NOVOSENSE
ROBUST & RELIABLE

NSR35 series

500mA 40-V, Low Iq, Automotive LDO

Datasheet (EN) 0V3

Product Overview

NSR35 series is 500mA low-dropout linear regulator designed for battery-direct-connection automotive applications. Wide supply voltage range from 3V to 40V makes NSR35 series a good fit for severe operating conditions including load dump, cold cranking and start-stop.

With 5μA quiescent current at light loads, NSR35 series is quite suitable for always-on automotive applications where standby power consumption is strictly restricted.

With integrated compensation implementation, NSR35 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 500mA
- Low Quiescent Current:
  - 270nA (Typ.) Shutdown Current when EN low
  - 5μA (Typ.) at No Load
- Low Dropout Voltage: 426mV Typical at 500mA Load
- Low ESR Ceramic Output Stability Capacitor (1μF – 200μF)
- Integrated Fault Protection:
  - Short-Circuit-to-GND protection
  - Thermal Shutdown

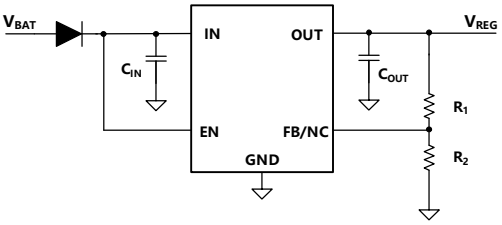
Applications

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

Device Information

Part Number	*Version Info*	*Package*
NSR35001-Q1	Adjustable output	TO263-5, TO252-5
NSR35025-Q1	2.5V fixed	TO252-5
NSR35033-Q1	3.3V fixed	TO252-5
NSR35050-Q1	5V fixed	TO252-5

Typical Application



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1. Pin Configuration and Functions

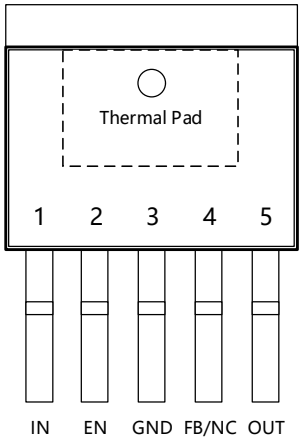


Figure 1 TO263-5 Version Pin-out

PIN NO.	SYMBOL	FUNCTION
1	IN	Power supply pin.
2	EN	Enable pin, enable or disable the device.
3	GND	Ground reference.
4	FB/NC	Feedback pin when output adjustable, or NC pin in output fixed variants.
5	OUT	Regulated output voltage pin.
FIN	GND	Ground reference.

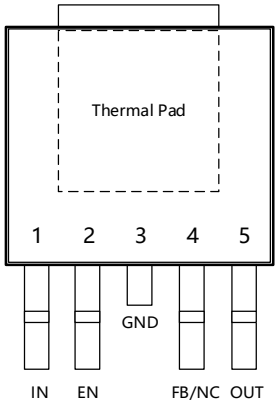


Figure 2 TO252-5 Version Pin-out

PIN NO.	SYMBOL	FUNCTION
1	IN	Power supply pin.

PIN NO.	SYMBOL	FUNCTION
2	EN	Enable pin, enable or disable the device.
3	GND	Ground reference.
4	FB/NC	Feedback pin when output adjustable, or NC pin in output fixed variants.
5	OUT	Regulated output voltage pin.
FIN	GND	Ground reference.

