CMOS Voltage Regulator, Very Low Dropout Bias Rail, 500 mA

NCP135

The NCP135 is a 500 mA VLDO equipped with NMOS pass transistor and a separate bias supply voltage (V_{BIAS}). The device provides very stable, accurate output voltage with low noise suitable for space constrained, noise sensitive applications. In order to optimize performance for battery operated portable applications, the NCP135 features low I_Q consumption. The NCP135 is offered in WDFN6 2 mm x 2 mm package.

Features

- Input Voltage Range: 0.4 V to 5.5 V
- Bias Voltage Range: 2.5 V to 5.5 V
- Fixed Output Voltage of 0.4 V and 0.75 V
- ±1% Accuracy over Temperature, 0.5% V_{OUT} @ 25°C
- Ultra−Low Dropout: Typ. 53 mV at 500 mA
- Very Low Bias Input Current of Typ. 35 μA
- Logic Level Enable Input for ON/OFF Control
- Output Active Discharge Option Available
- Stable with a 10 μF Ceramic Capacitor
- Available in WDFN6 2 mm x 2 mm, 0.65 mm pitch Package
- This is a Pb−Free Device

Typical Applications

- Battery−powered Equipment
- Smartphones, Tablets
- Cameras, DVRs, STB and Camcorders

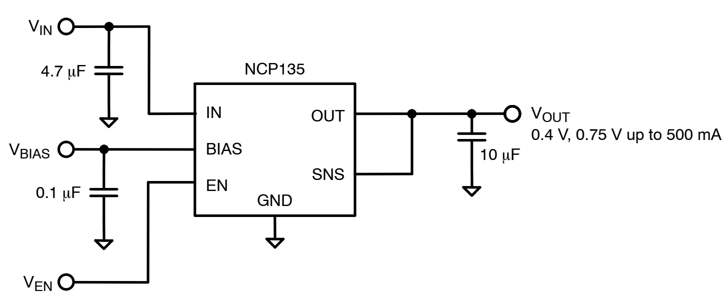

Figure 1. Typical Application Schematic

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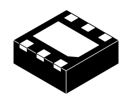
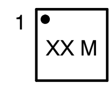


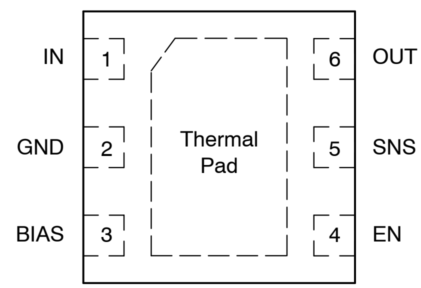
WDFN6
CASE 511BR

MARKING DIAGRAM



XX = Specific Device Code
M = Date Code

PIN CONNECTIONS

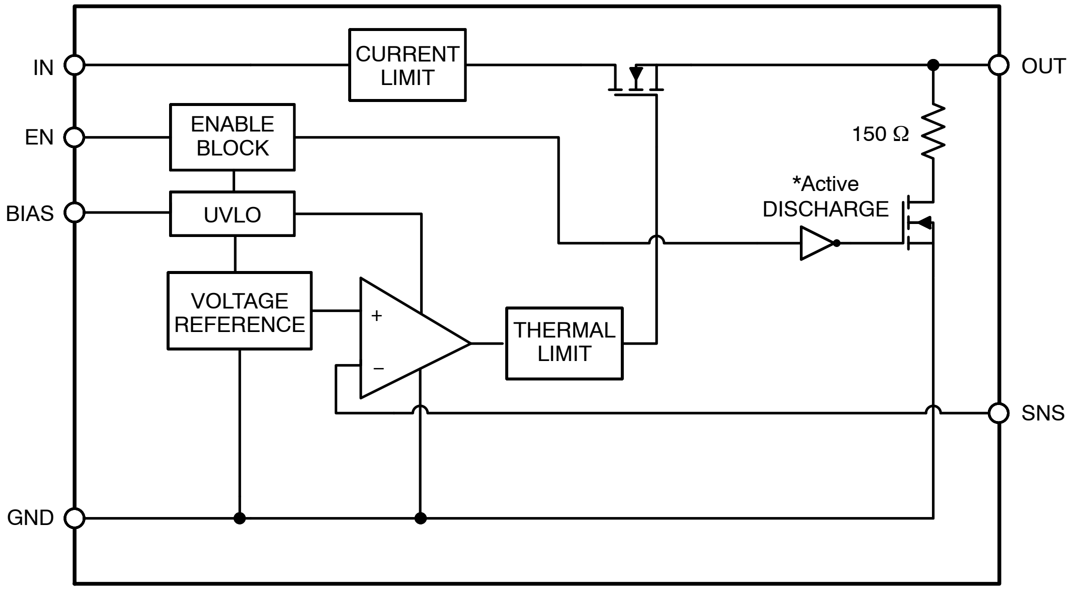


(Top View)

ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 10 of this data sheet.

August, 2020 − Rev. 1
Publication Order Number:
NCP135/D



*Active output discharge function is present only in NCP135A option devices.

Figure 2. Simplified Schematic Block Diagram

PIN FUNCTION DESCRIPTION

Pin No.	Pin Name	Description
1	VIN	Input Voltage Supply pin
2	GND	Ground pin
3	VBIAS	Bias voltage supply for internal control circuits. This pin is monitored by internal Under-Voltage Lockout Circuit.
4	EN	Enable pin. Driving this pin high enables the regulator. Driving this pin low puts the regulator into shutdown mode.
5	SNS	Output voltage Sensing Input. Connect to Output voltage node on the PCB.
6	VOUT	Regulated Output Voltage pin
Pad	Pad	Should be soldered to the ground plane for increased thermal performance.

