NCP623, NCV8623

Voltage Regulator - Low Dropout, Ultra Low Noise

150 mA

The NCP623/NCV8623 low dropout linear regulator can deliver up to 150 mA of output current with a typical dropout voltage of 180 mV. This low dropout feature helps to maintain a regulated output voltage for a longer period of time as the lifetime of the battery decreases.

It is the ideal choice for noise sensitive environments like portable applications where noise performance and space are at a premium. The typical output noise voltage specification is 25 μV_{RMS}. An additional noise saving feature of this device is its ability to filter choppy signals on the power supply by providing a typical DC ripple rejection of −90 dB and −70 dB at 1.0 kHz.

The NCP623 is designed to work with very low ESR capacitors such as ceramic capacitors which are common in the industry now.

Additional features such as thermal shutdown and short−circuit protection provide for a robust system design.

Features

- Very Low Quiescent Current 170 μA (ON, no load), 100 nA (OFF, no load)
- Very Low Dropout Voltage, Typical Value is 137 mV at an Output Current of 100 mA
- Very Low Noise with External Bypass Capacitor (10 nF), Typically 25 μV_{RMS} over 100 Hz to 100 kHz
- Internal Thermal Shutdown
- Extremely Tight Line Regulation Typically −90 dB
- Ripple Rejection −70 dB @ 1.0 kHz
- Line Transient Response: 1.0 mV for ΔV_{in} = 3.0 V
- Extremely Tight Load Regulation, Typically 20 mV at ΔI_{out} = 150 mA
- Multiple Output Voltages Available
- Logic Level ON/OFF Control (TTL−CMOS Compatible)
- Output Capacitor ESR Can Vary from 0 Ω to 3.0 Ω
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

Applications

- All Portable Systems, Battery Powered Systems, Cellular Telephones, Radio Control Systems, Toys and Low Voltage Systems

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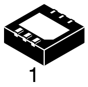
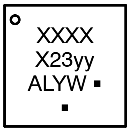
MARKING DIAGRAM



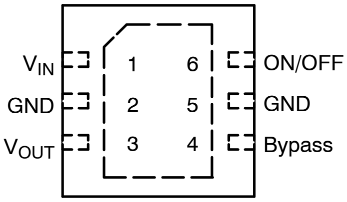
DFN6, 3X3
MN SUFFIX
CASE 488AE



XXXXX = Device Code
NCP623yy for NCP623
NCV8623yyfor NCV8623
yy = 25, 28, 30, 33, 40 or 50
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb Free Package

(Note: Microdot may be in either location)

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information on page 14 of this data sheet.

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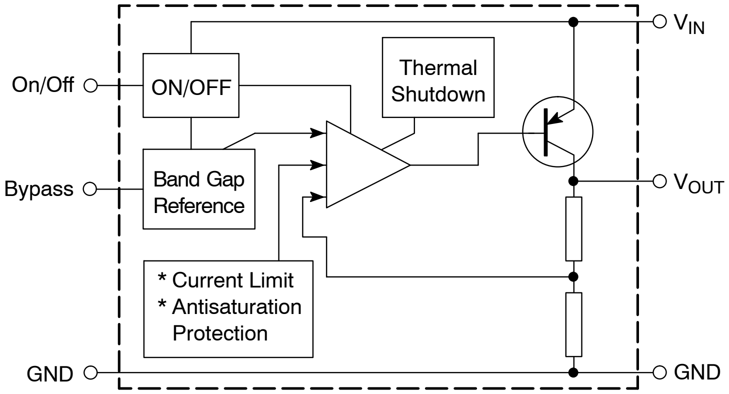


Figure 1. NCP623/NCV8623 Block Diagram

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{in}	12	V
Power Dissipation and Thermal Resistance Maximum Power Dissipation Case 488AE (DFN6, 3x3) MN Suffix Thermal Resistance, Junction−to−Air Thermal Resistance, Junction−to−Case	P_D $R_{\theta JA}$ **psi−JC* or Ψ_{JC}	Internally Limited 161 13	W °C/W
Operating Ambient Temperature Range NCP623 NCV8623	T_A	−40 to +85 −40 to +125	°C
Maximum Junction Temperature	T_{Jmax}	150	°C
Storage Temperature Range	T_{stg}	−60 to +150	°C
ESD Protection – Human Body Model – Machine Model	V_{ESD}	2000 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.

*“C” (“case”) is defined as the solder−attach interface between the center of the exposed pad on the bottom of the package, and the board to which it is attached.

** Refer to the JEDEC Specs (51−2, 51−6).

ELECTRICAL CHARACTERISTICS (For typical values T_A = 25°C, for min/max values; T_A = −40°C to +85°C for NCP623 and T_A = −40°C to +125°C for NCV8623, Max T_J = 150°C)