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
Junction Temperature	T_J	-40		150	°C
Storage Temperature	T_{stg}	-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}			500	mA
Enable Input Voltage	V_{EN}	0		V_{IN}	V
Input Capacitor Value	C_{IN}	0.1	1		μF
Output Capacitor Value	C_{OUT}	1		200	μF
Output Capacitor ESR Value	ESR	0.001		5	Ω

4. Thermal Information

Parameters	Symbol	TO263-5	TO252-5	Unit
IC Junction-to-Air Thermal Resistance	θ_{JA}	28.8	31	°C/W
Junction-to-board thermal resistance	θ_{JB}	2	2.1	°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	0.5	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}	646			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	μA	
Dropout voltage	$V_{Dropout}$		426	696	mV	V_{OUT} = V_{OUT_SET} x 0.95 I_{OUT} = 500mA
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}			50	mV	V_{IN} = 13.5 V, I_{OUT} = 1mA to 500mA
FB reference voltage	V_{FB_REF}	0.640	0.65	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
Device thermal shutdown temperature	T_{SD}		175		°C	

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Device thermal shutdown temperature hysteresis	T_{HYST}		20		°C	

6. Detailed Description

6.1. Overview

NSR35 series is 500mA low-dropout linear regulator designed for battery-direct-connection automotive applications. Wide supply voltage range from 3V to 40V makes NSR35 series a good fit for severe operating conditions including load dump, cold cranking and start-stop. With 5μA quiescent current at light loads, NSR35 series is quite suitable for always-on automotive applications where standby power consumption is strictly restricted. With integrated compensation implementation, NSR35 series can be stable with low-ESR (1mΩ to 5Ω) ceramic output capacitor, ranging from 1μF to 200μF.

6.2. Block Diagram

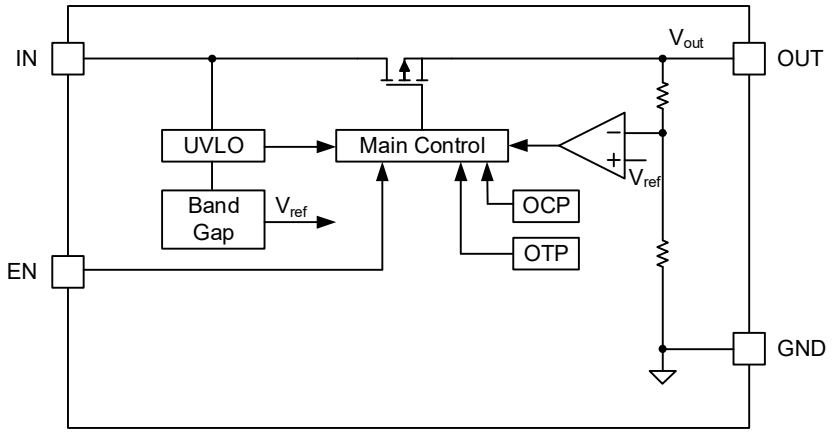


Figure 3 Functional Block Diagram of Fixed Vout Version

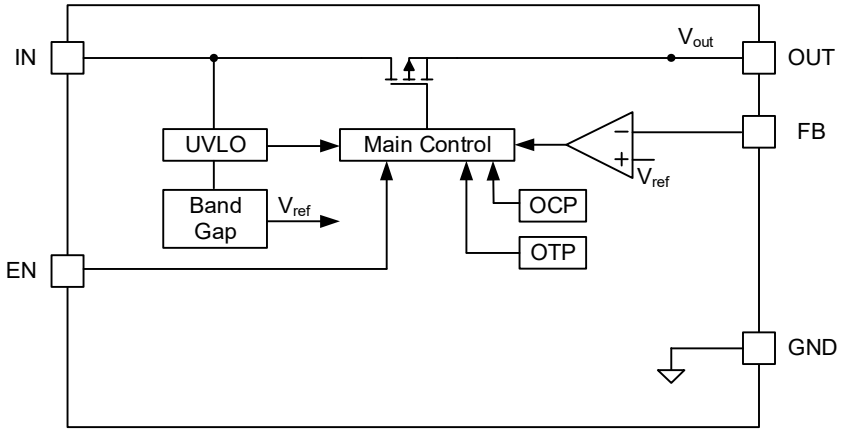


Figure 4 Functional Block Diagram of Adjustable Vout Version

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.

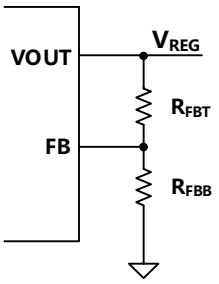


Figure 5 Feedback Resistors Connection

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. 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.