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage (Note 1)	V_{IN}	−0.3 to 6	V
Output Voltage	V_{OUT}	−0.3 to (V_{IN}+0.3) ≤ 6	V
Chip Enable, Bias and SNS Input	V_{EN}, V_{BIAS}, V_{SNS}	−0.3 to 6	V
Output Short Circuit Duration	t_{SC}	unlimited	s
Maximum Junction Temperature	T_J	125	°C
Storage Temperature	T_{STG}	−55 to 150	°C
ESD Capability, Human Body Model (Note 2)	ESD_{HBM}	2000	V
ESD Capability, Machine Model (Note 2)	ESD_{MM}	200	V

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
2. This device series incorporates ESD protection (except OUT pin) and is tested by the following methods:
   ESD Human Body Model tested per EIA/JESD22−A114
   ESD Machine Model tested per EIA/JESD22−A115
   Latchup Current Maximum Rating tested per JEDEC standard: JESD78.

THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Characteristics, WDFN6 2 mm x 2 mm Thermal Resistance, Junction−to−Air (Note 3)	$R_{\theta JA}$	97	°C/W

3. This data was derived by thermal simulations based on the JEDEC JESD51 series standards methodology. Only a single device mounted at the center of a high K (2s2p) 3 in x 3 in multilayer board with 1−ounce internal planes and 1−ounce copper on top and bottom. Top copper layer has a dedicated 25 sq mm copper area.

ELECTRICAL CHARACTERISTICS VOLTAGE VERSION – 0.4 V −40°C ≤ T_J ≤ 125°C; V_{BIAS} = 2.7 V or (V_{OUT} + 1.6 V), whichever is greater, V_{IN} = $V_{OUT(NOM)}$ + 0.3 V, I_{OUT} = 1 mA, V_{EN} = 1 V, C_{IN} = 4.7 μF, C_{OUT} = 10 μF, C_{BIAS} = 1 μF, unless otherwise noted. Typical values are at T_J = +25°C. Min/Max values are for −40°C ≤ T_J ≤ 125°C unless otherwise noted. (Note 4)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage Range		V_{IN}	V_{OUT} + V_{DO}		5.5	V
Operating Bias Voltage Range		V_{BIAS}	(V_{OUT} + 1.50) ≥ 2.5		5.5	V
Undervoltage Lock−out	V_{BIAS} Rising Hysteresis	UVLO		1.6 0.2		V
Nominal Output Voltage	T_J = +25°C	$V_{OUT(NOM)}$		0.400		V
Output Voltage Accuracy		V_{OUT}		±0.5		%
Output Voltage Accuracy	−40°C ≤ T_J ≤ 125°C, $V_{OUT(NOM)}$ + 0.3 V ≤ V_{IN} ≤ $V_{OUT(NOM)}$ + 1.0 V, 2.7 V or ($V_{OUT(NOM)}$ + 1.6 V), whichever is greater < V_{BIAS} < 5.5 V, 1 mA < I_{OUT} < 500 mA	V_{OUT}	−1.0		+1.0	%
V_{IN} Line Regulation	$V_{OUT(NOM)}$ + 0.3 V ≤ V_{IN} ≤ 5.0 V	$Line_{Reg}$		0.01		%/V
V_{BIAS} Line Regulation	2.7 V or ($V_{OUT(NOM)}$ + 1.6 V), whichever is greater < V_{BIAS} < 5.5 V	$Line_{Reg}$		0.01		%/V
Load Regulation	I_{OUT} = 1 mA to 500 mA	$Load_{Reg}$		0.5		mV
V_{IN} Dropout Voltage	I_{OUT} = 500 mA (Note 5)	V_{DO}		53	100	mV
Output Current Limit	V_{OUT} = 90% $V_{OUT(NOM)}$	I_{CL}	600	820	1200	mA
SNS Pin Operating Current		I_{SNS}		0.01	0.5	μA
Bias Pin Quiescent Current	V_{BIAS} = 2.7 V, I_{OUT} = 0 mA	I_{BIASQ}		35	55	μA
Bias Pin Disable Current	V_{EN} ≤ 0.4 V	$I_{BIAS(DIS)}$		0.2	1	μA
Vinput Pin Disable Current	V_{EN} ≤ 0.4 V	$I_{VIN(DIS)}$		0.01	1	μA
EN Pin Threshold Voltage	EN Input Voltage “H”	$V_{EN(H)}$	0.9			V
	EN Input Voltage “L”	$V_{EN(L)}$			0.4	
EN Pull Down Current	V_{EN} = 5.5 V	I_{EN}		0.3	1	μA
Turn−On Time	From assertion of V_{EN} to V_{OUT} = 98% $V_{OUT(NOM)}$	t_{ON}		150		μs
Power Supply Rejection Ratio	V_{IN} to V_{OUT}, f = 1 kHz, I_{OUT} = 10 mA, V_{IN} ≥ V_{OUT} +0.5 V	PSRR(V_{IN})		73		dB
	V_{BIAS} to V_{OUT}, f = 1 kHz, I_{OUT} = 10 mA, V_{IN} ≥ V_{OUT} +0.5 V	PSRR(V_{BIAS})		90		dB
Output Noise Voltage	V_{IN} = V_{OUT} +0.5 V, f = 10 Hz to 100 kHz	V_N		28.7		μV_{RMS}
Thermal Shutdown Threshold	Temperature increasing			160		°C
	Temperature decreasing			140		
Output Discharge Pull−Down	V_{EN} ≤ 0.4 V, V_{OUT} = 0.4 V, NCP135A options only	R_{DISCH}		150		Ω

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

4. Performance guaranteed over the indicated operating temperature range by design and/or characterization. Production tested at T_A = 25°C. Low duty cycle pulse techniques are used during the testing to maintain the junction temperature as close to ambient as possible.
5. Dropout voltage is characterized when V_{OUT} falls 3% below $V_{OUT(NOM)}$.