Characteristics	Symbol	Min	Typ	Max	Unit
CONTROL ELECTRICAL CHARACTERISTICS					
Input Voltage Range	$V_{ON/OFF}$	2.5	–	V_{in}	V
ON/OFF Input Current (All versions) $V_{ON/OFF}$ = 2.4 V	$I_{ON/OFF}$	–	2.5	–	μA
ON/OFF Input Voltages (All versions)	$V_{ON/OFF}$				V
Logic “0”, i.e. OFF State		–	–	0.3	
Logic “1”, i.e. ON State		2.2	–	–	
CURRENTS PARAMETERS					
Current Consumption in OFF State (All versions) OFF Mode Current: V_{IN} = V_{out} +1.0 V, I_{out} = 0 mA	IQ_{OFF}	–	0.1	2.0	μA
Current Consumption in ON State (All versions) ON Mode Sat Current: V_{in} = V_{out} + 1.0 V, I_{out} = 0 mA	IQ_{ON}	–	170	200	μA
Current Consumption in Saturation ON State (All versions) ON Mode Sat Current: V_{IN} = 2.5 V or V_{in} = V_{out} − 0.4 V (Whichever is Higher), I_{out} = 0 mA	IQ_{SAT}	–	900	1400	μA
Current Limit V_{in} = V_{out} + 1.0 V, (All versions) (Note 1)	I_{MAX}	175	210	–	mA
V_{in} = V_{out} + 1.0 V, T_A = 25°C, 1.0 mA < I_{out} < 150 mA	V_{out}				V
2.5 Suffix		2.45	2.5	2.55	
2.8 Suffix		2.74	2.8	2.86	
3.0 Suffix		2.94	3.0	3.06	
3.3 Suffix		3.23	3.3	3.37	
4.0 Suffix		3.92	4.0	4.08	
4.5 Suffix		4.41	4.5	4.59	
5.0 Suffix		4.90	5.0	5.1	
V_{in} = V_{out} + 1.0 V, −40°C < T_A < 85°C, 1.0 mA < I_{out} < 150 mA	V_{out}				V
2.5 Suffix		2.41	2.5	2.59	
2.8 Suffix		2.70	2.8	2.90	
3.0 Suffix		2.89	3.0	3.11	
3.3 Suffix		3.18	3.3	3.42	
4.0 Suffix		3.86	4.0	4.14	
4.5 Suffix		4.34	4.5	4.66	
5.0 Suffix		4.83	5.0	5.17	
LINE AND LOAD REGULATION, DROPOUT VOLTAGES					
Line Regulation (All versions) V_{out} + 1.0 V < V_{in} < 12 V, I_{out} = 60 mA	Reg_{line}	–	2.0	10	mV
Load Regulation (All versions) V_{in} = V_{out} + 1.0 V	Reg_{load}				mV
I_{out} = 1.0 to 60 mA		–	8.0	25	
I_{out} = 1.0 to 100 mA		–	15	35	
I_{out} = 1.0 to 150 mA		–	20	45	
Dropout Voltage (All versions)	V_{in} − V_{out}				mV
I_{out} = 10 mA		–	30	90	
I_{out} = 100 mA		–	137	230	
I_{out} = 150 mA		–	180	260	
DYNAMIC PARAMETERS					
Ripple Rejection (All versions) V_{in} = V_{out} + 1.0 V, V_{pp} = 1.0 V, f = 1.0 kHz, I_{out} = 60 mA		60	70	–	dB
Line Transient Response V_{in} = V_{out} + 1.0 V to V_{out} + 4.0 V, I_{out} = 60 mA, d(V_{in})/dt = 15 mV/μs		–	1.0	–	mV

ELECTRICAL CHARACTERISTICS (For typical values T_A = 25°C, for min/max values; T_A = −40°C to +85°C for NCP623 and T_A = −40°C to +125°C for NCV8623, Max T_J = 150°C)

Characteristics	Symbol	Min	Typ	Max	Unit
DYNAMIC PARAMETERS					
Output Noise Voltage (All versions) C_{out} = 1.0 μF, I_{out} = 60 mA, f = 100 Hz to 100 kHz	V_{RMS}				μVrms
C_{bypass} = 10 nF		–	25	–	
C_{bypass} = 1.0 nF		–	40	–	
C_{bypass} = 0 nF		–	65	–	
Output Noise Density C_{out} = 1.0 μF, I_{out} = 60 mA, f = 1.0 kHz	V_N	–	230	–	nV/√Hz
Output Rise Time (All versions) C_{out} = 1.0 μF, I_{out} = 30 mA, $V_{ON/OFF}$ = 0 to 2.4 V 1% of ON/OFF Signal to 99% of Nominal Output Voltage	t_r				
Without Bypass Capacitor		–	40	–	μs
With C_{bypass} = 10 nF		–	1.1	–	ms
THERMAL SHUTDOWN					
Thermal Shutdown (All versions)		–	150	–	°C

1. I_{MAX} (Output Current Limit) is the current measured when the output voltage drops below 0.3 V with respect to V_{out} at I_{out} = 30 mA.

DEFINITIONS

Load Regulation – The change in output voltage for a change in load current at constant chip temperature.

Dropout Voltage – The input/output differential at which the regulator output no longer maintains regulation against further reductions in input voltage. Measured when the output drops 100 mV below its nominal value (which is measured at 1.0 V differential), dropout voltage is affected by junction temperature, load current and minimum input supply requirements.

Output Noise Voltage – The RMS AC voltage at the output with a constant load and no input ripple, measured over a specified frequency range.

Maximum Power Dissipation – The maximum total dissipation for which the regulator will operate within specifications.

Quiescent Current – Current which is used to operate the regulator chip and is not delivered to the load.

Line Regulation – The change in input voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

Line Transient Response – Typical over– and undershoot response when input voltage is excited with a given slope.

Thermal Protection – Internal thermal shutdown circuitry is provided to protect the integrated circuit in the event that the maximum junction temperature is exceeded. When activated, typically 150°C, the regulator turns off. This feature is provided to prevent catastrophic failures from accidental overheating.

Maximum Package Power Dissipation – The maximum package power dissipation is the power dissipation level at which the junction temperature reaches its maximum value i.e. 125°C. The junction temperature is rising while the difference between the input power (V_{CC} X I_{CC}) and the output power (V_{out} X I_{out}) is increasing.

Depending on ambient temperature, it is possible to calculate the maximum power dissipation, maximum load current or maximum input voltage (see Application Hints: Protection).

The maximum power dissipation supported by the device is a lot increased when using appropriate application design. Mounting pad configuration on the PCB, the board material and also the ambient temperature are affected the rate of temperature rise. It means that when the I_C has good thermal conductivity through PCB, the junction temperature will be "low" even if the power dissipation is great.

The thermal resistance of the whole circuit can be evaluated by deliberately activating the thermal shutdown of the circuit (by increasing the output current or raising the input voltage for example).

Then you can calculate the power dissipation by subtracting the output power from the input power. All variables are then well known: power dissipation, thermal shutdown temperature (150°C for NCP623) and ambient temperature.

