

# NCV8664

## Linear Regulator - Low Dropout, Very Low $I_q$

The NCV8664 is a precision 3.3 V and 5.0 V fixed output, low dropout integrated voltage regulator with an output current capability of 150 mA. Careful management of light load current consumption, combined with a low leakage process, achieve a typical quiescent current of 22  $\mu$ A.

NCV8664 is pin and functionally compatible with NCV4264 and NCV4264-2, and it could replace these parts when very low quiescent current is required.

The output voltage is accurate within  $\pm 2.0\%$ , and maximum dropout voltage is 600 mV at full rated load current.

It is internally protected against input supply reversal, output overcurrent faults, and excess die temperature. No external components are required to enable these features.

### Features

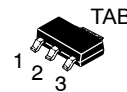
- 3.3 V, 5.0 V Fixed Output
- $\pm 2.0\%$  Output Accuracy, Over Full Temperature Range
- 30  $\mu$ A Maximum Quiescent Current at  $I_{OUT} = 100 \mu$ A
- 600 mV Maximum Dropout Voltage at 150 mA Load Current
- Wide Input Voltage Operating Range of 4.5 V to 45 V
- Internal Fault Protection
  - ◆ -42 V Reverse Voltage
  - ◆ Short Circuit/Overcurrent
  - ◆ Thermal Overload
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable
- EMC Compliant
- These are Pb-Free Devices



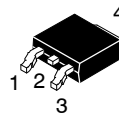
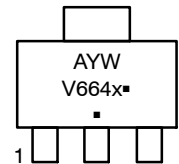
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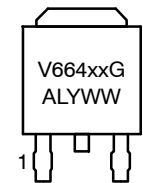
### MARKING DIAGRAMS



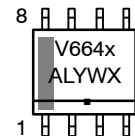
**SOT-223  
ST SUFFIX  
CASE 318E**



**DPAK  
DT SUFFIX  
CASE 369C**



**SOIC-8 Fused  
CASE 751**



xx = Voltage Rating DPAK  
(50 = 5.0 V Version)  
(33 = 3.3 V Version)  
x = Voltage Rating SOT223  
(5 = 5.0 V Version)  
(3 = 3.3 V Version)  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W, WW = Work Week  
■ or G = Pb-Free Package

(Note: Microdot may be in either location)

### PIN CONNECTIONS

(SOT-223/DPAK)		(SOIC-8 Fused)	
PIN	FUNCTION	PIN	FUNCTION
1	$V_{IN}$	1	NC
2, TAB	GND	2,	$V_{IN}$
3	$V_{OUT}$	3	GND
		4.	$V_{OUT}$
		5-8.	NC

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 11 of this data sheet.

# NCV8664

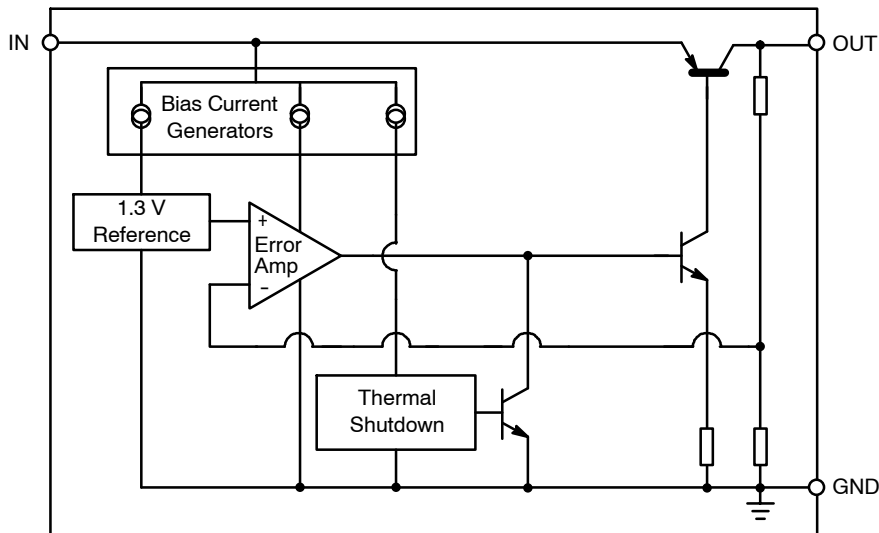


Figure 1. Block Diagram

## PIN FUNCTION DESCRIPTION

Pin No.		Symbol	Function
DPAK/SOT-223	SOIC-8		
1	2	$V_{IN}$	Unregulated input voltage; 4.5 V to 45 V.
2	3	GND	Ground; substrate.
3	4	$V_{OUT}$	Regulated output voltage; collector of the internal PNP pass transistor.
TAB	-	GND	Ground; substrate and best thermal connection to the die.
-	1, 5-8	NC	No Connection.

## OPERATING RANGE

Pin Symbol, Parameter	Symbol	Min	Max	Unit
$V_{IN}$ , DC Input Operating Voltage	$V_{IN}$	4.5	+45	V
Junction Temperature Operating Range	$T_J$	-40	+150	°C

## MAXIMUM RATINGS

Rating	Symbol	Min	Max	Unit
$V_{IN}$ , DC Voltage	$V_{IN}$	-42	+45	V
$V_{OUT}$ , DC Voltage	$V_{OUT}$	-0.3	+18	V
Storage Temperature	$T_{stg}$	-55	+150	°C
ESD Capability, Human Body Model (Note 1)	$V_{ESDHB}$	4000	-	V
ESD Capability, Machine Model (Note 1)	$V_{ESDMIM}$	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. This device series incorporates ESD protection and is tested by the following methods:

ESD HBM tested per AEC-Q100-002 (EIA/JESD22-A 114C)

ESD MM tested per AEC-Q100-003 (EIA/JESD22-A 115C)

## THERMAL RESISTANCE

Parameter	Symbol	Condition	Min	Max	Unit
Junction-to-Ambient	DPAK		-	101 (Note 2)	°C/W
	SOT-223		-	99 (Note 2)	
	SOIC-8 Fused		-	145	
Junction-to-Case	DPAK		-	9.0	°C/W
	SOT-223		-	17	
	SOIC-8 Fused		-	-	

2. 1 oz., 100 mm<sup>2</sup> copper area.