ELECTRICAL CHARACTERISTICS VOLTAGE VERSION – 0.75 V $-40°C \le T_J \le 125°C$; V_{BIAS} = 2.7 V or (V_{OUT} + 1.6 V), whichever is greater, $V_{IN} = V_{OUT(NOM)}$ + 0.3 V, I_{OUT} = 1 mA, V_{EN} = 1 V, C_{IN} = 4.7 μF, C_{OUT} = 10 μF, C_{BIAS} = 1 μF, unless otherwise noted. Typical values are at T_J = +25°C. Min/Max values are for $-40°C \le T_J \le 125°C$ unless otherwise noted. (Note 6)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage Range		V_{IN}	V_{OUT} + V_{DO}		5.5	V
Operating Bias Voltage Range		V_{BIAS}	(V_{OUT} + 1.50) ≥ 2.5		5.5	V
Undervoltage Lock–out	V_{BIAS} Rising Hysteresis	UVLO		1.6 0.2		V
Nominal Output Voltage	T_J = +25°C	$V_{OUT(NOM)}$		0.750		V
Output Voltage Accuracy		V_{OUT}		±0.5		%
Output Voltage Accuracy	$-40°C \le T_J \le 125°C$, $V_{OUT(NOM)} + 0.3\ V \le V_{IN} \le V_{OUT(NOM)} + 1.0$ V, 2.7 V or ($V_{OUT(NOM)}$ + 1.6 V), whichever is greater < V_{BIAS} < 5.5 V, 1 mA < I_{OUT} < 500 mA	V_{OUT}	−1.0		+1.0	%
V_{IN} Line Regulation	$V_{OUT(NOM)} + 0.3\ V \le V_{IN} \le 5.0$ V	$Line_{Reg}$		0.01		%/V
V_{BIAS} Line Regulation	2.7 V or ($V_{OUT(NOM)}$ + 1.6 V), whichever is greater < V_{BIAS} < 5.5 V	$Line_{Reg}$		0.01		%/V
Load Regulation	I_{OUT} = 1 mA to 500 mA	$Load_{Reg}$		0.5		mV
V_{IN} Dropout Voltage	I_{OUT} = 500 mA (Note 7)	V_{DO}		52	100	mV
Output Current Limit	V_{OUT} = 90% $V_{OUT(NOM)}$	I_{CL}	600	820	1200	mA
SNS Pin Operating Current		I_{SNS}		0.01	0.5	μA
Bias Pin Quiescent Current	V_{BIAS} = 2.7 V, I_{OUT} = 0 mA	I_{BIASQ}		35	55	μA
Bias Pin Disable Current	$V_{EN} \le 0.4$ V	$I_{BIAS(DIS)}$		0.2	1	μA
Vinput Pin Disable Current	$V_{EN} \le 0.4$ V	$I_{VIN(DIS)}$		0.01	1	μA
EN Pin Threshold Voltage	EN Input Voltage “H”	$V_{EN(H)}$	0.9			V
	EN Input Voltage “L”	$V_{EN(L)}$			0.4	
EN Pull Down Current	V_{EN} = 5.5 V	I_{EN}		0.3	1	μA
Turn–On Time	From assertion of V_{EN} to V_{OUT} = 98% $V_{OUT(NOM)}$	t_{ON}		198		μs
Power Supply Rejection Ratio	V_{IN} to V_{OUT}, f = 1 kHz, I_{OUT} = 10 mA, $V_{IN} \ge V_{OUT}$ +0.5 V	PSRR(V_{IN})		73		dB
	V_{BIAS} to V_{OUT}, f = 1 kHz, I_{OUT} = 10 mA, $V_{IN} \ge V_{OUT}$ +0.5 V	PSRR(V_{BIAS})		100		dB
Output Noise Voltage	$V_{IN} = V_{OUT}$ +0.5 V, f = 10 Hz to 100 kHz	V_N		35.3		μV_{RMS}
Thermal Shutdown Threshold	Temperature increasing			160		°C
	Temperature decreasing			140		
Output Discharge Pull–Down	$V_{EN} \le 0.4$ V, V_{OUT} = 0.4 V, NCP135A options only	R_{DISCH}		150		Ω

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

6. Performance guaranteed over the indicated operating temperature range by design and/or characterization. Production tested at T_A = 25°C. Low duty cycle pulse techniques are used during the testing to maintain the junction temperature as close to ambient as possible.
7. Dropout voltage is characterized when V_{OUT} falls 3% below $V_{OUT(NOM)}$.

TYPICAL CHARACTERISTICS

At T_J = +25°C, $V_{IN} = V_{OUT(NOM)}$ + 0.3 V, V_{BIAS} = 2.7 V, V_{EN} = 1.0 V, $V_{OUT(NOM)}$ = 0.4 V, I_{OUT} = 500 mA, C_{IN} = 1 μF, C_{BIAS} = 0.1 μF, and C_{OUT} = 10 μF (effective capacitance value), unless otherwise noted.