APPLICATION HINTS

Input Decoupling – As with any regulator, it is necessary to reduce the dynamic impedance of the supply rail that feeds the component. A 1.0 μF capacitor either ceramic or tantalum is recommended and should be connected close to the NCP623 package. Higher values will correspondingly improve the overall line transient response.

Output Decoupling – Output capacitors exhibiting ESRs ranging from a few mΩ up to 3.0 Ω can safely be used. The minimum decoupling value is 1.0 μF and can be augmented to fulfill stringent load transient requirements. The regulator works with ceramic chip capacitors as well as tantalum devices.

Noise Performances – Unlike other LDOs, the NCP623 is a true low−noise regulator. With a 10 nF bypass capacitor, it typically reaches 25 μVRMS overall noise between 100 Hz and 100 kHz. Spectral density graphics as well as noise dependency versus bypass capacitor information is included in this datasheet.

The bypass capacitor impacts the startup phase of the NCP623 as depicted by the data−sheet curves. A typical 1.0 ms settling time is achieved with a 10 nF bypass capacitor. However, due to its low−noise architecture, the NCP623 can operate without bypass and thus offers a typical 20 μs startup phase. In that case, the typical output noise stays lower than 65 μVRMS between 100 Hz − 100 kHz.

Protections – The NCP623 includes several protections functions. The output current is internally limited to a minimum of 175 mA while temperature shutdown occurs if the die heats up beyond 150°C. These value lets you assess the maximum differential voltage the device can sustain at a given output current before its protections come into play.

The maximum dissipation the package can handle is given by:

$$P_{max} = \frac{T_{Jmax} - T_A}{R_{\theta JA}}$$

If T_{Jmax} is internally limited to 150°C, then the NCP623 can dissipate up to 595 mW @ 25°C.

The power dissipated by the NCP623 can be calculated from the following formula:

$$Ptot = \langle V_{in} \cdot I_{gnd}(I_{out}) \rangle + \langle V_{in} - V_{out} \rangle \cdot I_{out}$$

or

$$Vin_{max} = \frac{Ptot + V_{out} \cdot I_{out}}{I_{gnd} + I_{out}}$$

If a 150 mA output current is needed, the ground current is extracted from the data−sheet curves: 6.5 mA @ 150 mA. For a NCP623NW28R2 (2.8 V), the maximum input voltage will then be 6.48 V, a rather comfortable margin.

Typical Application – The following figure portraits the typical application for the NCP623 where both input/output decoupling capacitors appear.

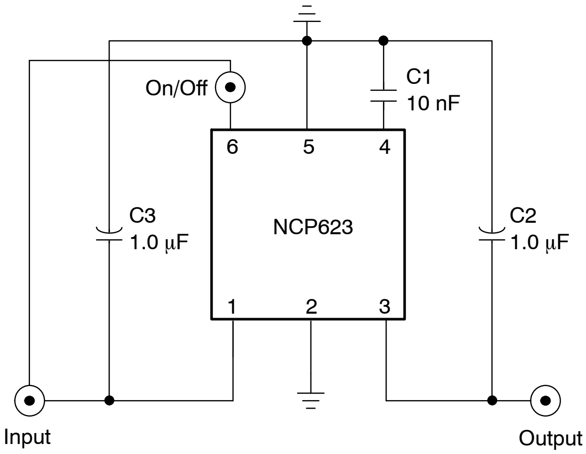


Figure 2. A Typical NCP623 Application with Recommended Capacitor Values

NCP623 Wake−up Improvement − In portable applications, an immediate response to an enable signal is vital. If noise is not a concern, the NCP623 without a bypass capacitor settles in nearly 20 μs and typically delivers 65 μVRMS between 100 Hz and 100 kHz.

In ultra low−noise systems, the designer needs a 10 nF bypass capacitor to decrease the noise down to 25 μVRMS between 100 Hz and 100 kHz. With the addition of the 10 nF capacitor, the wake−up time expands up to 1.0 ms as shown on the data−sheet curves. If an immediate response is wanted, Figure 3 provides a solution to charge the bypass capacitor with the enable signal without degrading the noise response of the NCP623.

At power−on, C4 is discharged. When the control logic sends its wake−up signal by going high, the PNP base is momentarily tied to ground. The PNP switch closes and immediately charges the bypass capacitor C1 toward its operating value. After a few μs, the PNP opens and becomes totally transparent to the regulator.

This circuit improves the response time of the regulator which drops from 1.0 ms down to 30 μs. The value of C4 needs to be tweaked in order to avoid any bypass capacitor overload during the wake−up transient.