6.3.6. 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

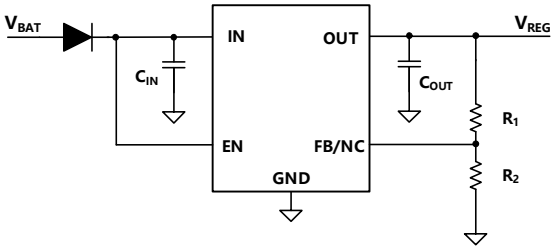


Figure 6 Typical application circuit

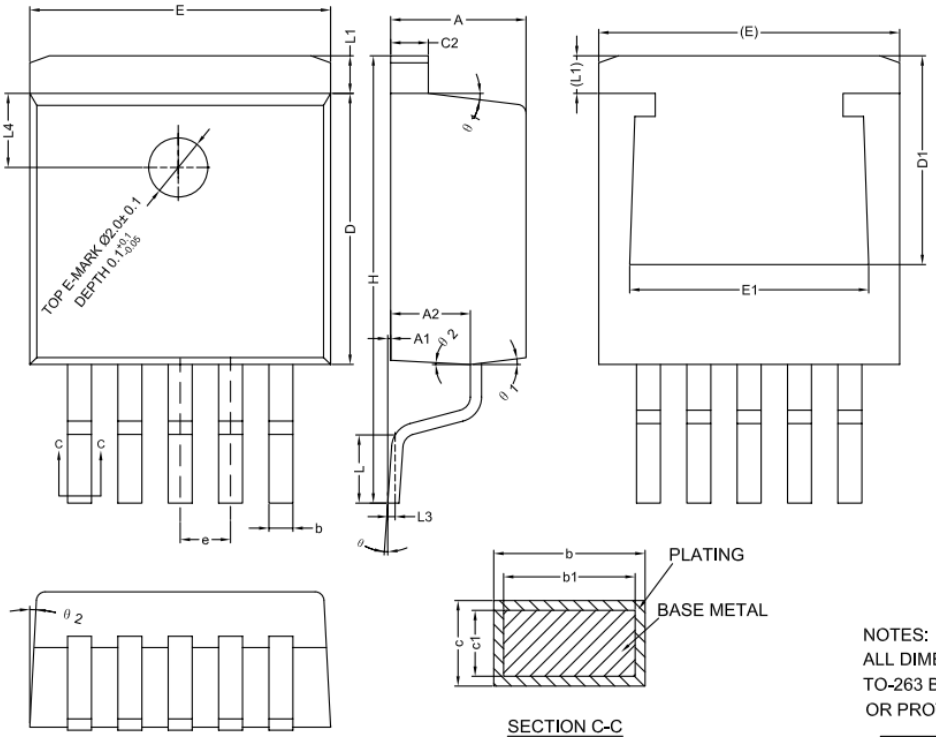
6.4.2. Input and Output Capacitor

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. TO263-5

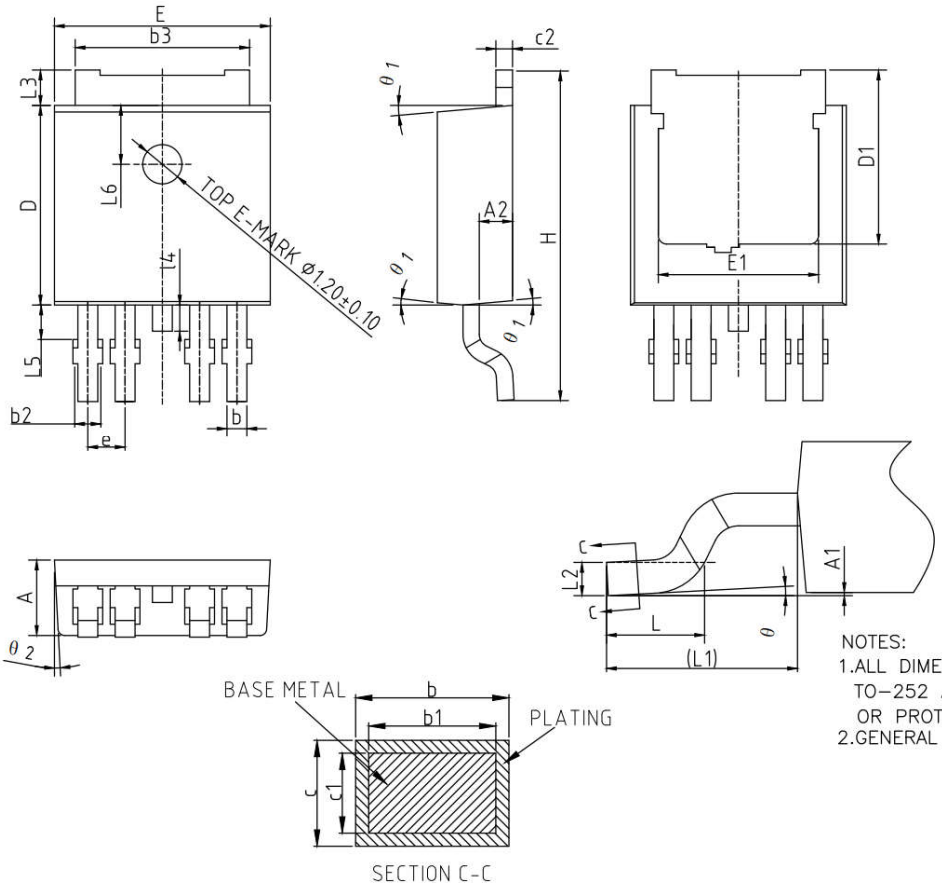


COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	4.40	4.57	4.70
A1	0	0.10	0.25
A2	2.59	2.69	2.79
b	0.77	-	0.90
b1	0.76	0.81	0.86
c	0.34	-	0.47
c1	0.33	0.38	0.43
c2	1.22	-	1.32
D	9.05	9.15	9.25
D1	6.86	-	7.50
E	10.06	10.16	10.26
E1	7.50	-	8.30
e		1.70BSC	
H	14.70	15.10	15.50
L	2.00	2.30	2.60
L1	1.17	1.27	1.40
L3		0.25BSC	
L4		2.00REF	
θ	0°	-	8°
θ 1	5°	7°	9°
θ 2	1°	3°	5°

NOTES:
ALL DIMENSIONS REFER TO JEDEC STANDARD TO-263 BA DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

7.2. TO252-5



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	2.20	2.30	2.38
A1	0	–	0.10
A2	0.90	1.00	1.10
b	0.57	–	0.70
b1	0.56	0.61	0.66
b2	0.57	–	0.86
b3	5.23	5.33	5.44
c	0.50	–	0.56
c1	0.50	0.51	0.52
c2	0.50	–	0.56
D	6.00	6.10	6.20
D1	5.00	–	–
E	6.50	6.60	6.70
E1	4.70	–	–
e		1.14BSC	
H	9.80	10.10	10.40
L	1.40	1.50	1.70
L1		2.90REF	
L2		0.51BSC	
L3	0.90	–	1.25
L4	0.60	0.80	1.00
L5	0.90	–	1.50
L6		1.80REF	
θ	0°	–	8°
θ1	3°	5°	7°
θ2	1°	3°	5°

NOTES:
1.ALL DIMENSIONS REFER TO JEDEC STANDARD TO-252 AD DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
2.GENERAL TOLERANCE ±0.10.

8. Order Information

Orderable Part Number	MSL	Package	SPQ
NSR35001-QTOBR	3	TO263-5	500
NSR35001-QTOAR	3	TO252-5	2500
NSR35025-QTOAR	3	TO252-5	2500
NSR35033-QTOAR	3	TO252-5	2500
NSR35050-QTOAR	3	TO252-5	2500

9. Revision history

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