# NCV8664

## LEAD SOLDERING TEMPERATURE AND MSL

Rating	Symbol	Min	Max	Unit
Lead Temperature Soldering Reflow (SMD Styles Only), Lead Free (Note 3)	$T_{\text{sld}}$	-	265 pk	°C
Moisture Sensitivity Level	SOT223 DPAK SOIC-8 Fused	3 2 1	- - -	-

3. Lead Free, 60 sec – 150 sec above 217°C, 40 sec max at peak.

## ELECTRICAL CHARACTERISTICS ( $V_{\text{IN}} = 13.5 \text{ V}$ , $T_{\text{J}} = -40^\circ\text{C}$ to $+150^\circ\text{C}$ , unless otherwise noted.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage 5.0 V Version	$V_{\text{OUT}}$	$0.1 \text{ mA} \leq I_{\text{OUT}} \leq 150 \text{ mA}$ (Note 4) $6.0 \text{ V} \leq V_{\text{IN}} \leq 28 \text{ V}$	4.900	5.000	5.100	V
Output Voltage 5.0 V Version	$V_{\text{OUT}}$	$0 \text{ mA} \leq I_{\text{OUT}} \leq 150 \text{ mA}$ $5.5 \text{ V} \leq V_{\text{IN}} \leq 28 \text{ V}$ $-40^\circ\text{C} \leq T_{\text{J}} \leq 125^\circ\text{C}$	4.900	5.000	5.100	V
Output Voltage 3.3 V Version	$V_{\text{OUT}}$	$0.1 \text{ mA} \leq I_{\text{OUT}} \leq 150 \text{ mA}$ (Note 4) $4.5 \text{ V} \leq V_{\text{IN}} \leq 28 \text{ V}$	3.234	3.300	3.366	V
Line Regulation 5.0 V Version	$\Delta V_{\text{OUT vs. } V_{\text{IN}}}$	$I_{\text{OUT}} = 5.0 \text{ mA}$ $6.0 \text{ V} \leq V_{\text{IN}} \leq 28 \text{ V}$	-25	5.0	+25	mV
Line Regulation 3.3 V Version	$\Delta V_{\text{OUT vs. } V_{\text{IN}}}$	$I_{\text{OUT}} = 5.0 \text{ mA}$ $4.5 \text{ V} \leq V_{\text{IN}} \leq 28 \text{ V}$	-25	5.0	+25	mV
Load Regulation	$\Delta V_{\text{OUT vs. } I_{\text{OUT}}}$	$1.0 \text{ mA} \leq I_{\text{OUT}} \leq 150 \text{ mA}$ (Note 4)	-35	5.0	+35	mV
Dropout Voltage 5.0 V Version	$V_{\text{IN}} - V_{\text{OUT}}$	$I_{\text{Q}} = 100 \text{ mA}$ (Notes 4 & 5) $I_{\text{Q}} = 150 \text{ mA}$ (Notes 4 & 5)	- -	265 315	500 600	mV
Dropout Voltage 3.3 V Version	$V_{\text{IN}} - V_{\text{OUT}}$	$I_{\text{Q}} = 100 \text{ mA}$ (Notes 4 & 7) $I_{\text{Q}} = 150 \text{ mA}$ (Notes 4 & 7)	- -	- -	1.266 1.266	V
Quiescent Current	$I_{\text{q}}$	$I_{\text{OUT}} = 100 \mu\text{A}$ $T_{\text{J}} = 25^\circ\text{C}$ $T_{\text{J}} = -40^\circ\text{C}$ to $+85^\circ\text{C}$	- -	21 22	29 30	$\mu\text{A}$
Active Ground Current	$I_{\text{G(ON)}}$	$I_{\text{OUT}} = 50 \text{ mA}$ (Note 4) $I_{\text{OUT}} = 150 \text{ mA}$ (Note 4)	- -	1.3 8.0	3 15	mA
Power Supply Rejection	PSRR	$V_{\text{RIPPLE}} = 0.5 V_{\text{P-P}}$ , $F = 100 \text{ Hz}$	-	67	-	dB
Output Capacitor for Stability 5.0 V Version	$C_{\text{OUT}}$ ESR	$I_{\text{OUT}} = 0.1 \text{ mA}$ to $150 \text{ mA}$ (Note 4)	10 -	- -	- 9.0	$\mu\text{F}$ $\Omega$
Output Capacitor for Stability 3.3 V Version	$C_{\text{OUT}}$ ESR	$I_{\text{OUT}} = 0.1 \text{ mA}$ to $150 \text{ mA}$ (Note 4)	22 -	- -	- 18	$\mu\text{F}$ $\Omega$

## PROTECTION

Current Limit	$I_{\text{OUT(LIM)}}$	$V_{\text{OUT}} = 4.5 \text{ V}$ (5.0 V Version) (Note 4) $V_{\text{OUT}} = 3.0 \text{ V}$ (3.3 V Version) (Note 4)	150 150	- -	500 500	mA
Short Circuit Current Limit	$I_{\text{OUT(SC)}}$	$V_{\text{OUT}} = 0 \text{ V}$ (Note 4)	100	-	500	mA
Thermal Shutdown Threshold	$T_{\text{TSD}}$	(Note 6)	150	-	200	°C

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.