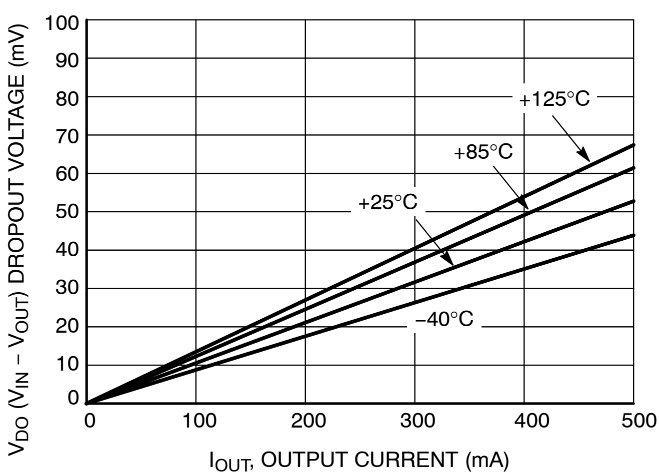


Figure 3. V_{IN} Dropout Voltage vs. I_{OUT} and Temperature T_J

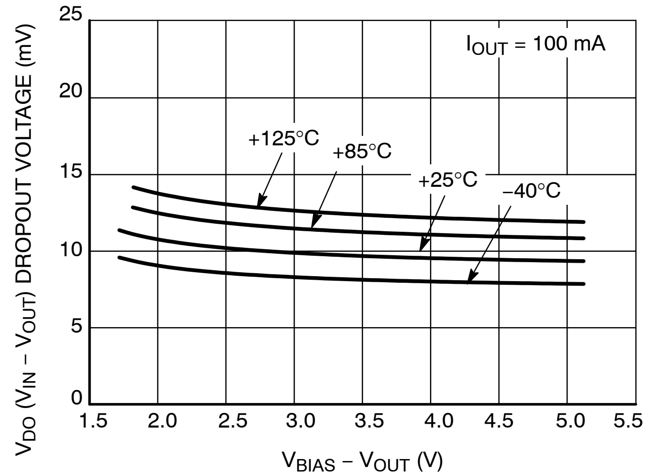


Figure 4. V_{IN} Dropout Voltage vs. (V_{BIAS} – V_{OUT}) and Temperature T_J

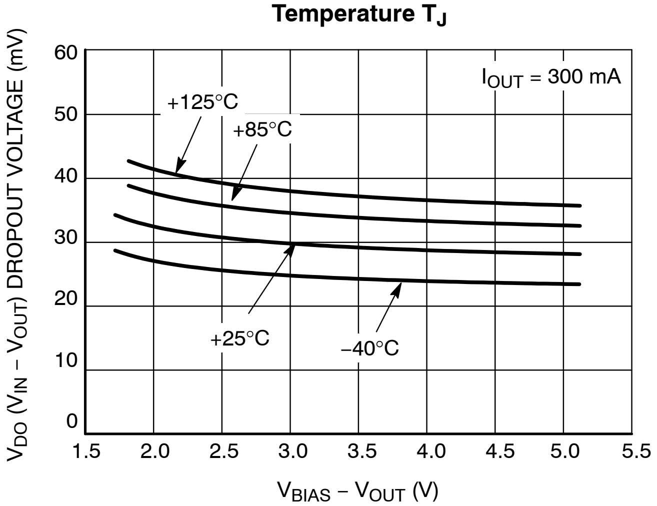


Figure 5. V_{IN} Dropout Voltage vs. (V_{BIAS} – V_{OUT}) and Temperature T_J

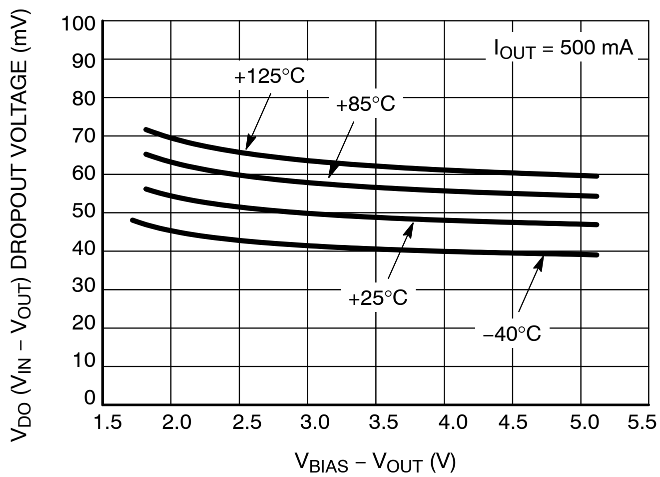


Figure 6. V_{IN} Dropout Voltage vs. (V_{BIAS} – V_{OUT}) and Temperature T_J

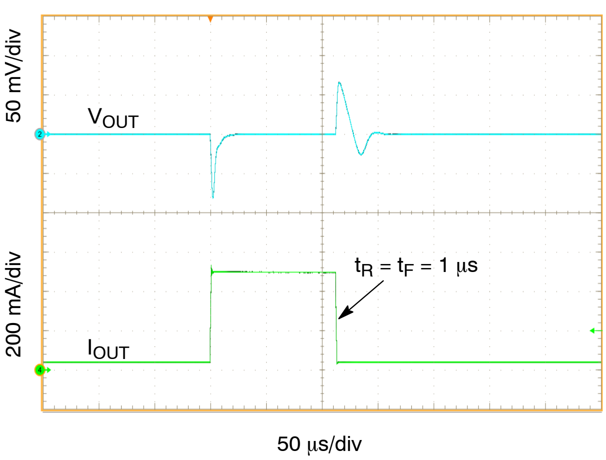


Figure 7. Load Transient Response, I_{OUT} = 50 mA to 500 mA, C_{OUT} = 10 μF

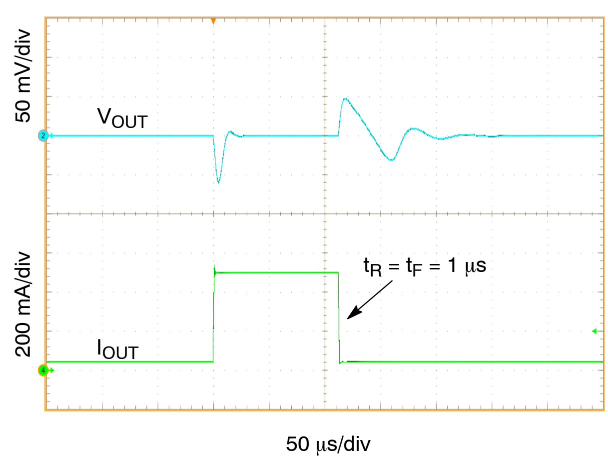


Figure 8. Load Transient Response, I_{OUT} = 50 mA to 500 mA, C_{OUT} = 22 μF

TYPICAL CHARACTERISTICS

At T_J = +25°C, $V_{IN} = V_{OUT(NOM)}$ + 0.3 V, V_{BIAS} = 2.7 V, V_{EN} = 1.0 V, $V_{OUT(NOM)}$ = 0.4 V, I_{OUT} = 500 mA, C_{IN} = 1 μF, C_{BIAS} = 0.1 μF, and C_{OUT} = 10 μF (effective capacitance value), unless otherwise noted.