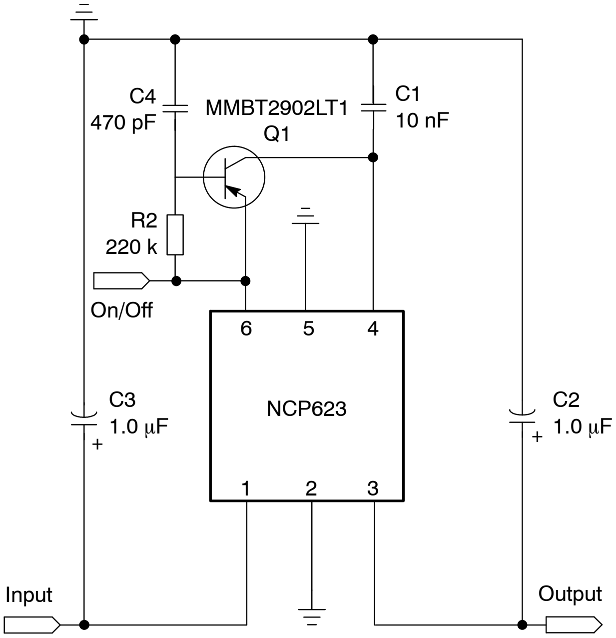


Figure 3. A PNP Transistor Drives the Bypass Pin when Enable Goes High

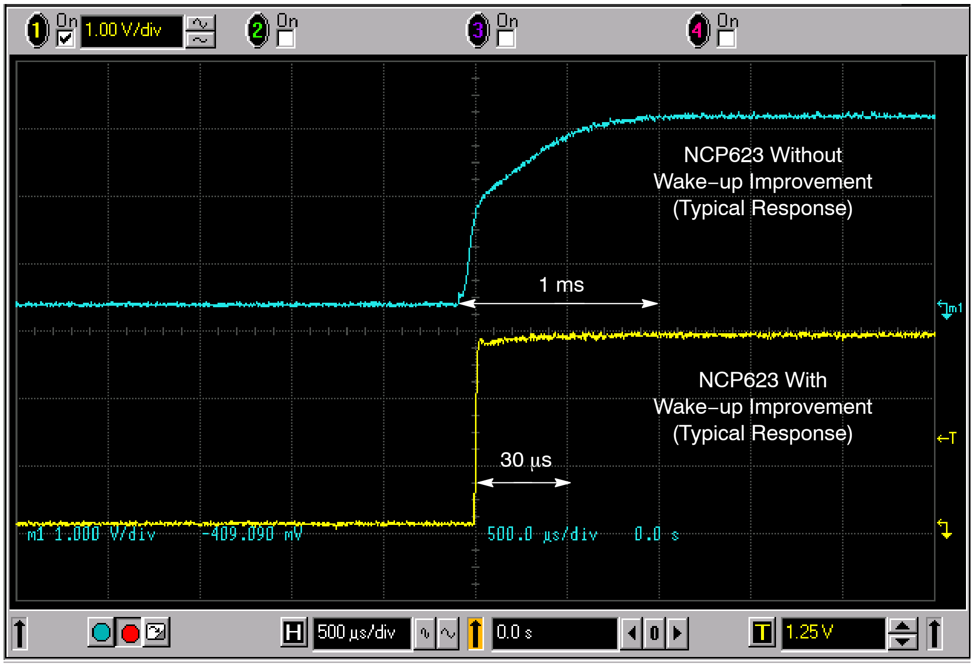


Figure 4. NCP623 Wake–up Improvement with Small PNP Transistor

The PNP connected to the bypass pin does not degrade the noise response of the NCP623. Figure 5 displays the noise density using the setup in Figure 3. The typical noise level is 26 μV_{RM} (100 Hz to 25 kHz) at I_{OUT} = 60 mA.

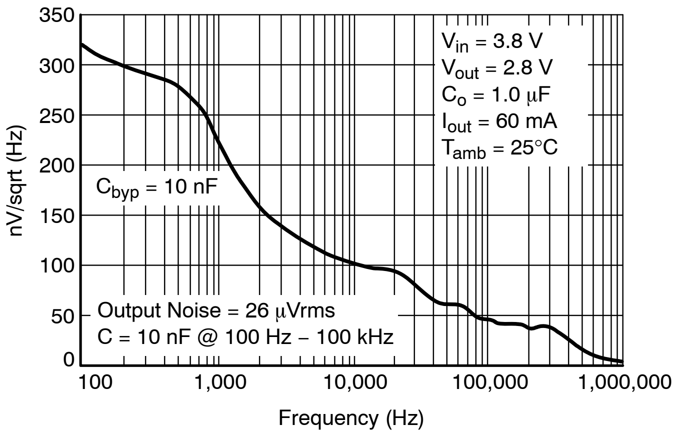


Figure 5. Noise Density of the NCP623 with a 10 nF Bypass Capacitor and a Wake–up Improvement Network

TYPICAL PERFORMANCE CHARACTERISTICS

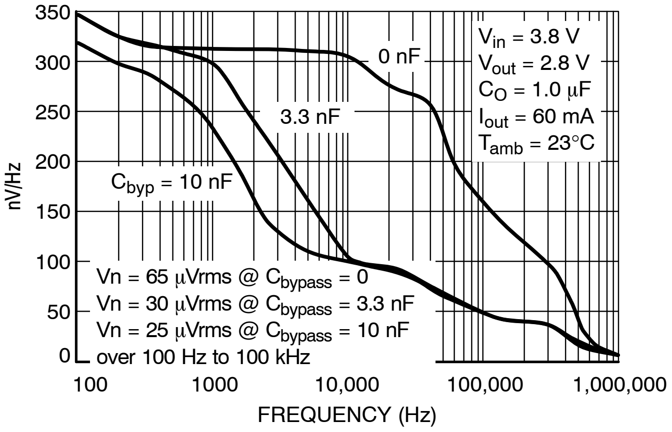


Figure 6. Noise Density versus Bypass Capacitor

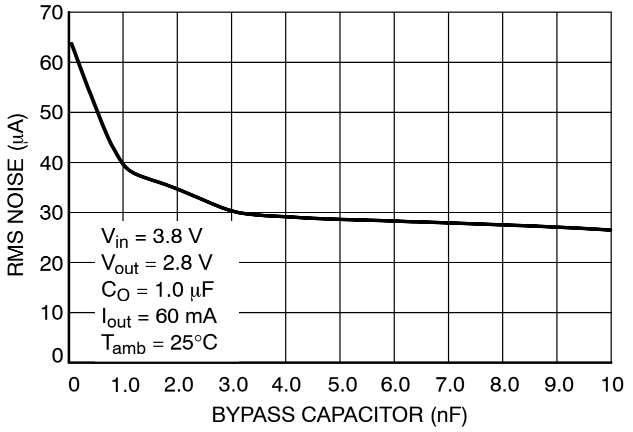


Figure 7. RMS Noise versus Bypass Capacitor (100 Hz – 100 kHz)