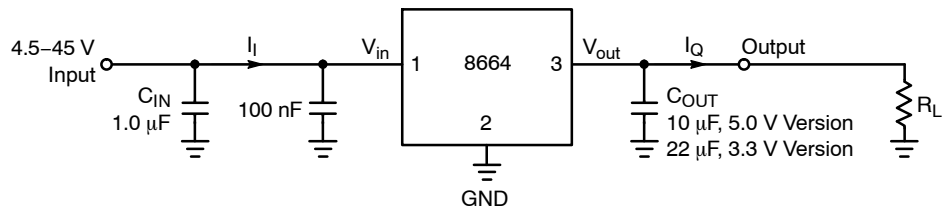
4. Use pulse loading to limit power dissipation.

5. Dropout voltage =  $(V_{\text{IN}} - V_{\text{OUT}})$ , measured when the output voltage has dropped 100 mV relative to the nominal value obtained with  $V_{\text{IN}} = 13.5 \text{ V}$ .

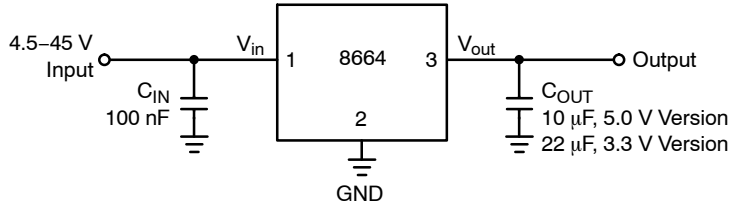
6. Not tested in production. Limits are guaranteed by design.

7.  $V_{\text{DO}} = V_{\text{IN}} - V_{\text{OUT}}$ . For output voltage set to  $< 4.5 \text{ V}$ ,  $V_{\text{DO}}$  will be constrained by the minimum input voltage.

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**Figure 2. Measurement Circuit**



