V_{IN}	3		40	V
Output Current Range	I_{OUT}			150	mA
Input Capacitor Value	C_{IN}	0.1	1		μF
Output Capacitor Value	C_{OUT}	2.2		100	μF
Output Capacitor ESR Value	ESR	0.001		3	Ω

5. Thermal Information

Parameters	Symbol	SOT-223	SOT-23-5L	DFN-8	Unit
IC Junction-to-Ambient Thermal Resistance	θ_{JA}	63.1	207.9	45.8	°C/W
Junction-to-case thermal resistance	θ_{JC}	46.3	121.9	9.0	°C/W
Junction-to-case characterization parameter	Ψ_{JC}	6.2	15.7	1.1	°C/W

(1) The thermal data is based on the JEDEC standard high-K profile, JESD 51-7, four layer board.

6. Specifications

6.1. Electrical Characteristics

NSR31 series

$V_{IN} = 13.5\text{ V}$, $T_A = -40\text{ }^{\circ}\text{C}$ to $125\text{ }^{\circ}\text{C}$. Unless otherwise noted, typical value is at $T_A = 25\text{ }^{\circ}\text{C}$.

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Supply Voltage and Current						
Supply voltage	V _{IN}	3		40	V	
Supply voltage threshold (Rising)	V _{IN,TH1}	2.97			V	V _{IN} ramps up
Supply voltage threshold (Falling)	V _{IN,TH2}			2.5	V	V _{IN} ramps down
Quiescent current	I _Q		5	8.8	μA	I _{OUT} = 0 mA
			8.2	12.7	μA	I _{OUT} = 0.2 mA
Regulated Output						
Output current limit	I _{OUT_CL}	160			mA	
Dropout voltage ⁽¹⁾	V _{Dropout}		620	1050	mV	V _{OUT} = V _{OUT_SET} X 0.95 I _{OUT} = 150 mA, Fixed 5V version
Output voltage accuracy	V _{OUT_ERR}	-2		2	%	I _{OUT} = 1 mA
Line regulation	V _{Line_Reg}			10	mV	V _{IN} = 6 to 40 V, I _{OUT} = 30 mA
Load regulation / Vout				1.5	%	V _{IN} = 13.5 V, I _{OUT} = 1 mA to 150 mA
Power supply ripple rejection	PSRR		85		dB	I _{OUT} = 10 mA, frequency = 100 Hz, C _{OUT} = 2.2 μF
			70		dB	I _{OUT} = 10 mA, frequency = 1 kHz, C _{OUT} = 2.2 μF
Operating Temperature						
Device thermal shutdown temperature	T _{SD}		175		°C	
Device thermal shutdown temperature hysteresis	T _{HYST}		20		°C	

(1) The dropout voltage refers to the minimum voltage between V_{IN} and V_{OUT} that needed for regulation.

6.2. Typical Performance Characteristics

Unless otherwise noted, typical value is at $V_{IN} = 13.5\text{ V}$.