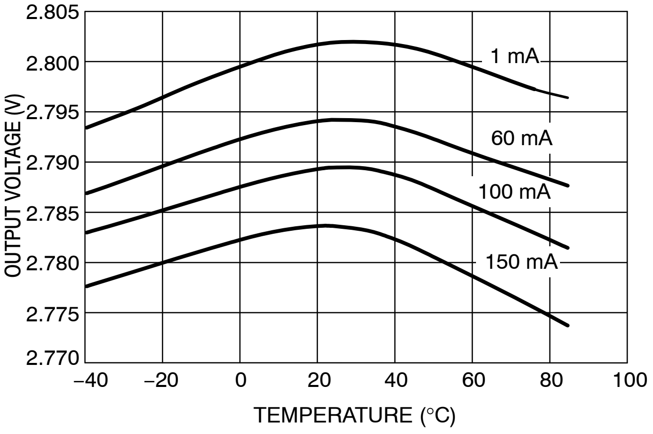


Figure 8. Output Voltage (2.8 V) versus Temperature

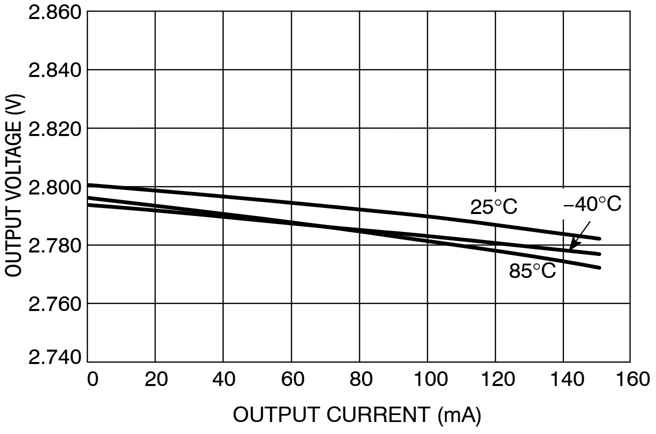


Figure 9. Output Voltage (2.8 V) versus I_{out}

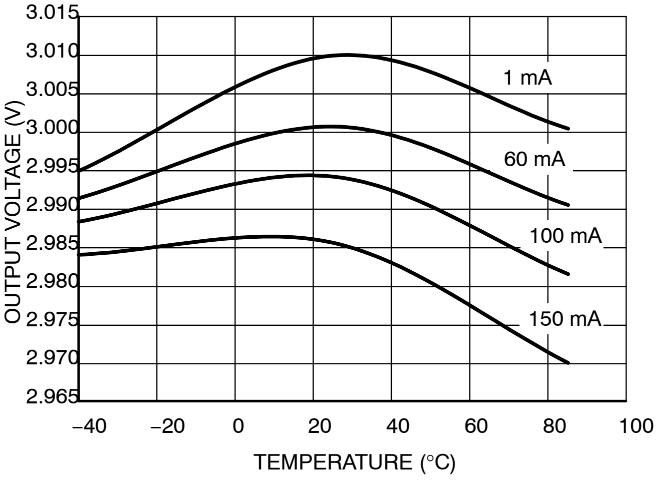


Figure 10. Output Voltage (3.0 V) versus Temperature

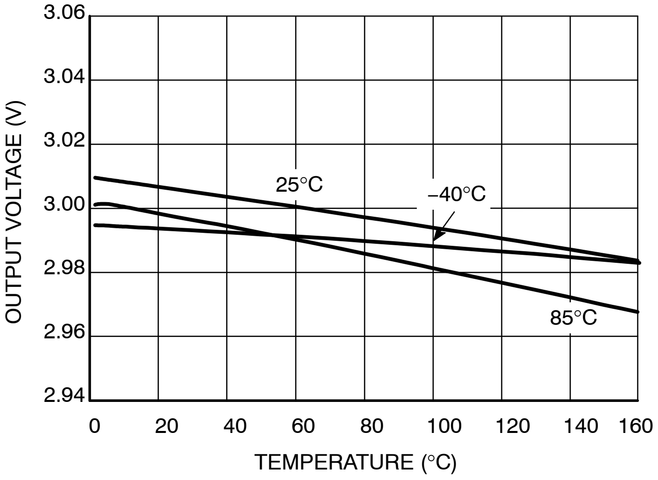


Figure 11. Output Voltage (3.0 V) versus I_{out}

TYPICAL PERFORMANCE CHARACTERISTICS

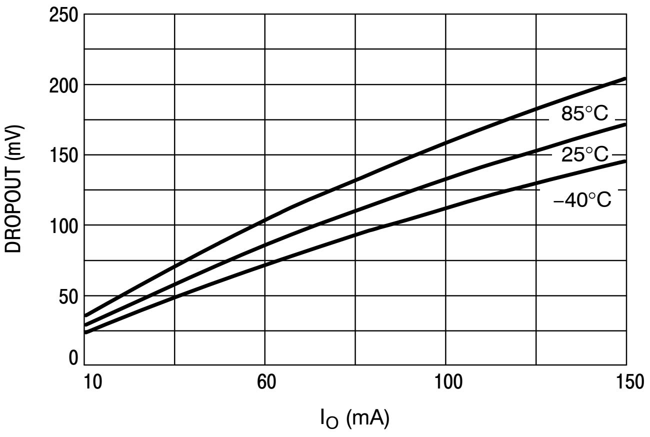


Figure 12. Dropout Voltage versus I_{out}

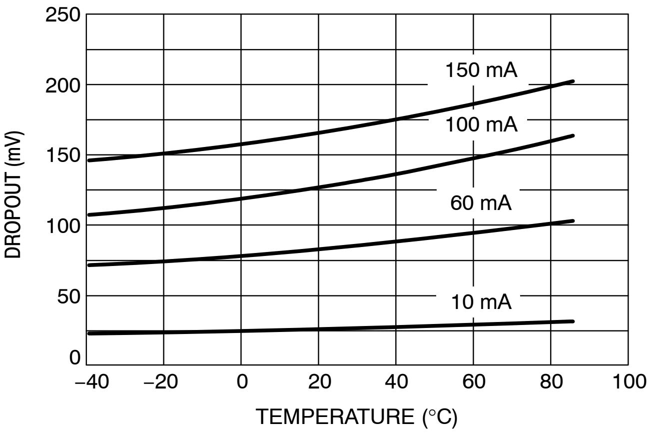


Figure 13. Dropout Voltage versus Temperature

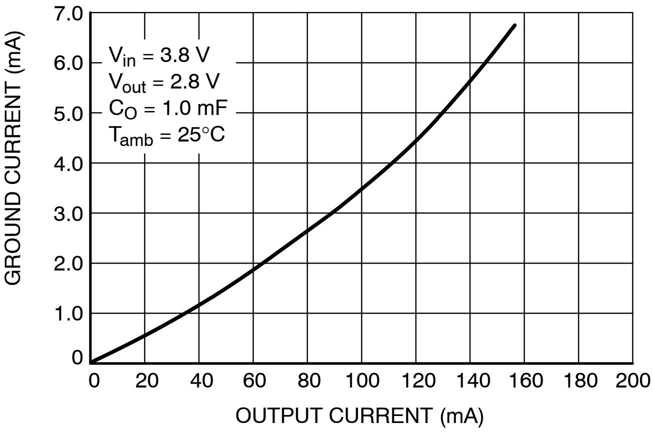


Figure 14. Ground Current versus Output Current

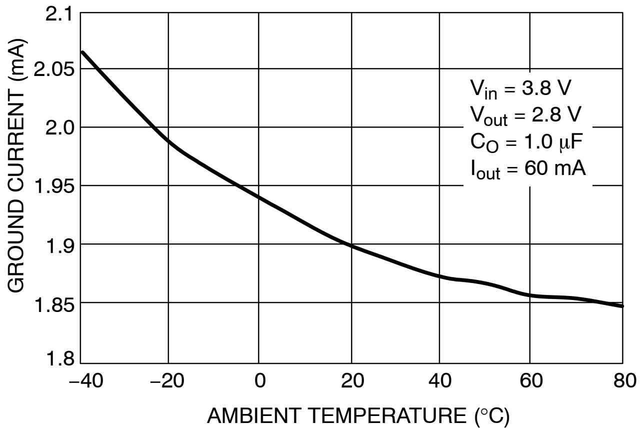


