NOVOSENSE
ROBUST & RELIABLE

NSR33 series

300mA 40-V, Low Iq, Automotive LDO

Datasheet (EN) 0V3

Product Overview

NSR33 series is 300mA low-dropout linear regulator designed for battery-direct-connection automotive applications. Wide supply voltage range from 3V to 40V makes NSR33 series a good fit for severe operating conditions including load dump, cold cranking and start-stop.

With 5μA quiescent current at light loads, NSR33 series is quite suitable for always-on automotive applications where standby power consumption is strictly restricted.

With integrated compensation implementation, NSR33 series can be stable with low-ESR (1mΩ to 5Ω) ceramic output capacitor, ranging from 1μF to 200μF.

The device features integrated short-circuit-to-GND and thermal shutdown protections. This device operates in ambient temperatures from –40°C to 125°C.

Key Features

- Qualified for Automotive Applications
- 3V to 40V Wide Supply Voltage Range
- Output Current Range: Up to 300mA
- Low Quiescent Current:
  - 270nA (Typ.) Shutdown Current when EN low
  - 5μA (Typ.) at No Loads
- Low Dropout Voltage: 263mV Typical at 300mA Load
- Low ESR Ceramic Output Stability Capacitor (1μF – 200μF)
- Integrated Power-On-Reset with Adjustable Delay Time (NSR331 series Only)
- Integrated Fault Protection:
  - Short-Circuit-to-GND protection
  - Thermal Shutdown

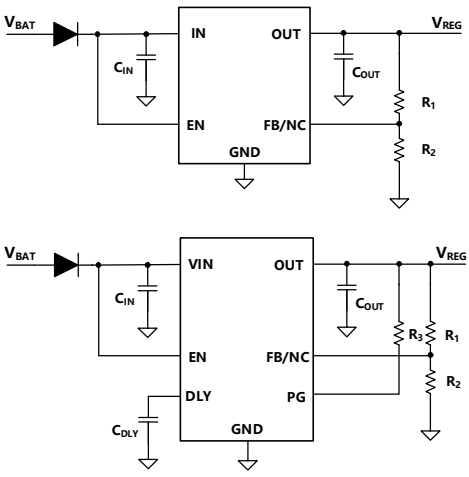
Applications

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

Device Information

Part Number	*Version Info*	*Package*
NSR33001-Q1	No PG, Adjustable output	MSOP-8
NSR33025-Q1	No PG, 2.5V fixed	MSOP-8
NSR33033-Q1	No PG, 3.3V fixed	MSOP-8
NSR33050-Q1	No PG, 5V fixed	MSOP-8
NSR33101-Q1	PG, Adjustable Output	MSOP-8
NSR33125-Q1	PG, 2.5V fixed	MSOP-8
NSR33133-Q1	PG, 3.3V fixed	MSOP-8
NSR33150-Q1	PG, 5V fixed	MSOP-8

Typical Application



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1. Pin Configuration and Functions

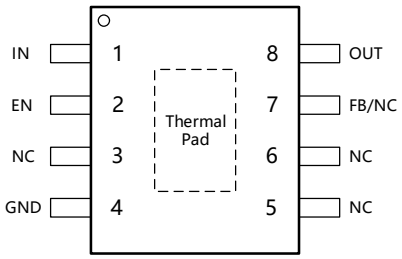


Figure 1 NSR330 Series Pin-out

PIN NO.	SYMBOL	FUNCTION
1	IN	Power supply pin.
2	EN	Enable pin, enable or disable the device.
3, 5, 6	NC	Not connected.
4	GND	Ground reference
7	FB/NC	Feedback pin when output adjustable, or NC pin in output fixed variants.
8	OUT	Regulated output voltage pin.

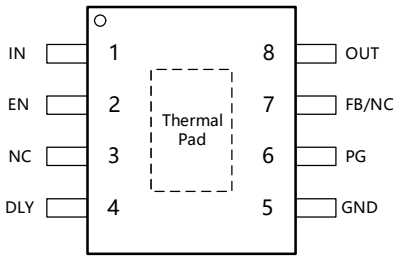


Figure 2 NSR331 Series Pin-out

PIN NO.	SYMBOL	FUNCTION
1	IN	Power supply pin.
2	EN	Enable pin, enable or disable the device.
3	NC	Not connected.
4	DLY	Reset delay timer pin, PG reset delay adjustment with different capacitor values connected to GND.
5	GND	Ground reference.
6	PG	Power good indication pin internally connected to the drain of a MOSFET. When used, connect to an external source with a proper pull-up resistor.
7	FB/NC	Feedback pin when output adjustable, or NC pin in output fixed variants.