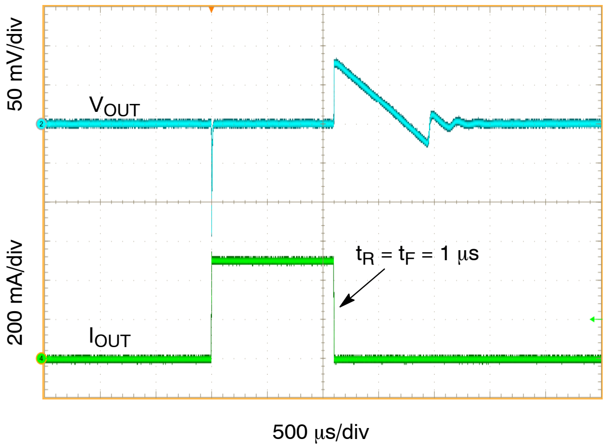


Figure 9. Load Transient Response, I_{OUT} = 1 mA to 500 mA, C_{OUT} = 10 μF

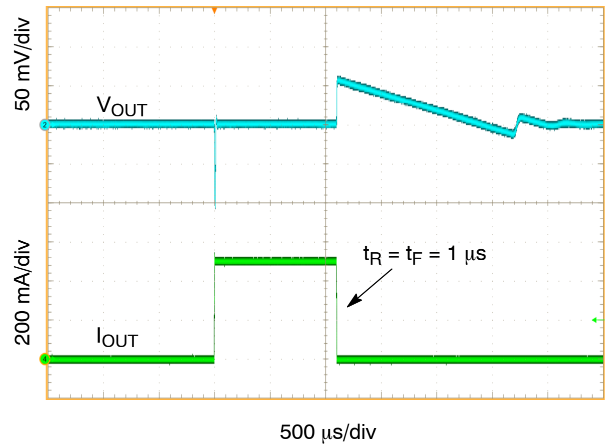


Figure 10. Load Transient Response, I_{OUT} = 1 mA to 500 mA, C_{OUT} = 22 μF

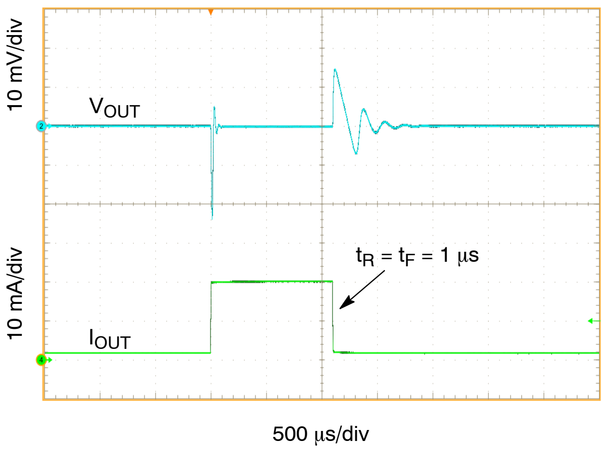


Figure 11. Load Transient Response, I_{OUT} = 1 mA to 20 mA, C_{OUT} = 10 μF

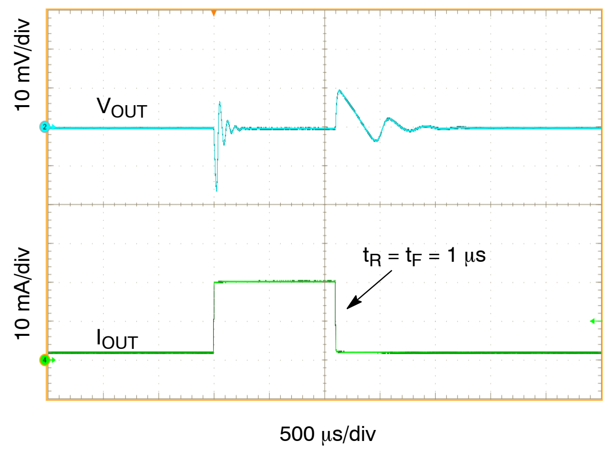


Figure 12. Load Transient Response, I_{OUT} = 1 mA to 20 mA, C_{OUT} = 22 μF

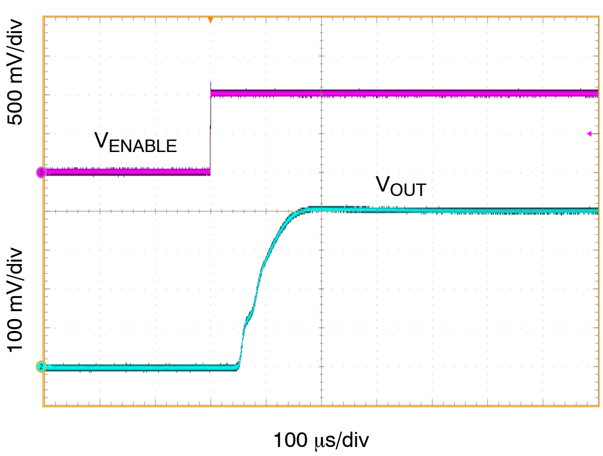


Figure 13. Enable Transient Response, I_{OUT} = 0 mA, C_{OUT} = 10 μF

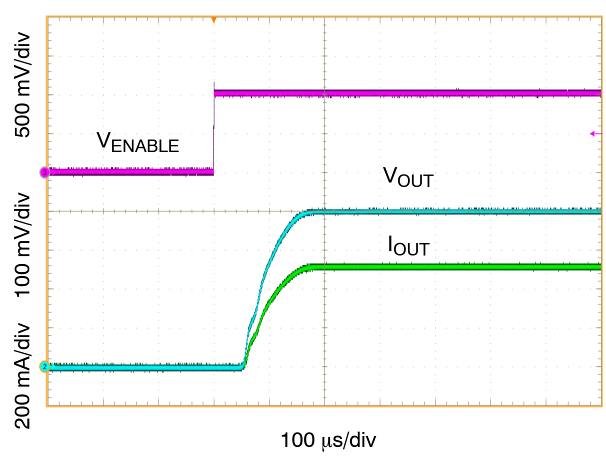


Figure 14. Enable Transient Response, Output Resistive Load 500 mA, C_{OUT} = 22 μF

TYPICAL CHARACTERISTICS

At T_J = +25°C, V_{IN} = $V_{OUT(NOM)}$ + 0.3 V, V_{BIAS} = 2.7 V, V_{EN} = 1.0 V, $V_{OUT(NOM)}$ = 0.4 V, I_{OUT} = 500 mA, C_{IN} = 1 μF, C_{BIAS} = 0.1 μF, and C_{OUT} = 10 μF (effective capacitance value), unless otherwise noted.

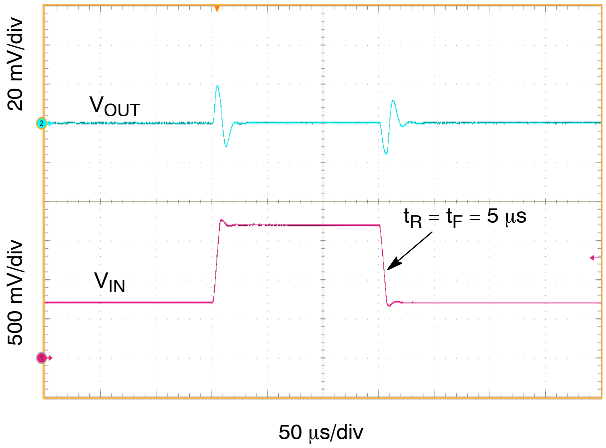


Figure 15. V_{IN} Line Transient Response, V_{IN} = 0.7 V to 1.7 V, I_{OUT} = 100 mA, C_{IN} = 0, C_{OUT} = 10 μF

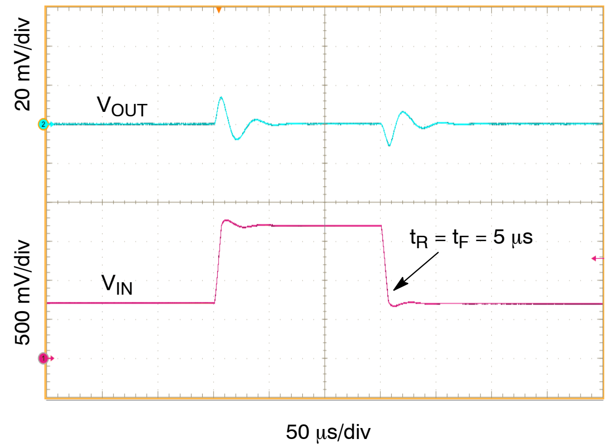


Figure 16. V_{IN} Line Transient Response, V_{IN} = 0.7 V to 1.7 V, I_{OUT} = 100 mA, C_{IN} = 0, C_{OUT} = 22 μF