Figure 15. Ground Current versus Ambient Temperature

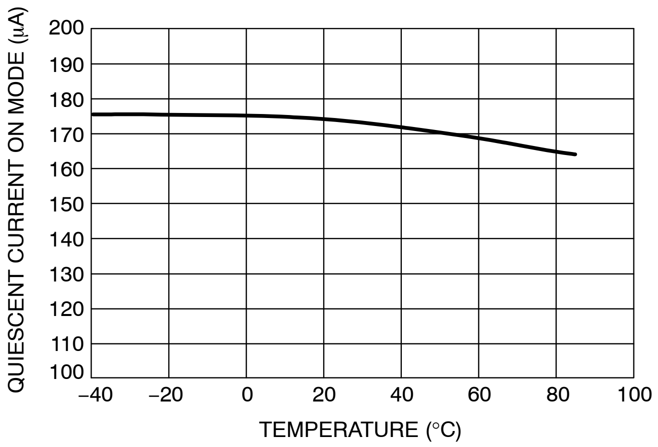


Figure 16. Quiescent Current versus Temperature

TYPICAL PERFORMANCE CHARACTERISTICS

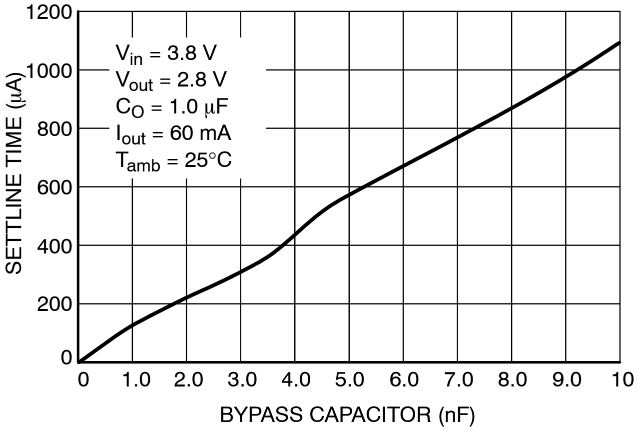


Figure 17. Output Voltage Settling Time versus Bypass Capacitor

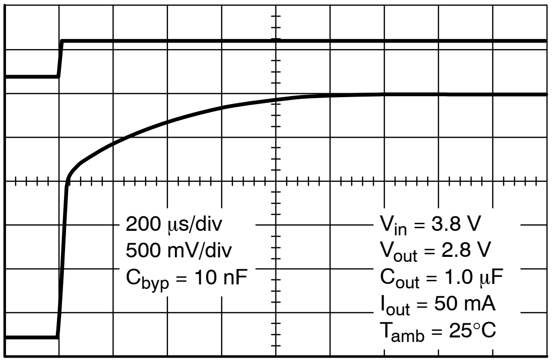


Figure 18. Output Voltage Settling Shape C_{bypass} = 10 nF

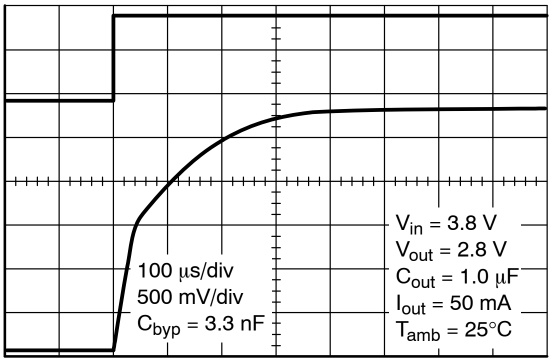


Figure 19. Output Voltage Settling Shape C_{bypass} = 3.3 nF

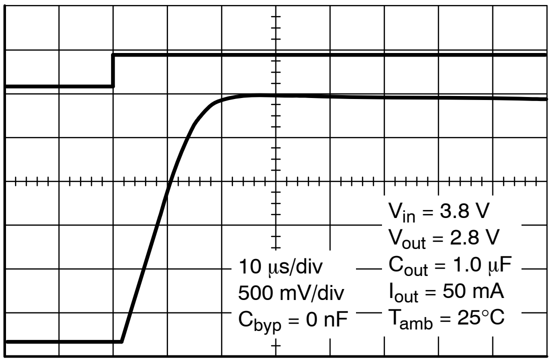


Figure 20. Output Voltage Settling Shape without Bypass Capacitor

TYPICAL PERFORMANCE CHARACTERISTICS

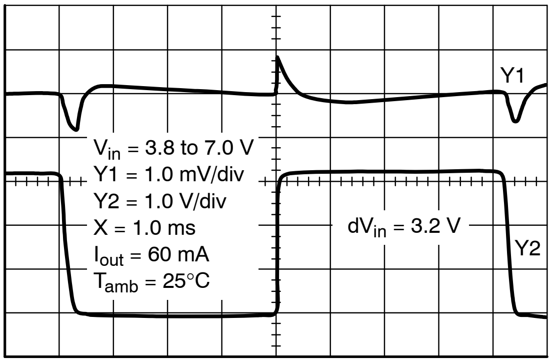
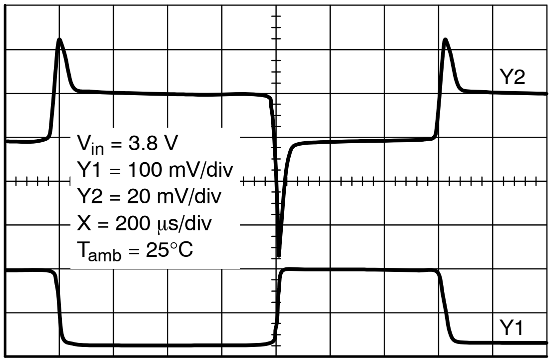