**Figure 3. Applications Circuit**

Typical Curves



Figure 4. ESR Characterization, 5.0 V Version



Figure 5. Output Voltage vs. Input Voltage, 5.0 V Version

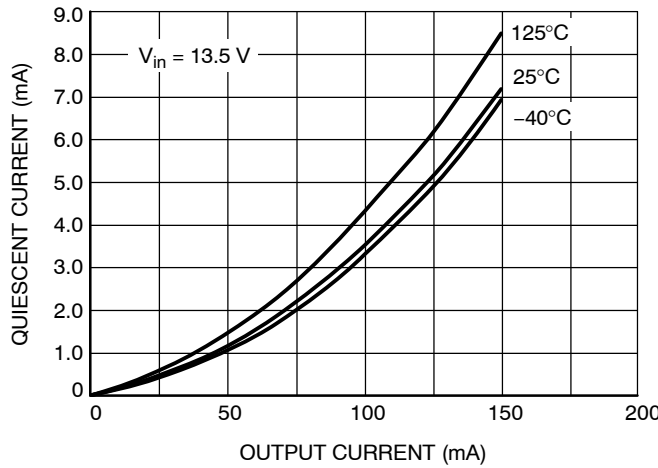


Figure 6. Current Consumption vs. Output Load, 5.0 V Version

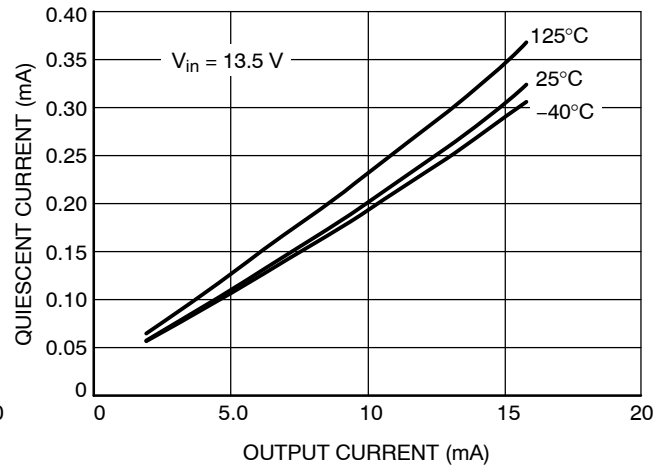


Figure 7. Current Consumption vs. Output Load (Low Load), 5.0 V Version

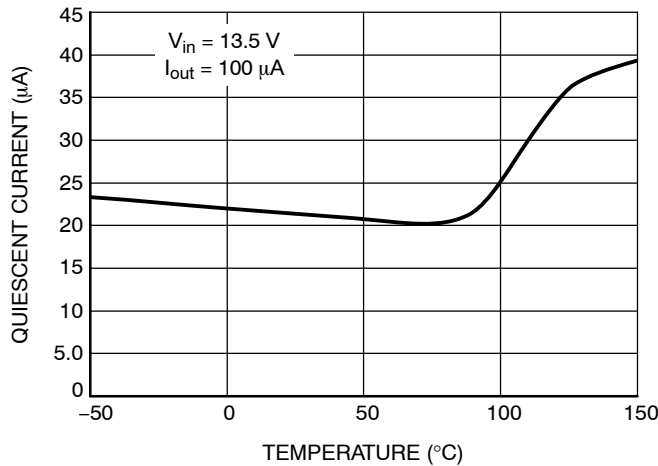


Figure 8. Quiescent Current vs. Temperature, 5.0 V Version

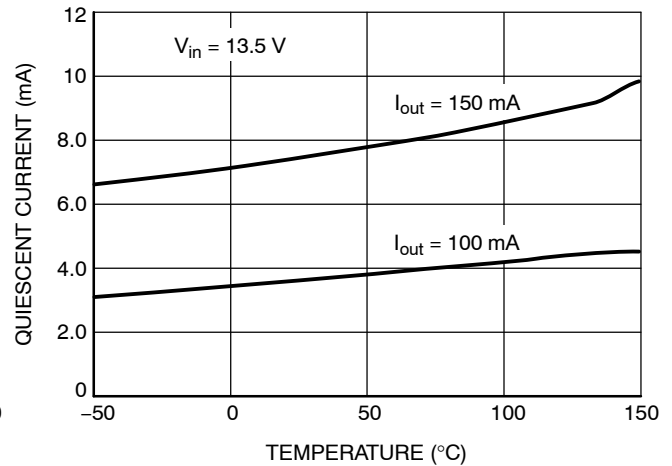


Figure 9. Quiescent Current vs. Temperature, 5.0 V Version

Typical Curves

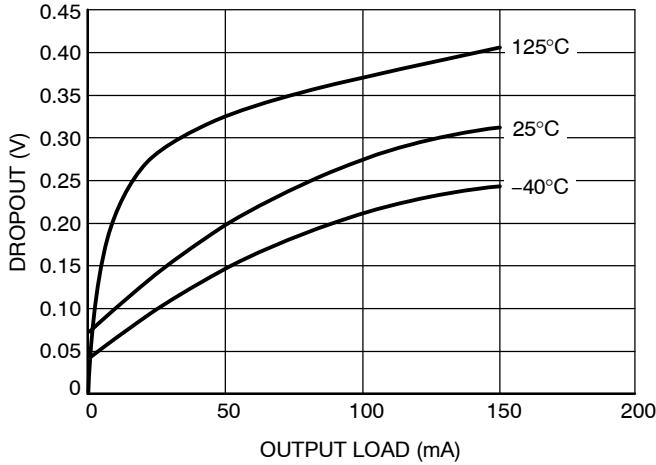


Figure 10. Dropout Voltage vs. Output Load, 5.0 V Version

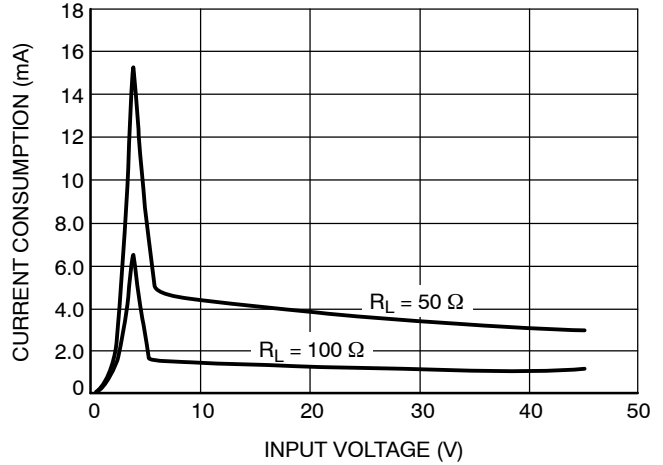


Figure 11. Current Consumption vs. Input Voltage, 5.0 V Version

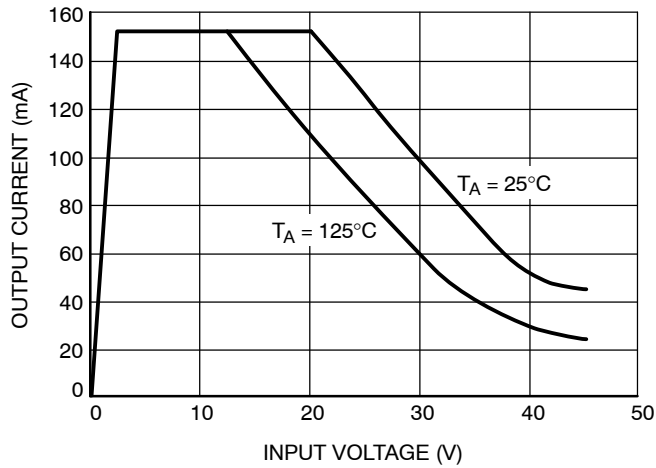


Figure 12. Output Current vs. Input Voltage, 5.0 V Version

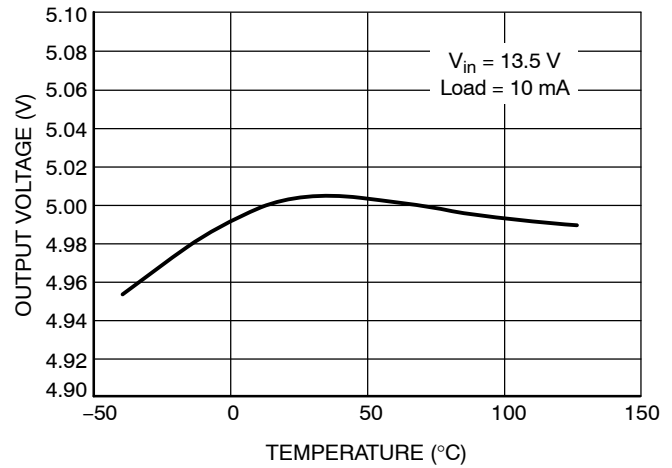


Figure 13. Output Voltage vs. Temperature, 5.0 V Version

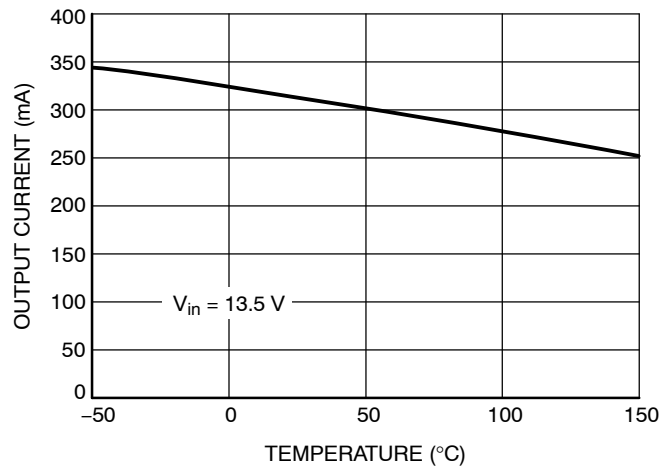


Figure 14. Current Limit vs. Temperature, 5.0 V Version

Typical Curves



Figure 15. ESR Stability, 3.3 V Version



Figure 16. Output Voltage vs. Input Voltage, 3.3 V Version

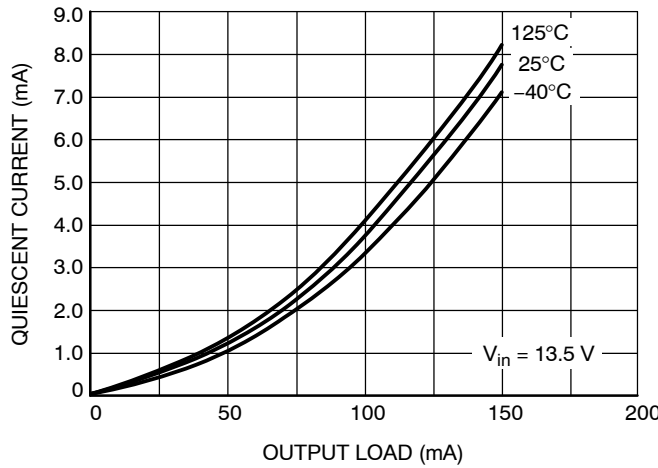


Figure 17. Current Consumption vs. Output Load, 3.3 V Version

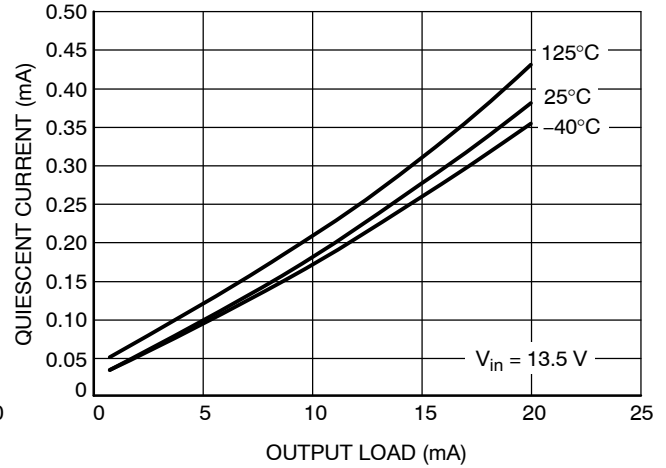


Figure 18. Current Consumption vs. Output Load (Low Load), 3.3 V Version

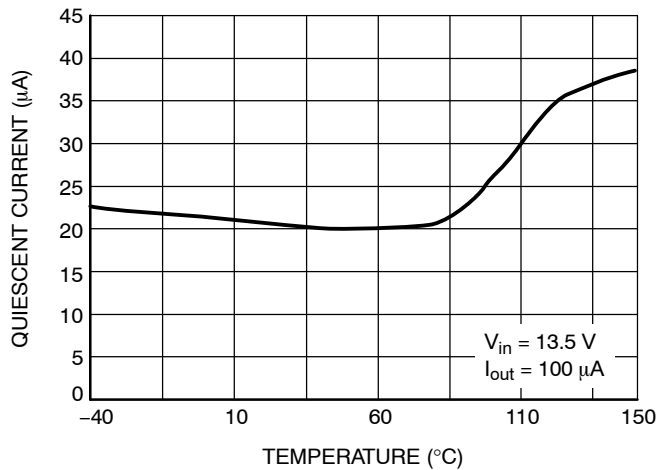


Figure 19. Quiescent Current vs. Temperature, 3.3 V Version

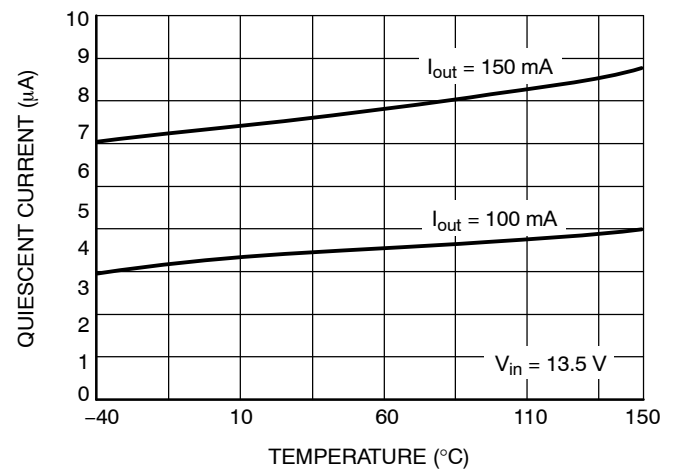