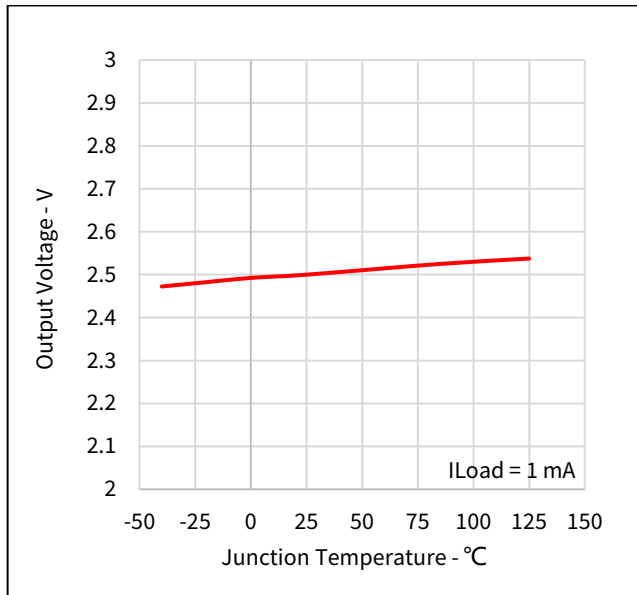


Figure 5 2.5-V Output Voltage vs Junction Temperature

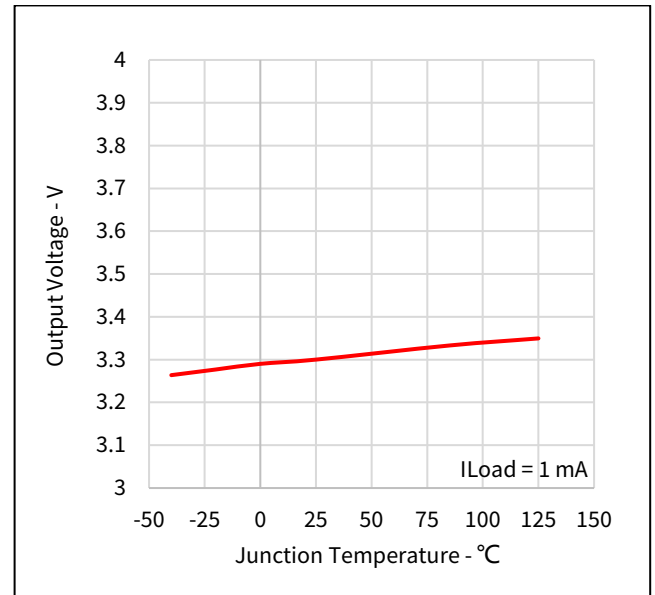


Figure 6 3.3-V Output Voltage vs Junction Temperature

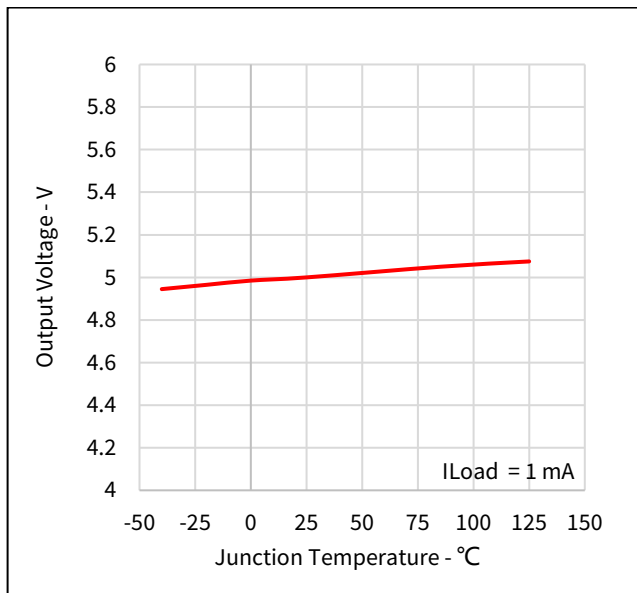


Figure 7 5-V Output Voltage vs Junction Temperature

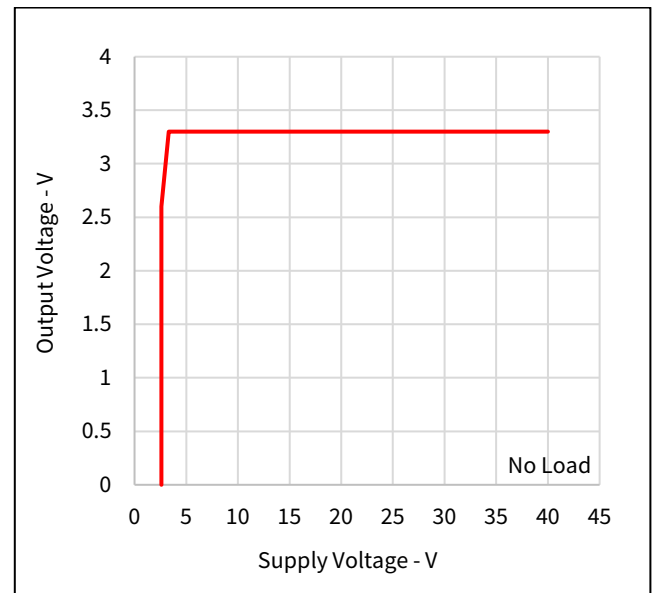


Figure 8 3.3-V Output Voltage vs Supply Voltage

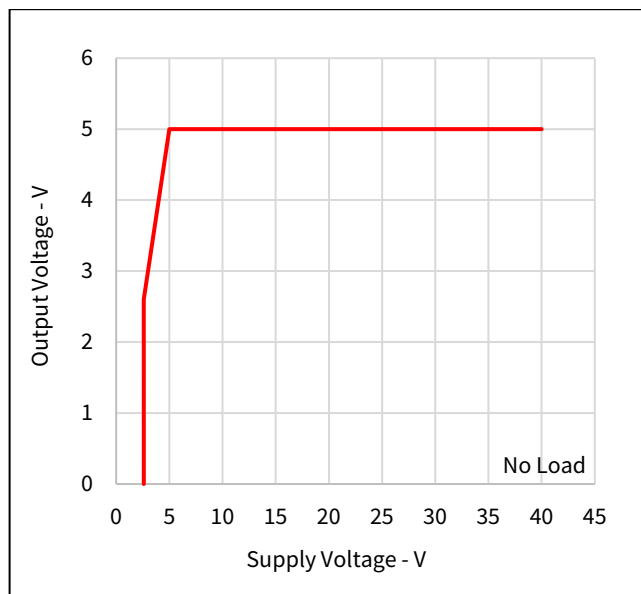


Figure 9 5-V Output Voltage vs Supply Voltage

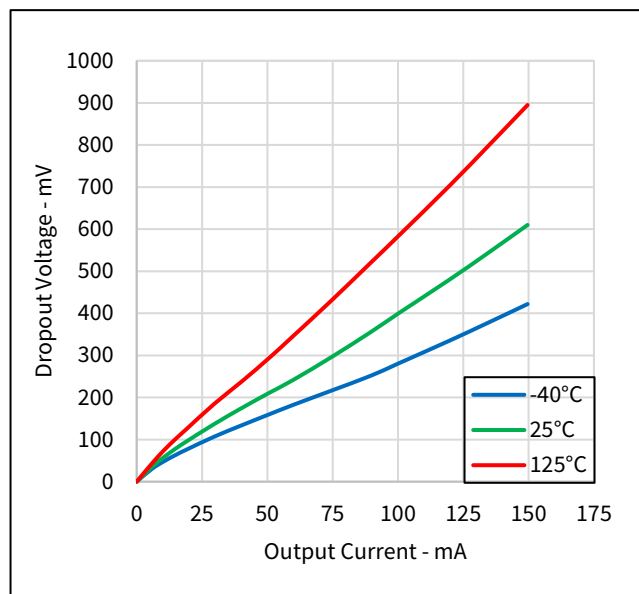


Figure 10 Dropout Voltage vs Output Current

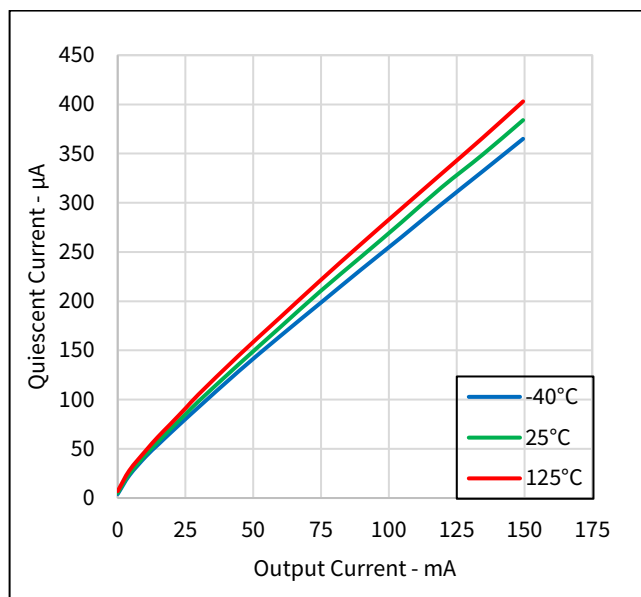


Figure 11 Quiescent Current vs Output Current

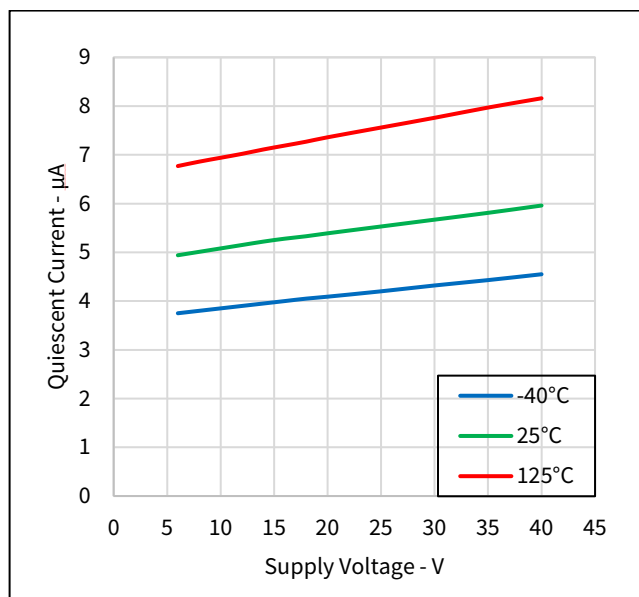


Figure 12 Quiescent Current vs Supply Voltage

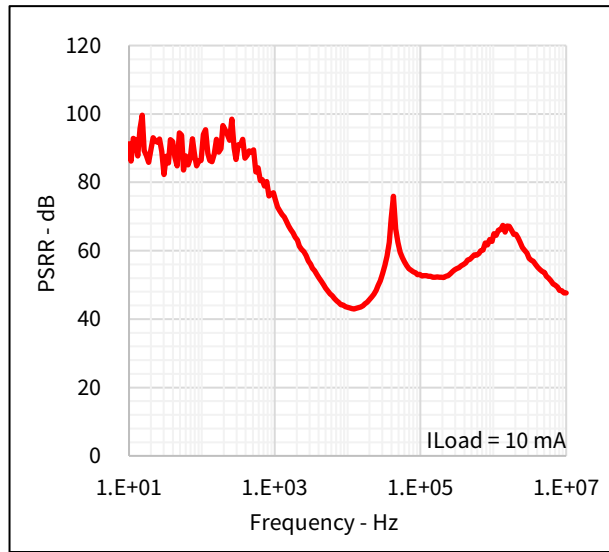


Figure 13 Power Supply Rejection Ratio (PSRR)