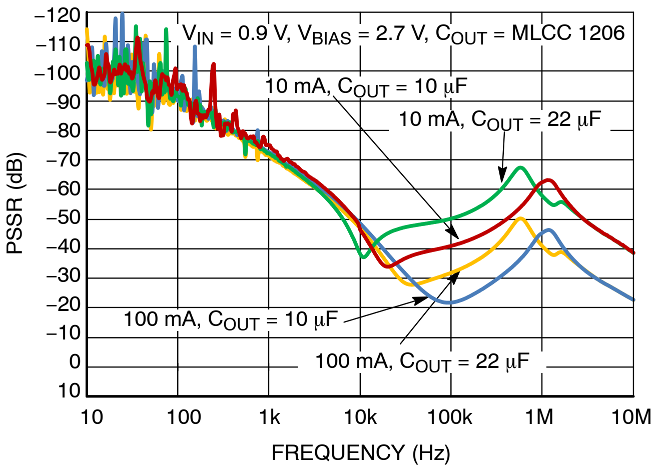


Figure 17. V_{IN} Power Supply Rejection Ratio vs. Frequency

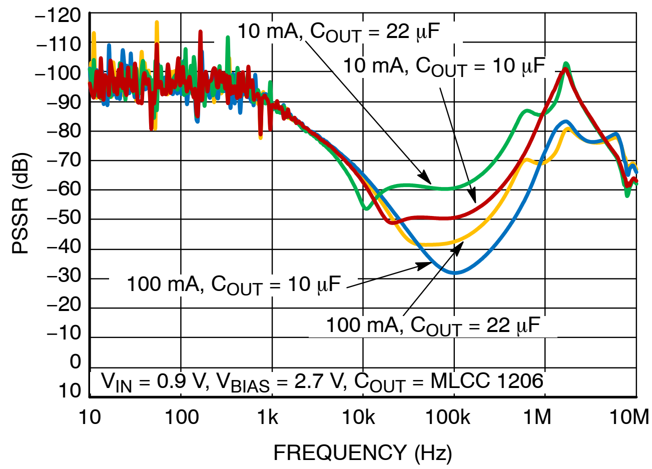


Figure 18. V_{BIAS} Power Supply Rejection Ratio vs. Frequency

TYPICAL CHARACTERISTICS

At T_J = +25°C, V_{IN} = $V_{OUT(NOM)}$ + 0.3 V, V_{BIAS} = 2.7 V, V_{EN} = 1.0 V, $V_{OUT(NOM)}$ = 0.4 V, I_{OUT} = 500 mA, C_{IN} = 1 μF, C_{BIAS} = 0.1 μF, and C_{OUT} = 10 μF (effective capacitance value), unless otherwise noted.

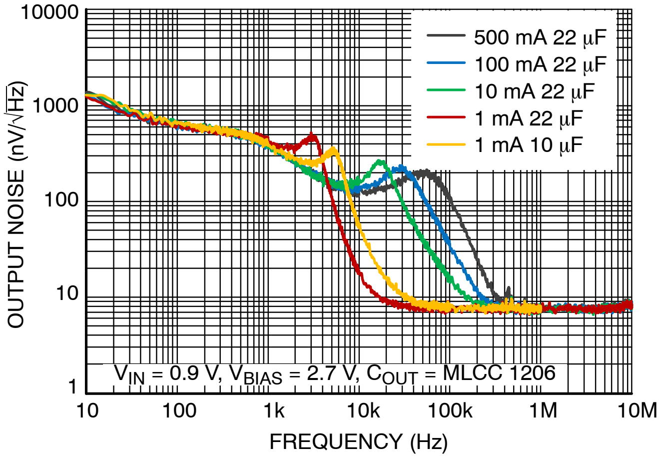


Figure 19. Output Voltage Noise Spectral Density at NCP135AMT040TBG

		RMS Output Noise Voltage (μV)	
I_{OUT}	C_{OUT}	**10 Hz – 100 kHz**	**100 Hz – 100 kHz**
1 mA	10 μF	28.67	27.54
1 mA	22 μF	28.19	27.28
10 mA	22 μF	36.23	35.49
100 mA	22 μF	45.44	44.87
500 mA	22 μF	54.54	54.04

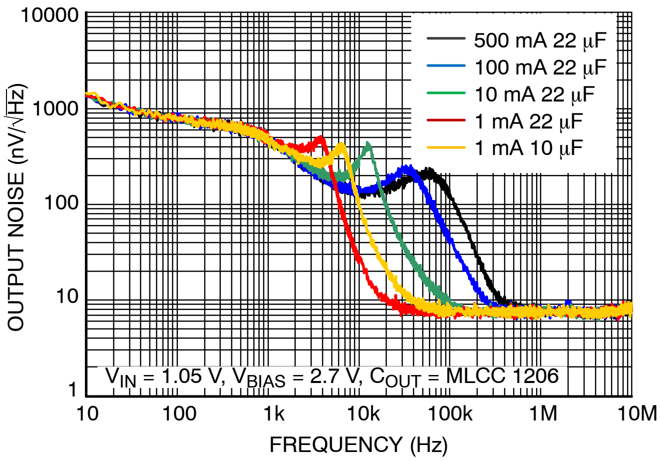


Figure 20. Output Voltage Noise Spectral Density at NCP135AMT040TBG

		RMS Output Noise Voltage (μV)	
I_{OUT}	C_{OUT}	**10 Hz – 100 kHz**	**100 Hz – 100 kHz**
1 mA	10 μF	35.34	34.22
1 mA	22 μF	33.39	32.22
10 mA	22 μF	41.85	40.91
100 mA	22 μF	51.70	50.98
500 mA	22 μF	59.78	59.16

APPLICATIONS INFORMATION

The NCP135 dual−rail very low dropout voltage regulator is using NMOS pass transistor for output voltage regulation from V_{IN} voltage. All the low current internal control circuitry is powered from the V_{BIAS} voltage.

The use of an NMOS pass transistor offers several advantages in applications. Unlike PMOS topology devices, the output capacitor has reduced impact on loop stability. V_{IN} to V_{OUT} operating voltage difference can be very low compared with standard PMOS regulators in very low Vin applications.

When enabled from Enable (EN) input, the NCP135 offers smooth monotonic start-up. The controlled voltage rising limits the inrush current.

The Enable (EN) input is equipped with internal hysteresis.

Dropout Voltage

The V_{IN} Dropout voltage is the voltage difference (V_{IN} – V_{OUT}) when V_{OUT} starts to decrease by percent specified in the Electrical Characteristics table with the V_{IN} voltage decreasing. V_{BIAS} is high enough; specific value is published in the Electrical Characteristics table.

Input and Output Capacitors

The device is designed to be stable for ceramic output capacitors with Effective capacitance in the range from 10 μF to 22 μF. The device is also stable with multiple capacitors in parallel, having the total effective capacitance in the specified range.

In applications where no low input supplies impedance available (PCB inductance in V_{IN} and/or V_{BIAS} inputs as example), the recommended C_{IN} = 1 μF and C_{BIAS} = 0.1 μF or greater. Ceramic capacitors are recommended. For the best performance all the capacitors should be connected to the NCP135 respective pins directly in the device PCB copper layer, not through vias having not negligible impedance.

When using small ceramic capacitor, their capacitance is not constant but varies with applied DC biasing voltage, temperature and tolerance. The effective capacitance can be much lower than their nominal capacitance value, most importantly in negative temperatures and higher LDO output voltages. That is why the recommended Output capacitor capacitance value is specified as Effective value in the specific application conditions.

Enable Operation

The enable pin will turn the regulator on or off. The threshold limits are covered in the electrical characteristics table in this data sheet. If the enable function is not to be used then the pin should be connected to V_{IN} or V_{BIAS}.

Current Limitation

The internal Current Limitation circuitry allows the device to supply the full nominal current and surges but protects the device against Current Overload or Short.

Thermal Protection

Internal thermal shutdown (TSD) circuitry is provided to protect the integrated circuit in the event that the maximum junction temperature is exceeded. When TSD activated, the regulator output turns off. When cooling down under the low temperature threshold, device output is activated again. This TSD feature is provided to prevent failures from accidental overheating.

Activation of the thermal protection circuit indicates excessive power dissipation or inadequate heatsinking. For reliable operation, junction temperature should be limited to +125°C maximum.

ORDERING INFORMATION

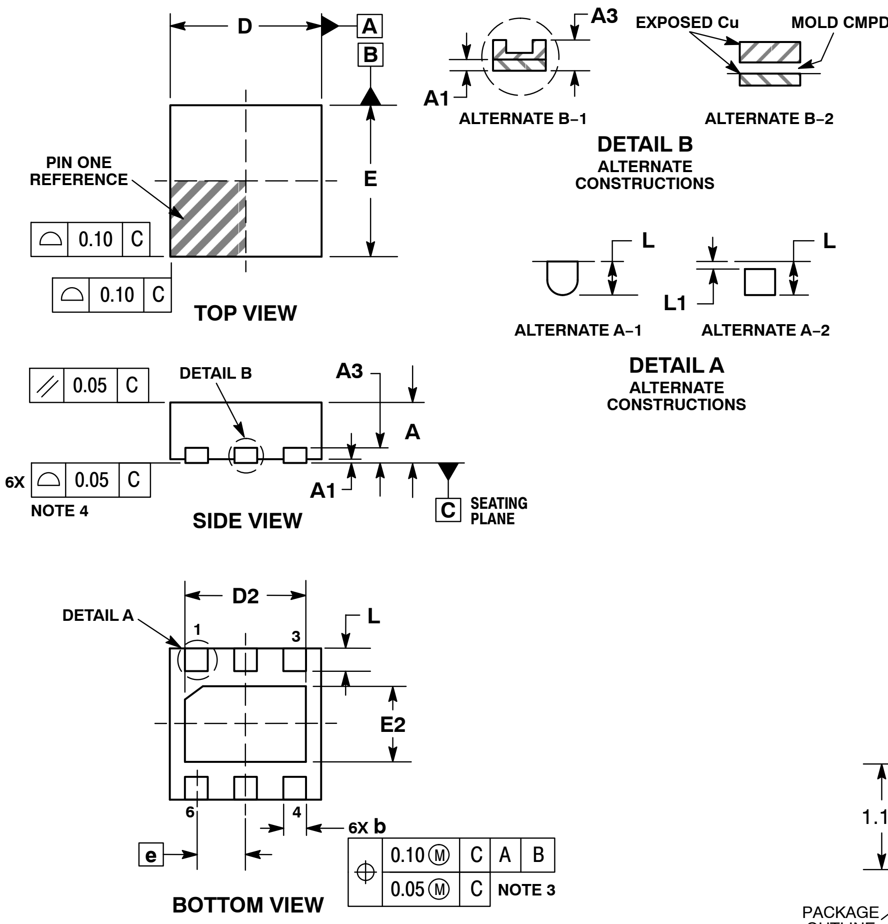
Device	Marking	Option	Package	Shipping†
NCP135AMT040TBG	KA	Output Active Discharge	WDFN6 (Pb−Free)	3000 / Tape & Reel
NCP135BMT040TBG	KC	Non−Active Discharge		
NCP135AMT075TBG	KG	Output Active Discharge		

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

To order other package and voltage variants, please contact your ON Semiconductor sales representative

PACKAGE DIMENSIONS

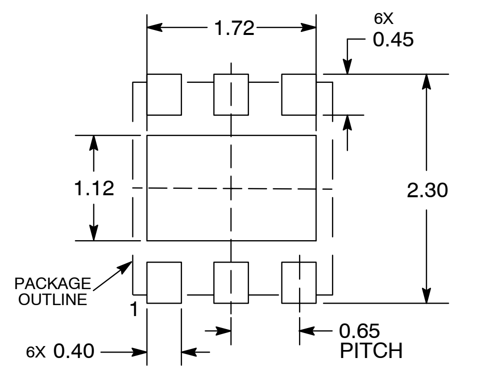
WDFN6 2x2, 0.65P
CASE 511BR
ISSUE B



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.25 mm FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. FOR DEVICES CONTAINING WETTABLE FLANK OPTION, DETAIL A ALTERNATE CONSTRUCTION A-2 AND DETAIL B ALTERNATE CONSTRUCTION B-2 ARE NOT APPLICABLE.

	MILLIMETERS	
DIM	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
A3	0.20 REF	
b	0.25	0.35
D	2.00 BSC	
D2	1.50	1.70
E	2.00 BSC	
E2	0.90	1.10
e	0.65 BSC	
L	0.20	0.40
L1	---	0.15

RECOMMENDED MOUNTING FOOTPRINT



DIMENSIONS: MILLIMETERS

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