Figure 20. Quiescent Current vs. Temperature, 3.3 V Version

Typical Curves

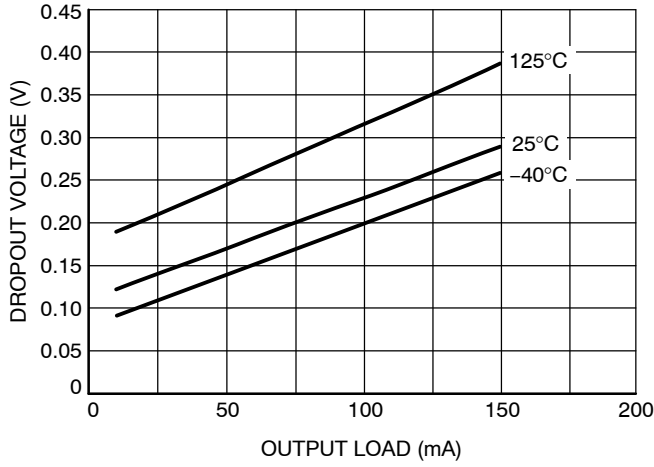


Figure 21. Dropout Voltage, 3.3 V Version

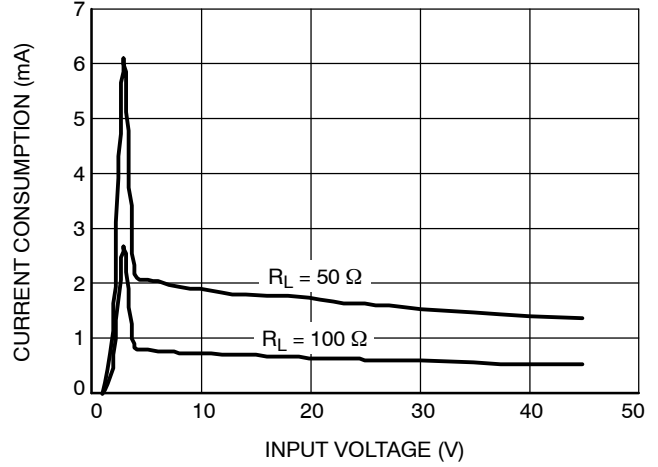


Figure 22. Current Consumption vs. Input Voltage, 3.3 V Version

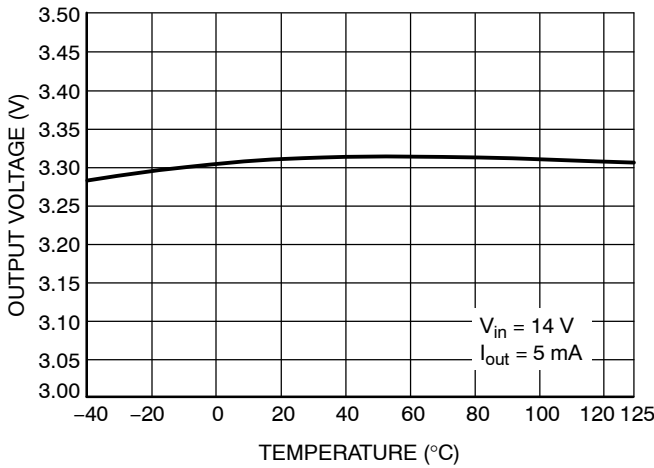


Figure 23. Output Voltage vs. Temperature, 3.3 V Version

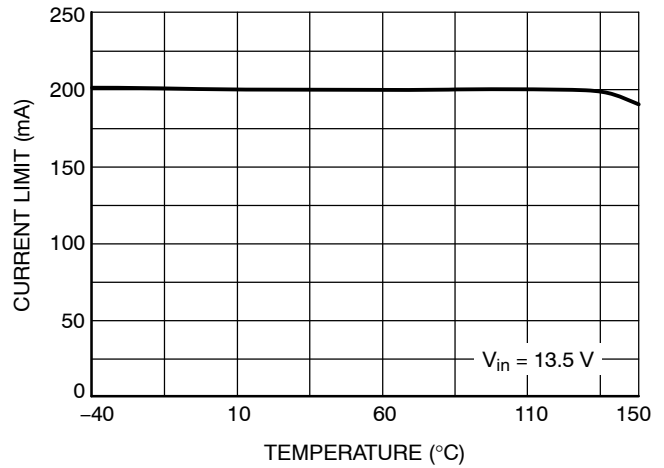


Figure 24. Short Circuit Current Limit vs. Temperature, 3.3 V Version



**Circuit Description**

The NCV8664 is a precision trimmed 3.3 V and 5.0 V fixed output regulator. Careful management of light load consumption combined with a low leakage process results in a typical quiescent current of 22  $\mu$ A. The device has current capability of 150 mA, with 600 mV of dropout voltage at full rated load current. The regulation is provided by a PNP pass transistor controlled by an error amplifier with a bandgap reference. The regulator is protected by both current limit and short circuit protection. Thermal shutdown occurs above 150°C to protect the IC during overloads and extreme ambient temperatures.

**Regulator**

The error amplifier compares the reference voltage to a sample of the output voltage ( $V_{out}$ ) and drives the base of a PNP series pass transistor by a buffer. The reference is a bandgap design to give it a temperature-stable output. Saturation control of the PNP is a function of the load current and input voltage. Over saturation of the output power device is prevented, and quiescent current in the ground pin is minimized. The NCV8664 is equipped with foldback current protection. This protection is designed to reduce the current limit during an overcurrent situation.