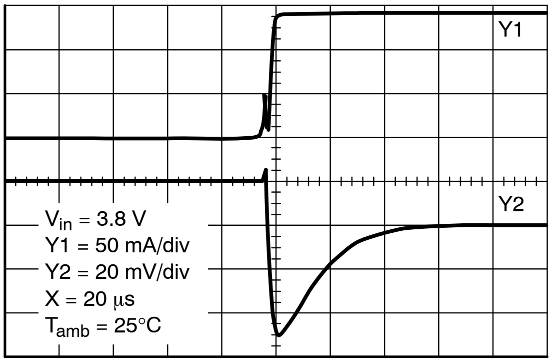


Figure 21. Line Transient Response



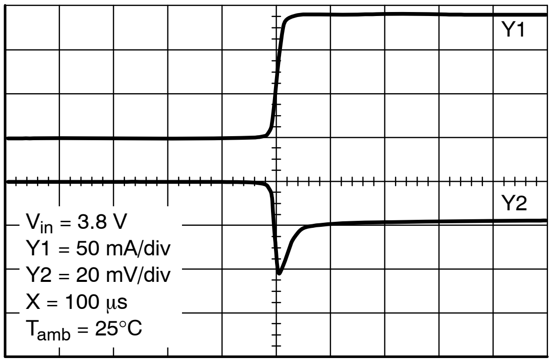
Y1: OUTPUT CURRENT, Y2: OUTPUT VOLTAGE

Figure 22. I_{out} = 3.0 mA to 150 mA



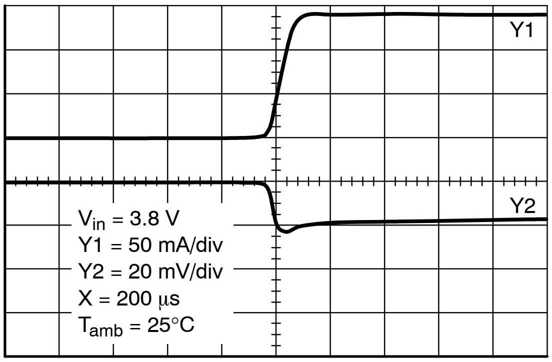
Y1: OUTPUT CURRENT, Y2: OUTPUT VOLTAGE

Figure 23. I_{Slope} = 100 mA/μs (Large Scale)
I_{out} = 3.0 mA to 150 mA



Y1: OUTPUT CURRENT, Y2: OUTPUT VOLTAGE

Figure 24. I_{Slope} = 6.0 mA/μs (Large Scale)
I_{out} = 3.0 mA to 150 mA



Y1: OUTPUT CURRENT, Y2: OUTPUT VOLTAGE

Figure 25. I_{Slope} = 2.0 mA/μs (Large Scale)
I_{out} = 3.0 mA to 150 mA

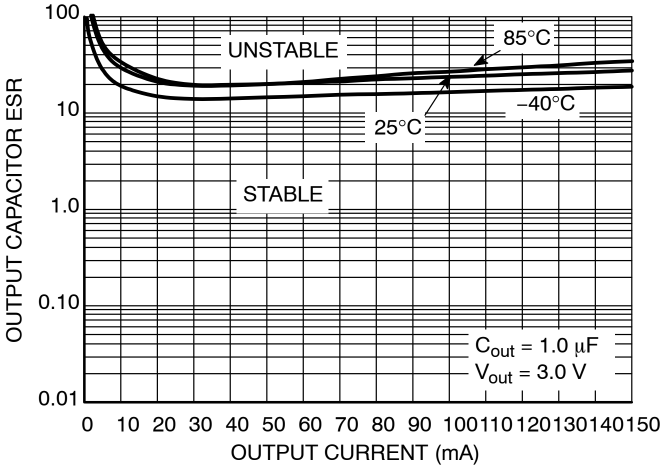


Figure 26. Output Stability versus Output Current Over Temperature (1.0 μF, 3.0 V)