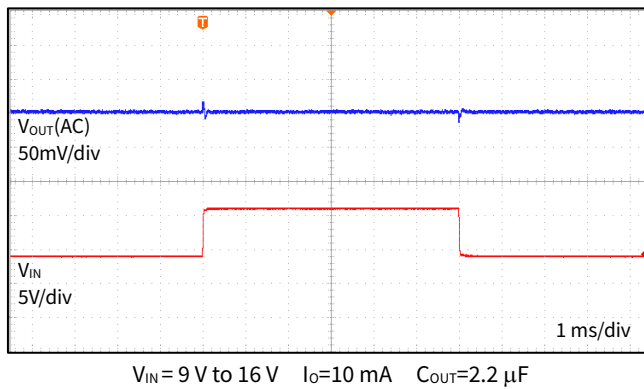


Figure 14 Line Transient

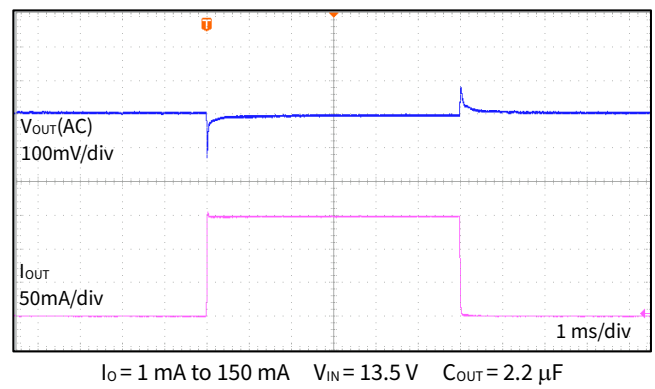


Figure 15 Load Transient

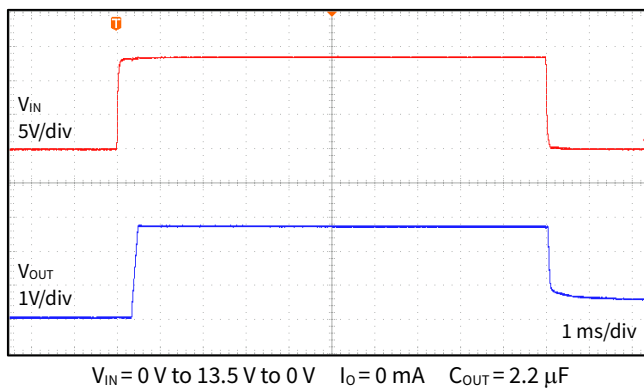


Figure 16 Power Up & Down

7. Detailed Description

7.1. Overview

NSR31 series is 150 mA low-dropout linear regulator designed for battery-direct-connection automotive applications. Wide supply voltage range from 3 V to 40 V makes NSR31 series a good fit for severe operating conditions including load dump, cold cranking and start-stop. With 5 μ A quiescent current at light loads, NSR31 series is quite suitable for always-on automotive applications where standby power consumption is strictly restricted. With integrated compensation implementation, NSR31 series can be stable with low-ESR ceramic output capacitor, ranging from 2.2 μ F to 100 μ F.

7.2. Block Diagram

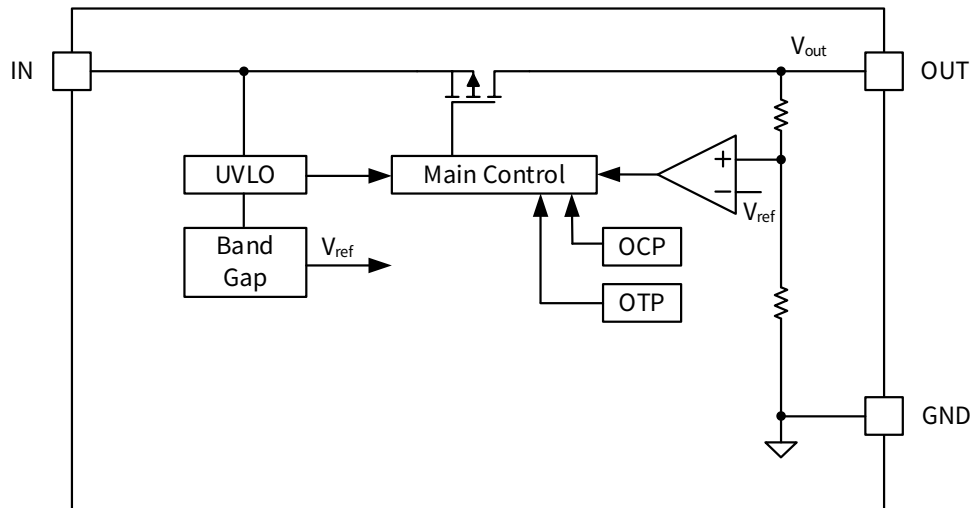


Figure 17 Functional Block Diagram

7.3. Feature Description

7.3.1. Input

The IN pin is a high-voltage-tolerant pin. A capacitor with a value higher than 0.1 μ F is recommended to be connected close to this pin to better the transient performance.

7.3.2. Input Under-voltage Lockout (UVLO)

When input voltage is lower than UVLO threshold ($V_{IN,TH2}$), output is shut off as the device shuts down. When the input voltage rises to the turn-on threshold voltage ($V_{IN,TH1}$), the device restarts. The turn-on threshold voltage is higher than the UVLO threshold voltage.

7.3.3. Output

The OUT pin is regulated by internal reference to 2.5 V, 3.3 V and 5 V. To obtain a desired output voltage, a higher level input voltage is needed to apply in input pin. When input voltage is very close to desired output voltage in heavy load, or lower than desired output, the output tracks the input minus a drop based on the load current.

7.3.4. Output Current Limit

The output has a current limit protection, when load current is higher than current limit threshold or output is shorted to ground, output current is limited at threshold level.

7.3.5. Thermal Shutdown (TSD)

When junction temperature exceeds thermal protection threshold (T_{SD}), the device shuts down immediately. When the junction temperature falls below the TSD trip point minus the hysteresis of TSD (T_{HYST}), the output turns on again.

7.4. Typical Application

7.4.1. Application Circuit

NSR31 series is 150 mA low-dropout linear regulator designed for battery-direct-connection automotive applications. With supply voltage range from 3 V to 40 V and 5 μ A quiescent current at light loads, NSR31 series is quite suitable for always-on automotive applications where standby power consumption is strictly restricted. The following application schematic shows the typical usage of the NSR31 series.