**Regulator Stability Considerations**

The input capacitor  $C_{IN}$  in Figure 2 is necessary for compensating input line reactance. Possible oscillations caused by input inductance and input capacitance can be damped by using a resistor of approximately 1  $\Omega$  in series with  $C_{IN}$ . The output or compensation capacitor,  $C_{OUT}$  helps determine three main characteristics of a linear regulator: startup delay, load transient response and loop stability. The capacitor value and type should be based on cost, availability, size and temperature constraints. Tantalum, aluminum electrolytic, film, or ceramic capacitors are all acceptable solutions, however, attention must be paid to ESR constraints. The aluminum electrolytic capacitor is the least expensive solution, but, if the circuit operates at low temperatures ( $-25^{\circ}\text{C}$  to  $-40^{\circ}\text{C}$ ), both the value and ESR of the capacitor will vary considerably. The capacitor manufacturer's data sheet usually provides this information. The value for the output capacitor  $C_{OUT}$  shown in Figure 2 should work for most applications; however, it is not necessarily the optimized solution. Stability is guaranteed at values  $C_{OUT} \geq 10 \mu\text{F}$  and  $\text{ESR} \leq 9 \Omega$  for 5.0 V version, and  $C_{OUT} \geq 22 \mu\text{F}$  and  $\text{ESR} \leq 18 \Omega$  for 3.3 V version, within the operating temperature range. Actual limits are shown in a graph in the Typical Performance Characteristics section.

**Calculating Power Dissipation in a Single Output Linear Regulator**

The maximum power dissipation for a single output regulator (Figure 3) is:

$$P_{D(\text{max})} = [V_{IN(\text{max})} - V_{OUT(\text{min})}] \cdot I_{Q(\text{max})} + V_{I(\text{max})} \cdot I_q \quad (\text{eq. 1})$$

Where:

$V_{IN(\text{max})}$  is the maximum input voltage,

$V_{OUT(\text{min})}$  is the minimum output voltage,

$I_{Q(\text{max})}$  is the maximum output current for the application, and  $I_q$  is the quiescent current the regulator consumes at  $I_{Q(\text{max})}$ .

Once the value of  $P_{D(\text{Max})}$  is known, the maximum permissible value of  $R_{\theta JA}$  can be calculated:

$$P_{\theta JA} = \frac{150^{\circ}\text{C} - T_A}{P_D} \quad (\text{eq. 2})$$

The value of  $R_{\theta JA}$  can then be compared with those in the package section of the data sheet. Those packages with  $R_{\theta JA}$ 's less than the calculated value in Equation 2 will keep the die temperature below 150°C. In some cases, none of the packages will be sufficient to dissipate the heat generated by the IC, and an external heat sink will be required. The current flow and voltages are shown in the Measurement Circuit Diagram.

**Heat Sinks**

For proper heat sinking of the SOIC-8 Lead device, connect pins 5 – 8 to the heat sink.

A heat sink effectively increases the surface area of the package to improve the flow of heat away from the IC and into the surrounding air. Each material in the heat flow path between the IC and the outside environment will have a thermal resistance. Like series electrical resistances, these resistances are summed to determine the value of  $R_{\theta JA}$ :

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CS} + R_{\theta SA} \quad (\text{eq. 3})$$

Where:

$R_{\theta JC}$  = the junction-to-case thermal resistance,

$R_{\theta CS}$  = the case-to-heat sink thermal resistance, and

$R_{\theta SA}$  = the heat sink-to-ambient thermal resistance.

$R_{\theta JA}$  appears in the package section of the data sheet.

Like  $R_{\theta JA}$ , it too is a function of package type.  $R_{\theta CS}$  and  $R_{\theta SA}$  are functions of the package type, heat sink and the interface between them. These values appear in data sheets of heat sink manufacturers. Thermal, mounting, and heat sinking are discussed in the ON Semiconductor application note AN1040/D, available on the ON Semiconductor Website.

# NCV8664

## EMC-Characteristics: Conducted Susceptibility

All EMC-Characteristics are based on limited samples and not part of production testing, according to 47A/658/CD IEC62132-4 (Direct Power Injection)

**Direct Power Injection:** 33 dBm forward power CW

**Acceptance Criteria:** Amplitude Dev. max 2% of Output Voltage

## Test Conditions

Supply Voltage  $V_{IN} = 12\text{ V}$   
 Temperature  $T_A = 23^\circ\text{C} \pm 5^\circ\text{C}$   
 Load  $R_L = 35\ \Omega$

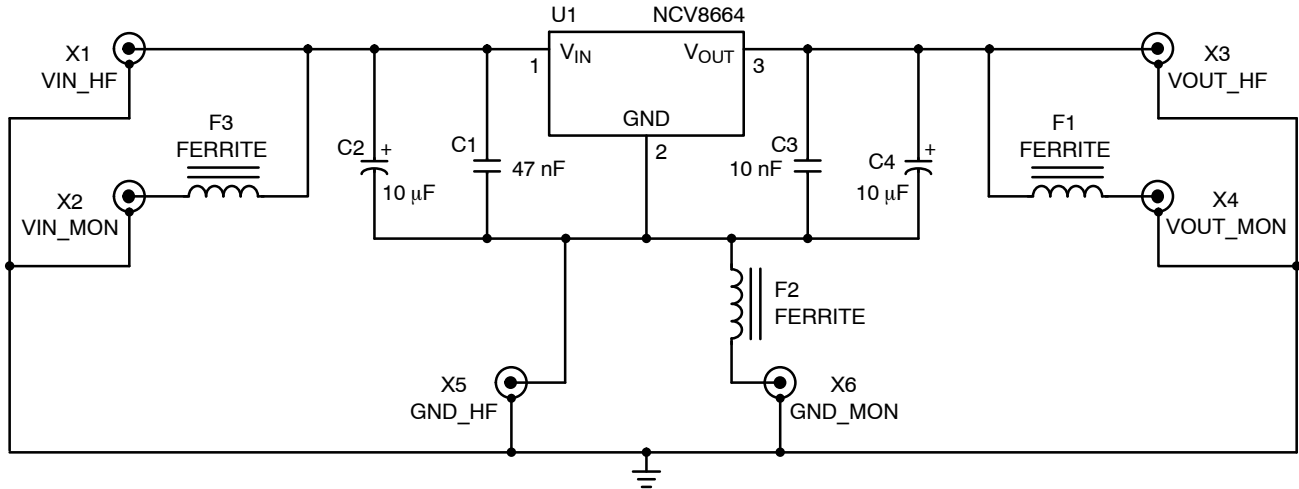


Figure 25. Test Circuit

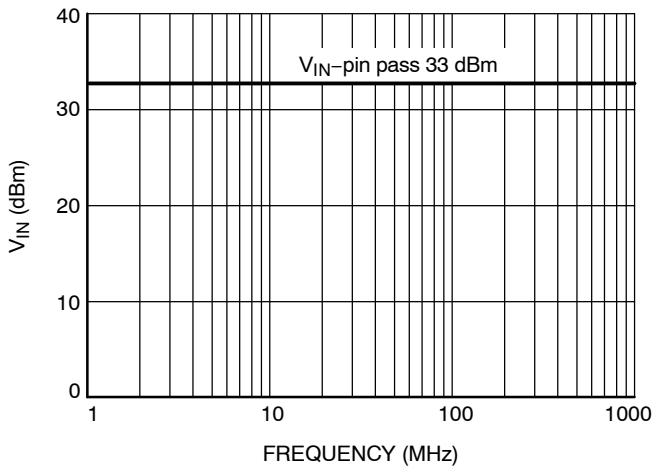


Figure 26. Typical  $V_{IN}$ -pin Susceptibility

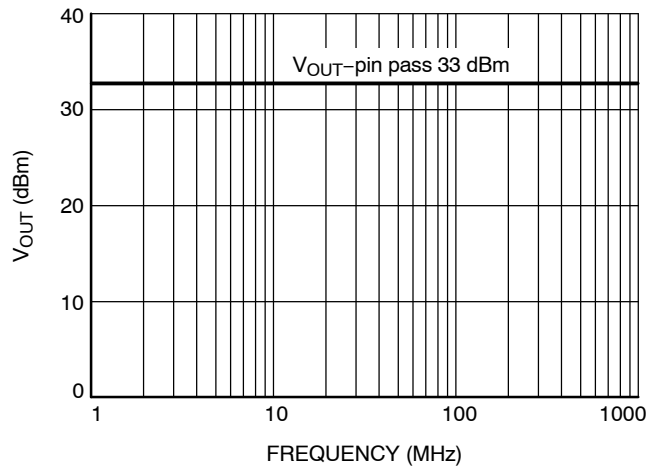


Figure 27. Typical  $V_{OUT}$ -pin Susceptibility

# NCV8664

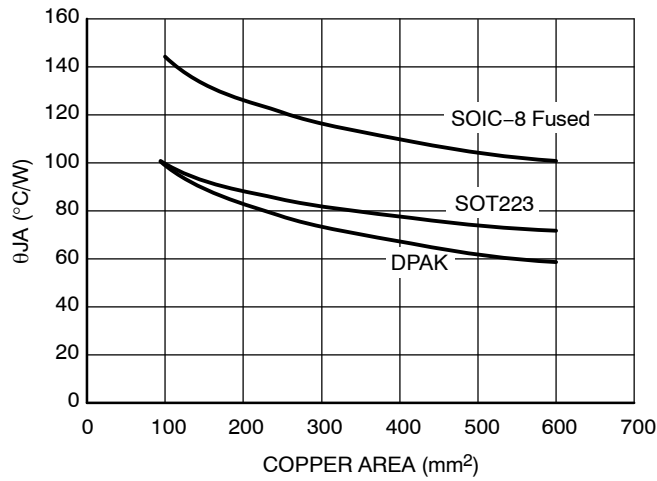


Figure 28.  $\theta_{JA}$  vs. Copper Spreader Area

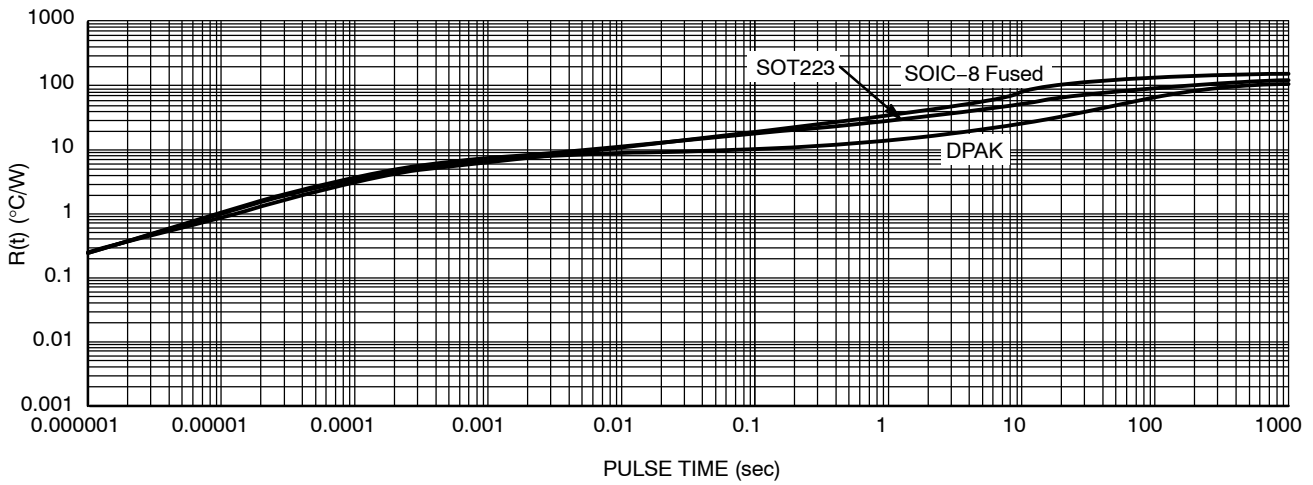


Figure 29. Single-Pulse Heating Curves

## ORDERING INFORMATION

Device*	Marking	Package	Shipping†
NCV8664D50R2G	V6645	SOIC-8 Fused (Pb-Free)	2500 / Tape & Reel
NCV8664D50G	V6645	SOIC-8 Fused (Pb-Free)	98 Units / Rail
NCV8664DT50RKG	V66450G	DPAK (Pb-Free)	2500 / Tape & Reel
NCV8664DT33RKG	V66433G	DPAK (Pb-Free)	2500 / Tape & Reel
NCV8664ST50T3G	V6645	SOT-223 (Pb-Free)	4000 / Tape & Reel
NCV8664ST33T3G	V6643	SOT-223 (Pb-Free)	4000 / Tape & Reel

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

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