PIN NO.	SYMBOL	FUNCTION
8	OUT	Regulated output voltage pin.

2. Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit
Input Voltage of IN	V_{IN}	-0.3		45	V
Input Voltage of EN	V_{EN}	-0.3		V_{IN}	V
Regulated Output Voltage	V_{OUT}	-0.3		20 (≤ V_{IN} + 0.3)	V
FB Pin Voltage	V_{FB}	-0.3		7	V
PG Pin Voltage	V_{PG}	-0.3		20	V
DLY pin Voltage	V_{DLY}	-0.3		6	V
Junction Temperature	T_J	-40		150	°C
Storage Temperature	T_{est}	-40		150	°C
Electrostatic discharge, Human-body model	HBM	-2000		2000	V
Electrostatic discharge, Charged-device model	CDM	-750		750	V

3. Recommended Operating Conditions

Parameters	Symbol	min	typ	max	unit
Power Supply Voltage	V_{IN}	3		40	V
Output Voltage Range	V_{OUT}	0.65		18	V
Output Current Range	I_{OUT}			300	mA
Enable Input Voltage	V_{EN}	0		V_{IN}	V
Power Good Output Voltage	V_{PG}			18	V
Delay Pin Voltage	V_{DLY}			5.5	V
Input Capacitor Value	C_{IN}	0.1	1		fun
Output Capacitor Value	C_{OUT}	1		200	μF
Output Capacitor ESR Value	ESR	0.001		5	Ω
Power Good Delay Capacitor	C_{DLY}			1	μF

4. Thermal Information

Parameters	*Symbol*	*MSOP-8*	*Unit*
IC Junction-to-Air Thermal Resistance	θ_{JA}	49.9	°C/W
Junction-to-board thermal resistance	θ_{JB}	3	°C/W

5. Specifications

(V_{IN}=13.5V, Ta=-40°C to 125°C. Unless otherwise noted, typical value is at Ta = 25°C.)

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Supply voltage	V_{IN}	3		40	V	
Supply voltage threshold (Rising)	$V_{IN,TH1}$			2.9	V	V_{IN} ramps up
Supply voltage threshold (Falling)	$V_{IN,TH2}$	2.7			V	V_{IN} ramps down
Shutdown current	I_{SD}		0.27	0.4	µA	EN low
Quiescent current	I_Q		5	8.9	µA	EN high, I_{OUT} = 0mA
			6	10	µA	EN high, I_{OUT} = 0.2mA
Output current limit	I_{OUT_CL}	438			mA	
EN input threshold	V_{EN_H}	1.7			V	High level logic input
	V_{EN_L}			1.17	V	Low level logic input
EN input current	I_{EN}		0.1	1	µA	
Dropout voltage	$V_{Dropout}$		263	438	mV	V_{OUT} = V_{OUT_SET} x 0.95 I_{OUT} = 300mA
Output voltage accuracy	V_{OUT_ERR}	-2		2	%	
Line regulation	V_{Line_Reg}			20	mV	V_{IN} = 6 to 40 V, I_{OUT} = 30 mA
Load regulation	V_{Load_Reg}			36	mV	V_{IN} = 13.5 V, I_{OUT} = 1mA to 300mA
FB reference voltage	V_{FB_REF}	0.640	0.650	0.665	V	Adjustable version only
Power supply ripple rejection	PSRR		80		dB	V_{Ripple_pp} = 0.5 V, I_{OUT} = 10 mA, frequency = 100 Hz, C_{OUT} = 2.2 µF
			44		dB	V_{Ripple_pp} = 0.5 V, I_{OUT} = 10 mA, frequency = 1kHz, C_{OUT} = 2.2 µF

Parameters	Symbol	Min	Typ	Max	Unit	Comments
PG reset output, low voltage	V_{PG_LO}			0.18	V	I_{PG_LO}=0.5mA
PG leakage current	V_{PG_lkg}			0.05	μA	PG leakage current when pulled high
Power Good Threshold (Rising)	V_{PG_TH1}		90		$\%V_{OUT}$	Vout ramps up
Power Good Threshold (Falling)	V_{PG_TH2}		88		$\%V_{OUT}$	Vout ramps down
DLY external capacitor charging current	I_{DLY_CHG}		1.5		μA	
DLY threshold	V_{DLY_TH}		1		V	
Device thermal shutdown temperature	T_{SD}		175		°C	
Device thermal shutdown temperature hysteresis	T_{HYST}		20		°C	
Power Good Reset Delay time	t_{PG_FIX}		300		μS	No capacitor on DLY pin
Power Good Reset Deglitch time	$t_{PG\_Deglitch}$		250		μS	

6. Detailed Description

6.1. Overview

NSR33 series is 300mA low-dropout linear regulator designed for battery-direct-connection automotive applications. Wide supply voltage range from 3V to 40V makes NSR33 series a good fit for severe operating conditions including load dump, cold cranking and start-stop. With 5μA quiescent current at light loads, NSR33 series is quite suitable for always-on automotive applications where standby power consumption is strictly restricted. With integrated compensation implementation, NSR33 series can be stable with low-ESR (1mΩ to 5Ω) ceramic output capacitor, ranging from 1μF to 200μF.

6.2. Block Diagram

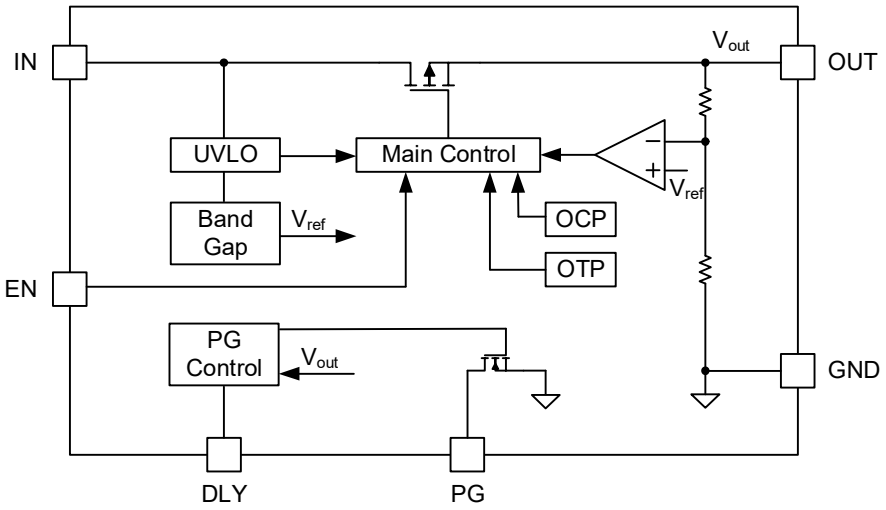


Figure 3 Functional Block Diagram of Fixed Vout Version

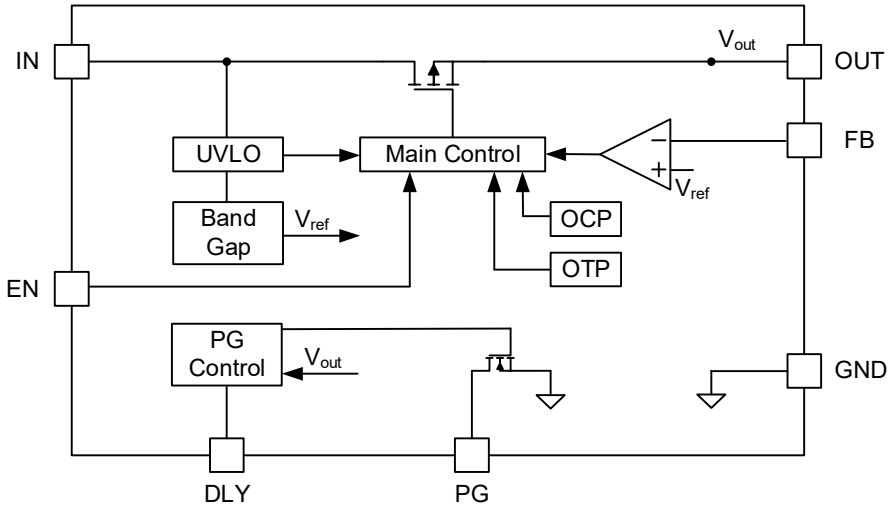


Figure 4 Functional Block Diagram of Adjustable Vout Version

6.3. Feature Description

6.3.1. Input

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

6.3.2. Input Under-voltage Lockout (UVLO)

When input voltage is lower than UVLO threshold, output is shut off as the device shuts down.

6.3.3. Enable (EN)

When EN input is connected to a voltage higher than EN rising threshold (1.7V minimum), the device is ON. When EN input voltage is lower than EN falling threshold (1.17V maximum), the device is OFF.

6.3.4. Output and Feedback (FB)

For fixed output versions, the OUT pin is the regulated by internal reference to 2.5V, 3.3V and 5V. 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.

For adjustable output versions, the OUT pin is regulated by internal reference and external feedback resistors divider connected to FB pin.

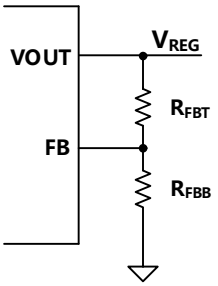


Figure 5 Feedback Resistors Connection

The output voltage is calculated as:

$$V_{OUT} = \frac{R_{FBT} + R_{FBB}}{R_{FBB}} \times V_{REF}$$

Typical value of V_{REF} is 0.65V.

6.3.5. Power Good (PG) and Reset Delay Timer (DLY)

PG pin is an open-drain output. When used, connect it to an external voltage source or output voltage with a proper pull-up resistor. When regulated output voltage is lower than PG falling threshold, the internal MOSFET is opened and PG pin is set as low. When regulated output voltage exceeds PG rising threshold, the internal MOSFET is closed and PG pin is set as high.

DLY pin is used to setting the timer delay before the reset pin is asserted high by connecting an external capacitor to ground. When this pin is open, the typical delay time is 300μs. When this pin is connected to an external capacitor, the delay time is calculated as:

$$t_{DLY} = \frac{C_{DLY} \times 1V}{1.5\ \mu A}$$

After the PG pin is high, the DLY capacitor discharges.

6.3.6. 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.

6.3.7. Thermal Shutdown (TSD)

In normal working condition, the junction temperature should not exceed 150℃ for long-time working stability. When junction temperature exceeds thermal protection threshold, the device shuts down immediately. When the junction temperature falls below the TSD trip point minus the hysteresis of TSD, the output turns on again.

6.4. Typical Application

6.4.1. Application Circuit

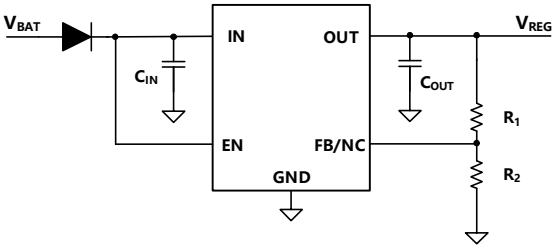


Figure 6 Typical application circuit of NSR330 series

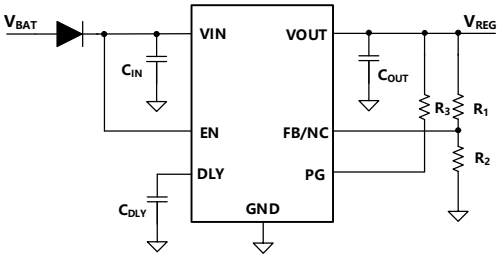


Figure 7 Typical application circuit of NSR331 series

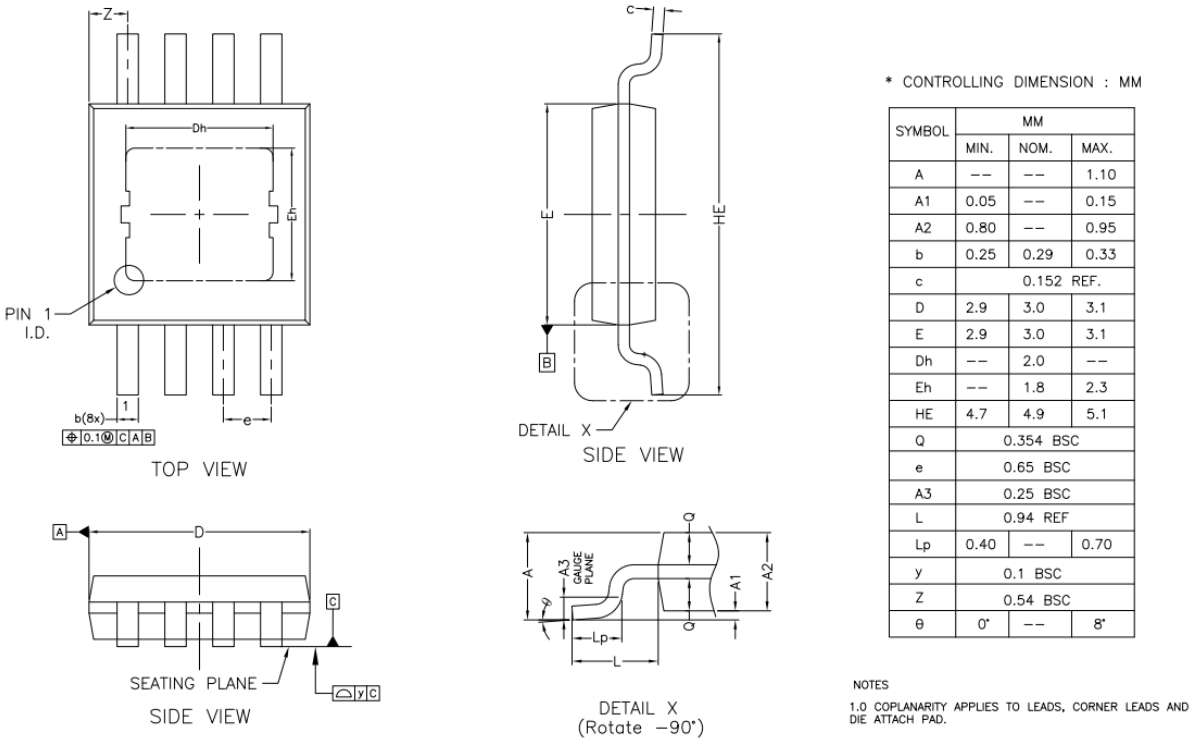
6.4.2. Input and Output Capacitor

For input, a decoupling capacitor is needed with a minimum 0.1 µF 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 1 µF and 200 µF. The ESR value range should be less than 5Ω. A low ESR, X5R- or X7R-type ceramic capacitor is recommended.

7. Package Information

7.1. MSOP-8



* CONTROLLING DIMENSION : MM

SYMBOL	MM		
	MIN.	NOM.	MAX.
A	--	--	1.10
A1	0.05	--	0.15
A2	0.80	--	0.95
b	0.25	0.29	0.33
c		0.152 REF.	
D	2.9	3.0	3.1
E	2.9	3.0	3.1
Dh	--	2.0	--
Eh	--	1.8	2.3
HE	4.7	4.9	5.1
Q		0.354 BSC	
e		0.65 BSC	
A3		0.25 BSC	
L		0.94 REF	
Lp	0.40	--	0.70
y		0.1 BSC	
Z		0.54 BSC	
θ	0°	--	8°

NOTES

1.0 COPLANARITY APPLIES TO LEADS, CORNER LEADS AND DIE ATTACH PAD.

8. Order Information

Orderable Part Number	MSL	Package	SPQ
NSR33001-QHMSR	3	MSOP-8	2500
NSR33025-QHMSR	3	MSOP-8	2500
NSR33033-QHMSR	3	MSOP-8	2500
NSR33050-QHMSR	3	MSOP-8	2500
NSR33101-QHMSR	3	MSOP-8	2500
NSR33125-QHMSR	3	MSOP-8	2500
NSR33133-QHMSR	3	MSOP-8	2500
NSR33150-QHMSR	3	MSOP-8	2500

9. Revision history

Revision	Description	Date
0V1	Initial version	2021/08
0V2	Update key specs	2021/11
0V3	Order Information updates	2022/03