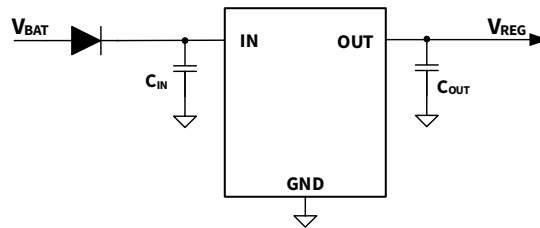


Figure 18 Typical application circuit of NSR31 series

7.4.2. Input and Output Capacitor

For input, a decoupling capacitor is needed with a minimum 0.1 μ F capacitance. The voltage rating must be greater than the maximum input voltage. A low ESR, X5R- or X7R-type ceramic capacitor is recommended.

For output, the device requires an output capacitor for loop stability. The output capacitor value should be between 2.2 μ F and 100 μ F. The ESR value range should be less than 3 Ω . A low ESR, X5R- or X7R-type ceramic capacitor is recommended.

7.4.3. Power Dissipation and Thermal Calculations

The power dissipation and junction temperature of the chip need to be evaluated before use. For the NSR31 series, the power dissipation of the chip consists of two parts: 1. Power dissipation due to MOSFET voltage drop from input to output. 2. Power dissipation generated by other basic circuits in the chip. The above power dissipation can be calculated using the following formula, where P_D stands for power dissipation.

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

I_Q is much smaller than I_{OUT} when the chip loading, the second term of formula above can be ignored in most cases. Under certain heat dissipation conditions, the chip junction temperature (T_J) can be calculated by combining the top case temperature (T_C) and the Junction-to-case characterization parameter (Ψ_{JC}), as shown in the formula below:

$$T_J = \Psi_{JC} \times P_D + T_C$$

It's recommended to estimate the junction temperature for the application to avoid long-term operating temperatures exceeding 150 $^{\circ}$ C.

8. Layout Example

8.1. Layout Guidelines

For input trace, capacitors should be close to IN pin and GND pin, the distance should be less than 10 mm. For output trace, capacitors should be close to current path. Both input and output traces should be wide enough for rating current capability. For GND trace, large polygon plane should be used for better heat dissipation, via arrays are recommended connect multiple layers to improve thermal performance.

8.2. Layout Example

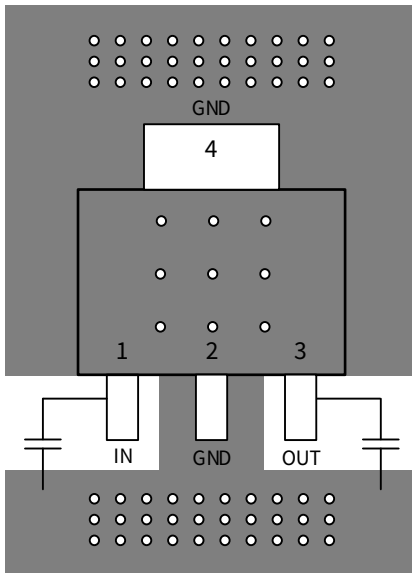


Figure 19 SOT-223 Layout Example

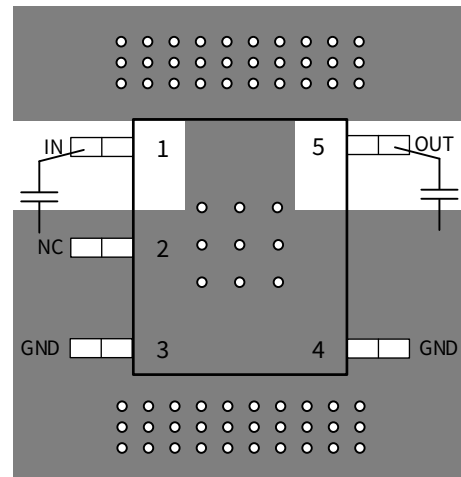


Figure 20 SOT-23-5L(NSR310 Version) Layout Example

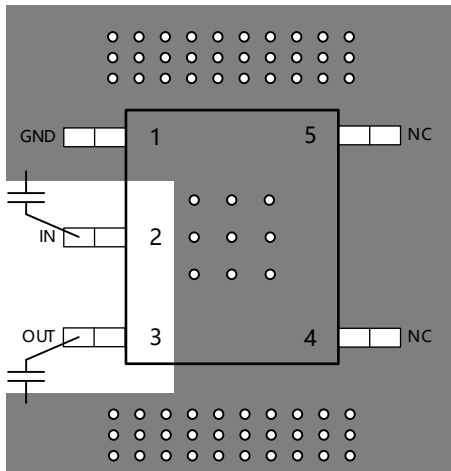


Figure 21 SOT-23-5L(NSR311 Version) Layout Example

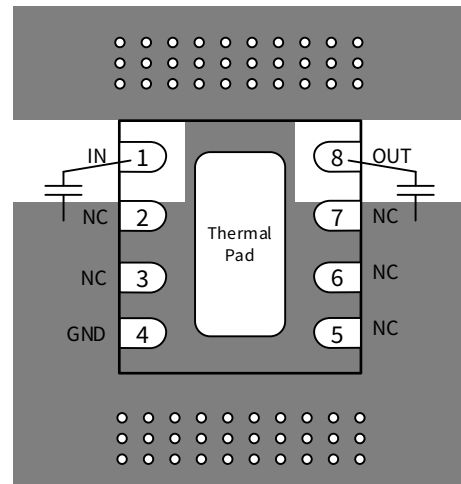
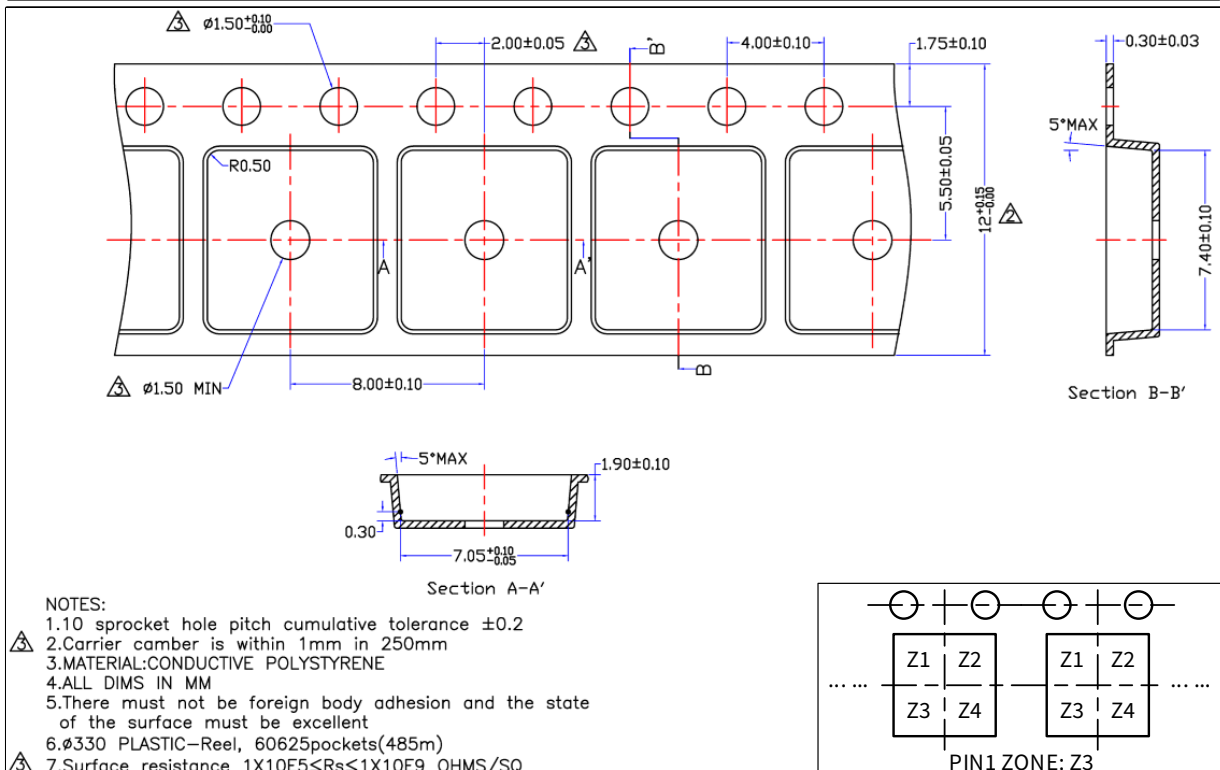
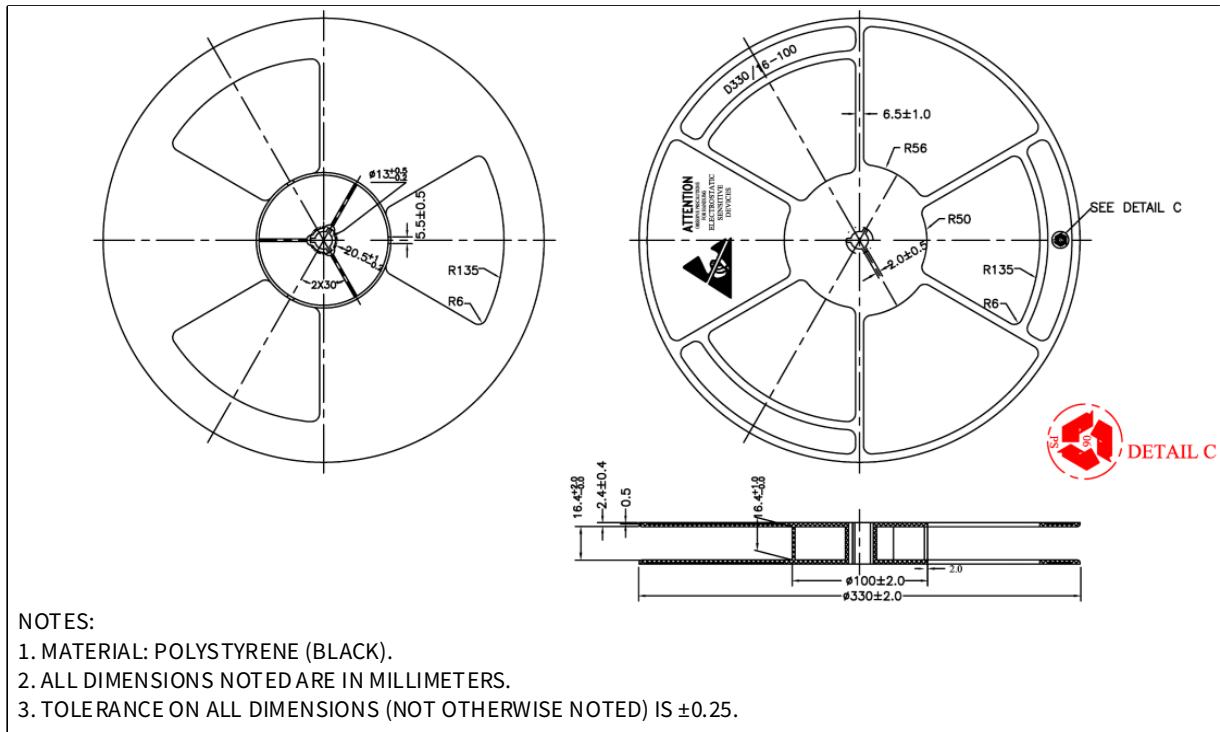


Figure 22 DFN-8 Layout Example

9. Package Information

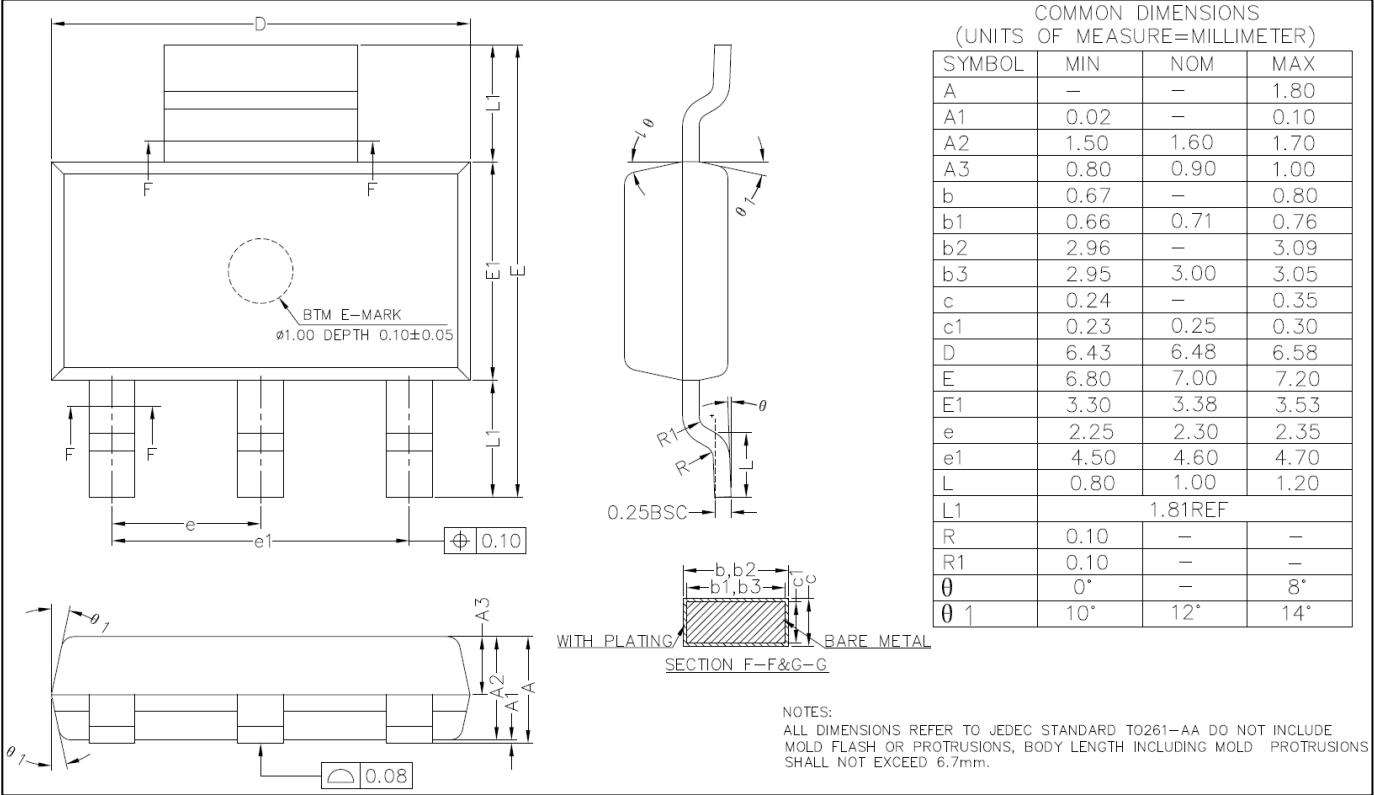
9.1. SOT-223

9.1.1. Tape and Reel

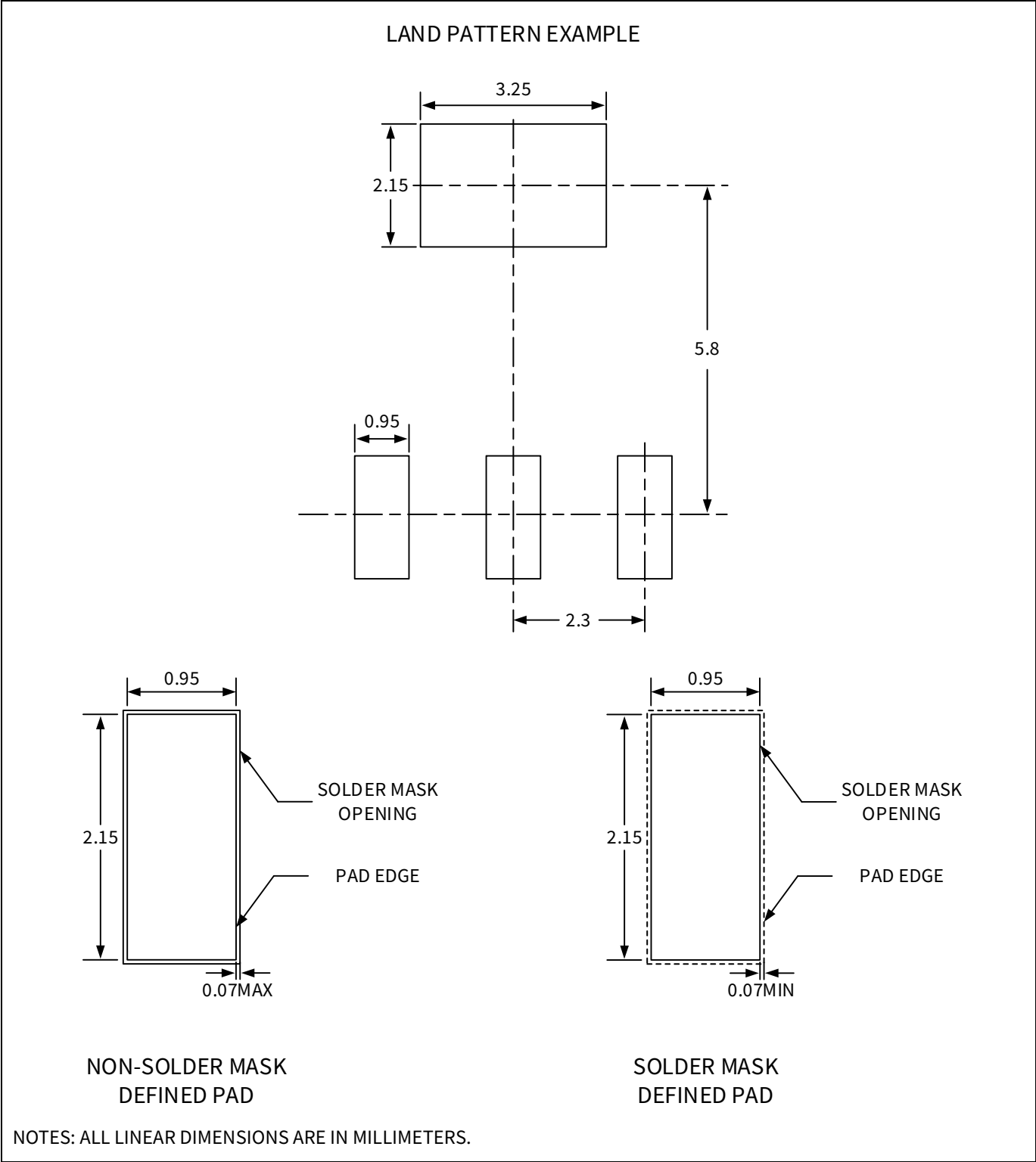


NSR31 series

9.1.2. Mechanical Data

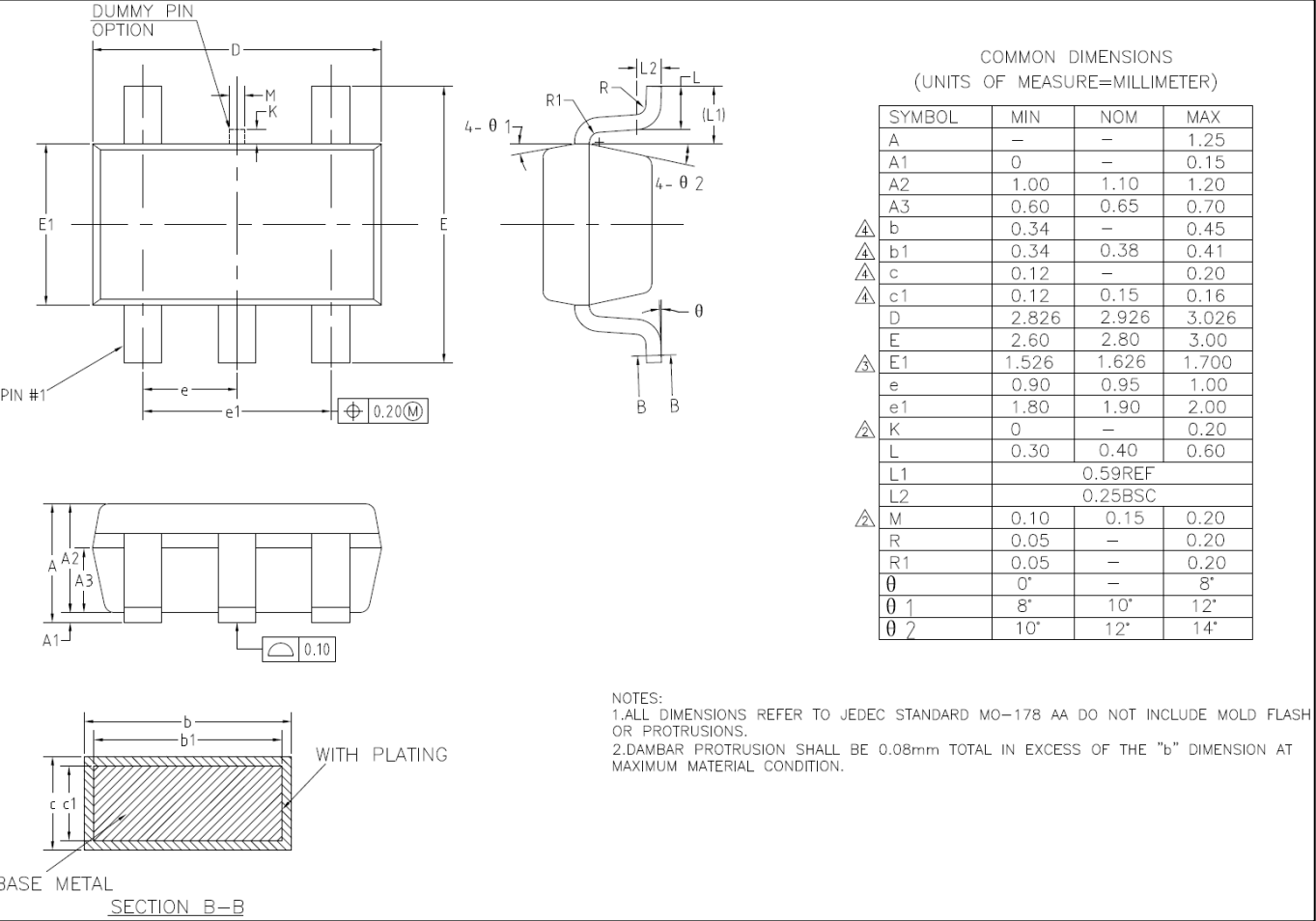


9.1.3. Recommended Land Pattern

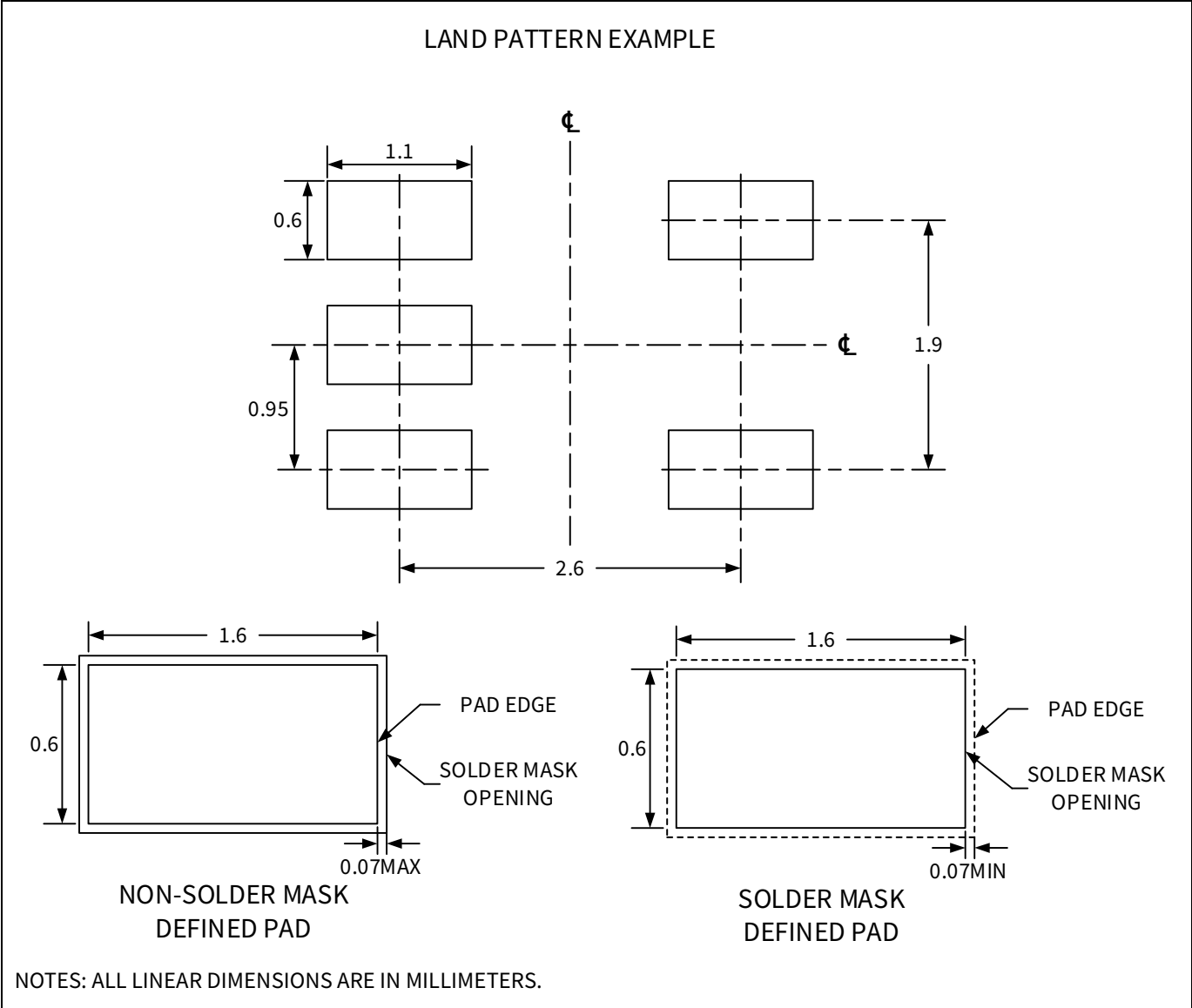


NSR31 series

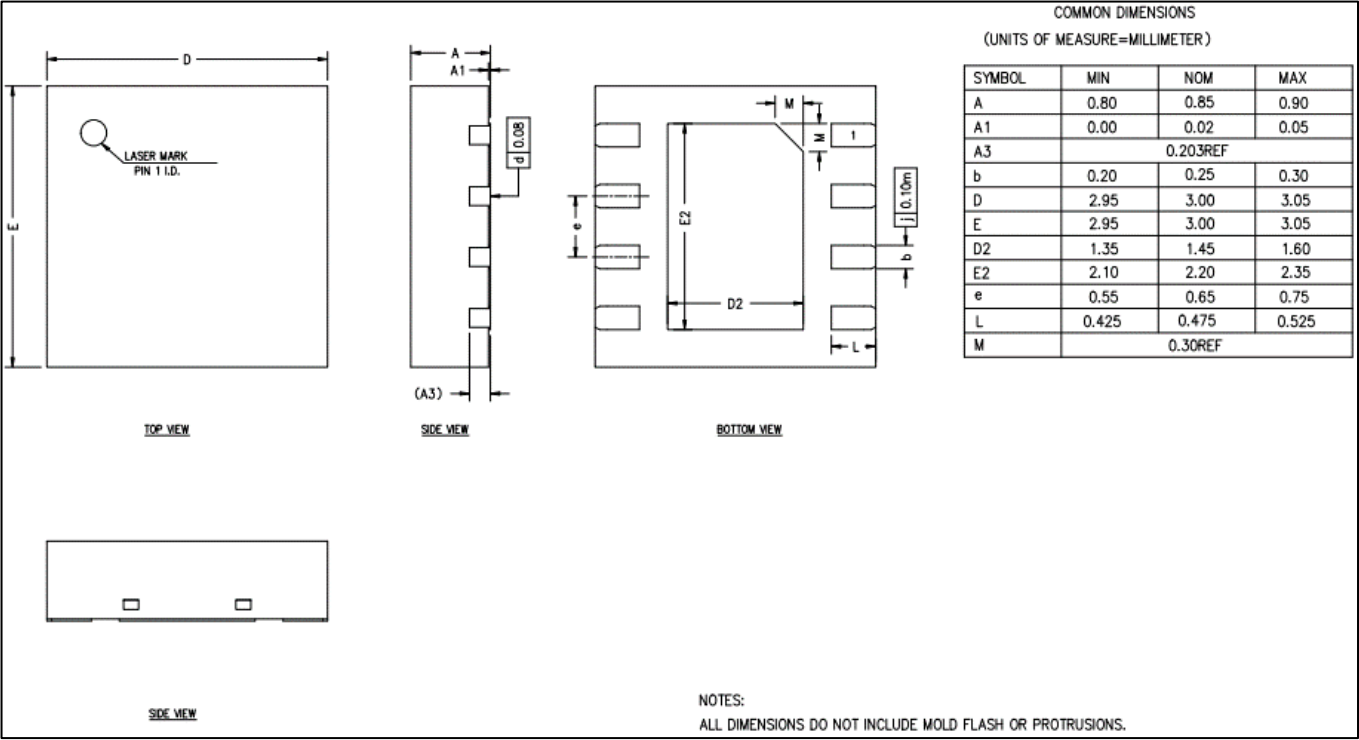
9.2.2. Mechanical Data



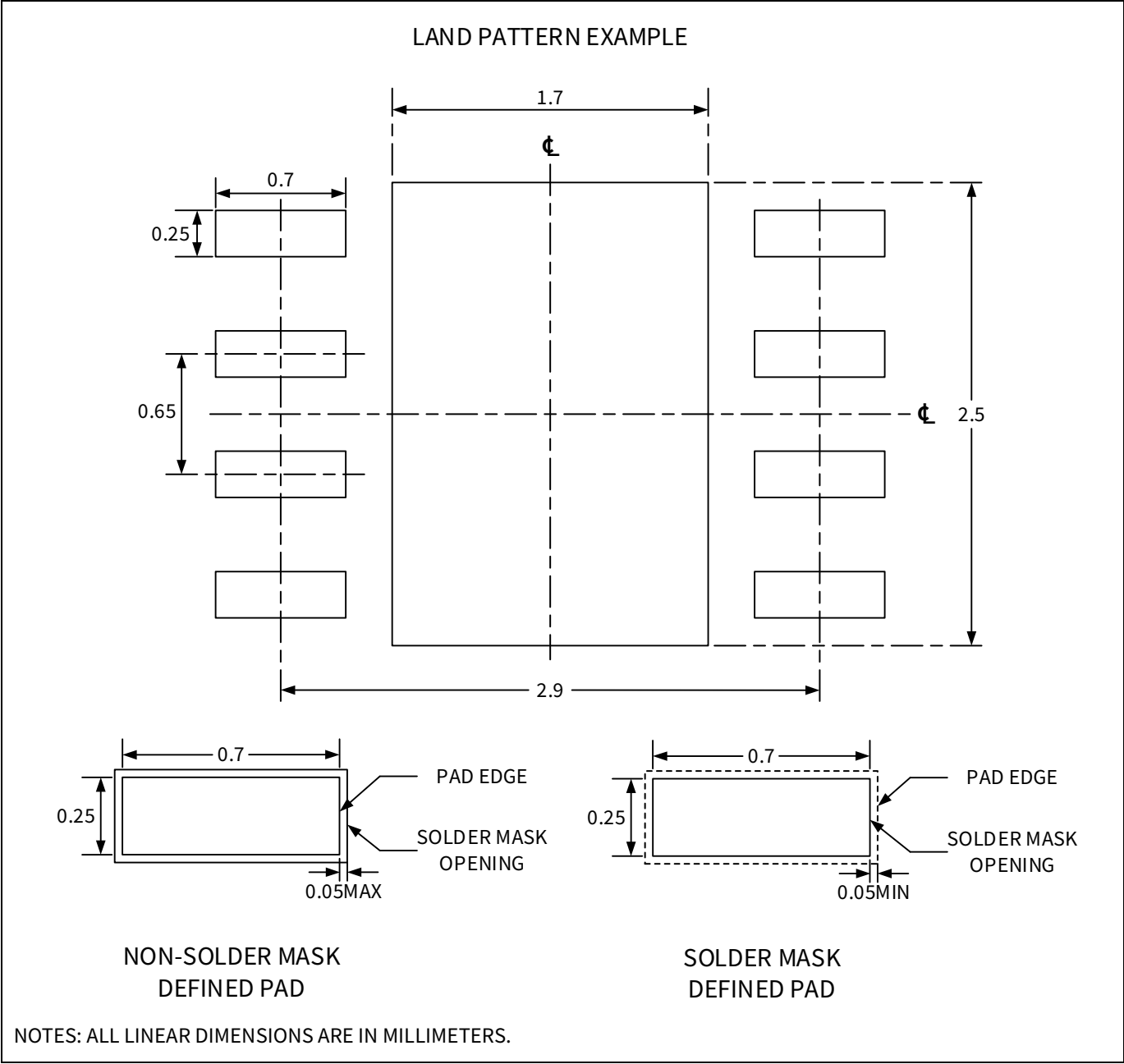
9.2.3. Recommended Land Pattern



9.3.2. Mechanical Data



9.3.3. Recommended Land Pattern



10. Order Information

Orderable Part Number	MSL	Package	SPQ	Marking
NSR31050-QSTBR	3	SOT-223	2500	050Q
NSR31033-QSTBR	3	SOT-223	2500	033Q
NSR31025-QSTBR	3	SOT-223	2500	025Q
NSR31050-QSTAR	3	SOT-23-5L	2500	050Q
NSR31033-QSTAR	3	SOT-23-5L	2500	033Q
NSR31025-QSTAR	3	SOT-23-5L	2500	025Q
NSR31050-QDNR	1	DFN-8	3000	050Q
NSR31033-QDNR	1	DFN-8	3000	033Q
NSR31025-QDNR	1	DFN-8	3000	025Q
NSR31150-QSTAR	3	SOT-23-5L	2500	050F
NSR31133-QSTAR	3	SOT-23-5L	2500	033F

11. Revision history

Revision	Description	Date
1V0	Initial released version	2023/12

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