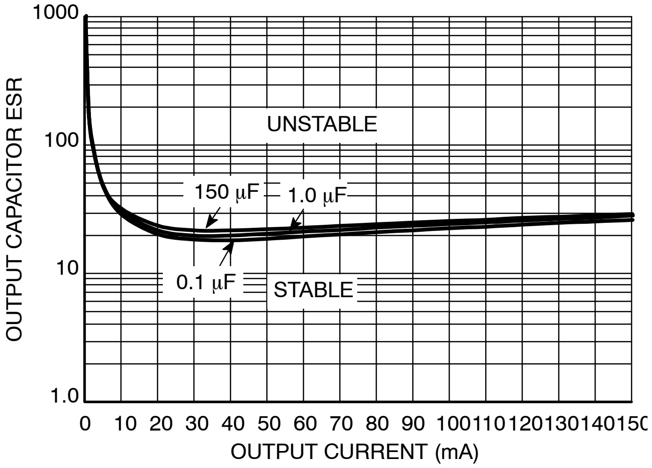


Figure 27. Output Stability with Output Capacitor Change

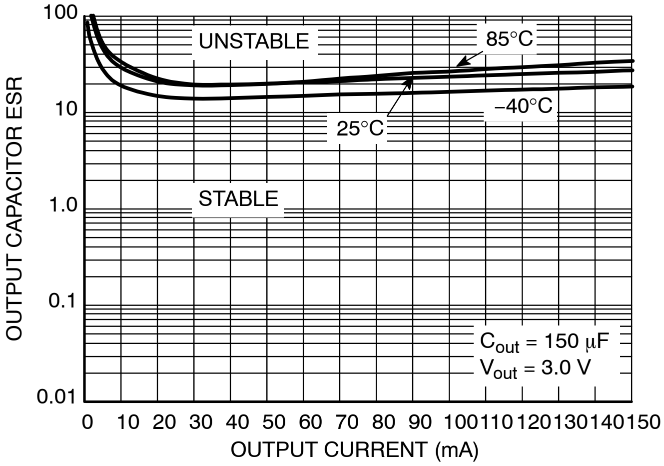


Figure 28. Output Stability versus Output Current Over Temperature (150 μF, 3.0 V)

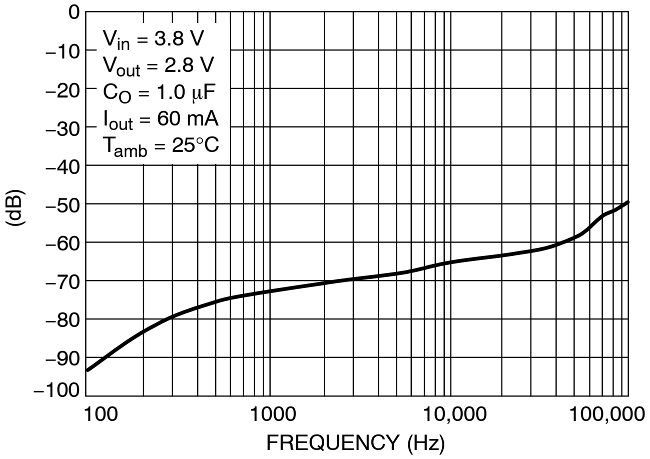


Figure 29. Ripple Rejection versus Frequency with 10 nF Bypass Capacitor

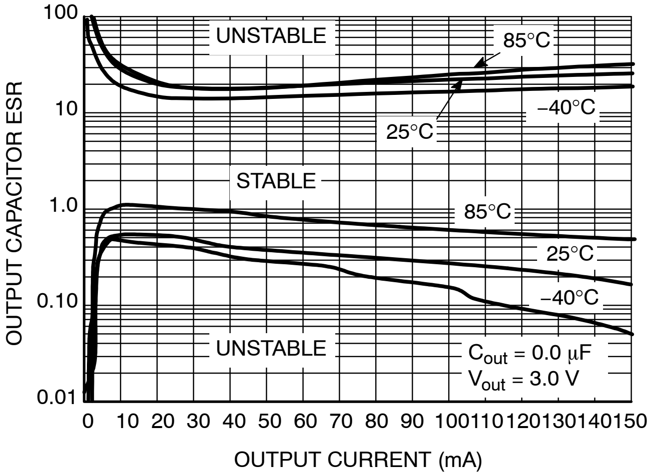


Figure 31. Output Stability versus Output Current Over Temperature (0.1 μF, 3.0 V)

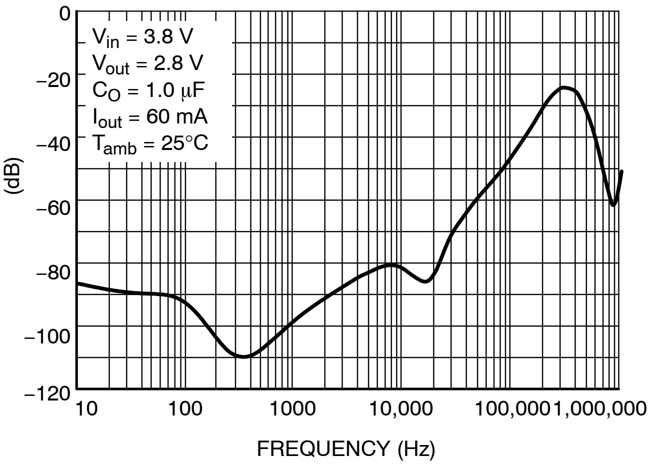


Figure 30. Ripple Rejection versus Frequency without Bypass Capacitor

ORDERING INFORMATION

Device	Version	Marking	Package	Shipping†
NCP623MN−25R2G	2.5 V	25	DFN6, 3x3 (Pb−Free)	3000 Tape & Reel
NCV8623MN−25R2G*				
NCP623MN−28R2G	2.8 V	28		
NCV8623MN−28R2G*				
NCP623MN−30R2G	3.0 V	30		
NCV8623MN−30R2G*				
NCP623MN−33R2G	3.3 V	33		
NCV8623MN−33R2G*				
NCP623MN−40R2G	4.0 V	40		
NCV8623MN−40R2G*				
NCP623MN−50R2G	5.0 V	50		
NCV8623MN−50R2G*				

†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.

*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable.