

NCV8664

Ultra-Low I_q Low Dropout Linear Regulator

The NCV8664 is a precision 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 μ 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

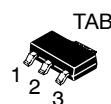
- 5.0 V Fixed Output
- $\pm 2.0\%$ Output Accuracy, Over Full Temperature Range
- 30 μ A Maximum Quiescent Current at $I_{OUT} = 100 \mu$ A
- 600 mV Maximum Dropout Voltage at 150 mA Load Current
- Wide Input Voltage Operating Range of 5.5 V to 45 V
- Internal Fault Protection
 - ◆ -42 V Reverse Voltage
 - ◆ Short Circuit/Overcurrent
 - ◆ Thermal Overload
- NCV Prefix for Automotive and Other Applications Requiring Site and Control Changes
- AEC-Q100 Qualified
- This is a Pb-Free Device



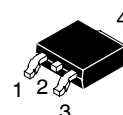
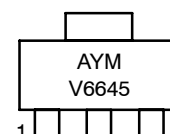
ON Semiconductor®

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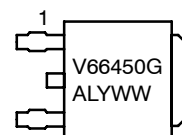
MARKING DIAGRAMS



SOT-223
ST SUFFIX
CASE 318E



DPAK
DT SUFFIX
CASE 369C



A = Assembly Location
L = Wafer Lot
Y = Year
WW = Work Week
M = Date Code
G = Pb-Free Package

PIN CONNECTIONS

PIN	FUNCTION
1	V_{IN}
2, TAB	GND
3	V_{OUT}

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

NCV8664

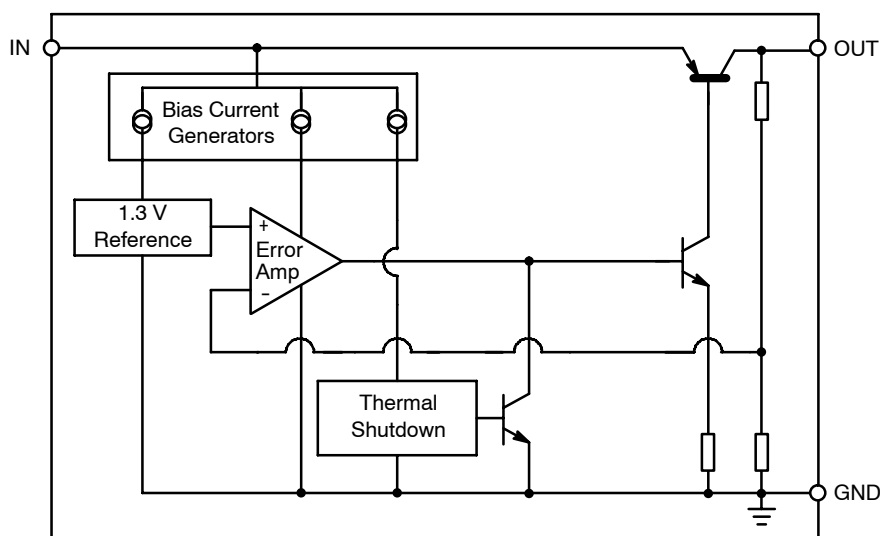


Figure 1. Block Diagram

PIN FUNCTION DESCRIPTION

Pin No.	Symbol	Function
1	V_{IN}	Unregulated input voltage; 5.5 V to 45 V.
2	GND	Ground; substrate.
3	V_{OUT}	Regulated output voltage; collector of the internal PNP pass transistor.
TAB	GND	Ground; substrate and best thermal connection to the die.

OPERATING RANGE

Pin Symbol, Parameter	Symbol	Min	Max	Unit
V_{IN} , DC Input Operating Voltage	V_{IN}	5.5	+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	+16	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 Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

- 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	$R_{\theta JA}$	DPAK	-	101 (Note 2)	°C/W
Junction-to-Ambient	$R_{\theta JA}$	SOT-223	-	99 (Note 2)	°C/W
Junction-to-Case	$R_{\theta JC}$	DPAK	-	9.0	°C/W
Junction-to-Case	$R_{\theta JC}$	SOT-223	-	17	°C/W

- 1 oz., 100 mm² copper area.

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Lead Soldering Temperature and MSL

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

3. Lead Free, 60 sec – 150 sec above 217 $^{\circ}\text{C}$, 40 sec max at peak.

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

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	V_{OUT}	$0.1\text{ mA} \leq I_{OUT} \leq 150\text{ mA}$ (Note 4) $6.0\text{ V} \leq V_{IN} \leq 28\text{ V}$	4.900	5.000	5.100	V
Line Regulation	ΔV_{OUT} vs. V_{IN}	$I_{OUT} = 5.0\text{ mA}$ $6.0\text{ V} \leq V_{IN} \leq 28\text{ V}$	-25	5.0	+25	mV
Load Regulation	ΔV_{OUT} vs. I_{OUT}	$1.0\text{ mA} \leq I_{OUT} \leq 150\text{ mA}$ (Note 4)	-35	5.0	+35	mV
Dropout Voltage	$V_{IN} - V_{OUT}$	$I_Q = 100\text{ mA}$ (Notes 4 & 5) $I_Q = 150\text{ mA}$ (Notes 4 & 5)	-	265 315	500 600	mV
Quiescent Current	I_Q	$I_{OUT} = 100\text{ }\mu\text{A}$ $T_J = 25^{\circ}\text{C}$ $T_J = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$	- -	21 22	29 30	μA
Active Ground Current	$I_{G(ON)}$	$I_{OUT} = 50\text{ mA}$ (Note 4) $I_{OUT} = 150\text{ mA}$ (Note 4)	- -	1.3 8.0	3 15	mA
Power Supply Rejection	PSRR	$V_{RIPPLE} = 0.5\text{ V}_{P-P}$, $F = 100\text{ Hz}$	-	TBD	-	%/V
Output Capacitor for Stability	C_{OUT} ESR	$I_{OUT} = 0.1\text{ mA}$ to 150 mA (Note 4)	10 -	- -	- 9.0	μF Ω

PROTECTION

Current Limit	$I_{OUT(LIM)}$	$V_{OUT} = 4.5\text{ V}$ (Note 4)	150	-	500	mA
Short Circuit Current Limit	$I_{OUT(SC)}$	$V_{OUT} = 0\text{ V}$ (Note 4)	100	-	500	mA
Thermal Shutdown Threshold	T_{TSD}	(Note 9)	150	-	200	$^{\circ}\text{C}$

4. Use pulse loading to limit power dissipation.

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

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

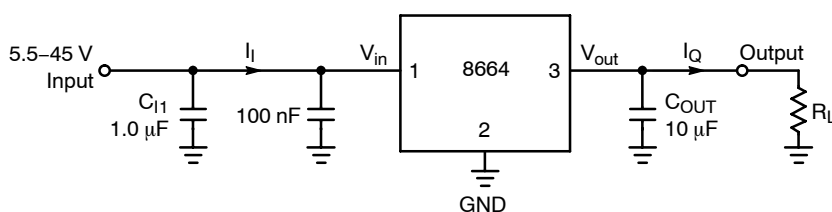


Figure 2. Measurement Circuit

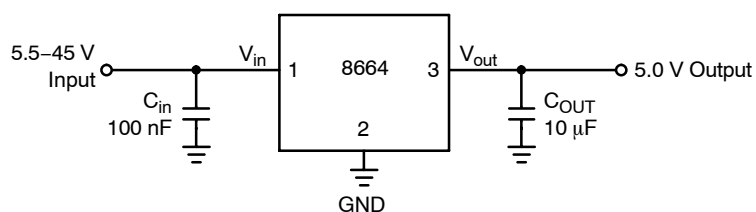


Figure 3. Applications Circuit

NCV8664

Typical Curves

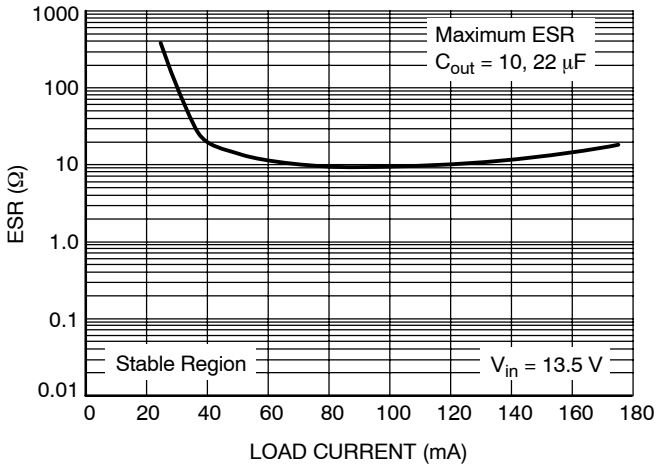


Figure 4. ESR Characterization

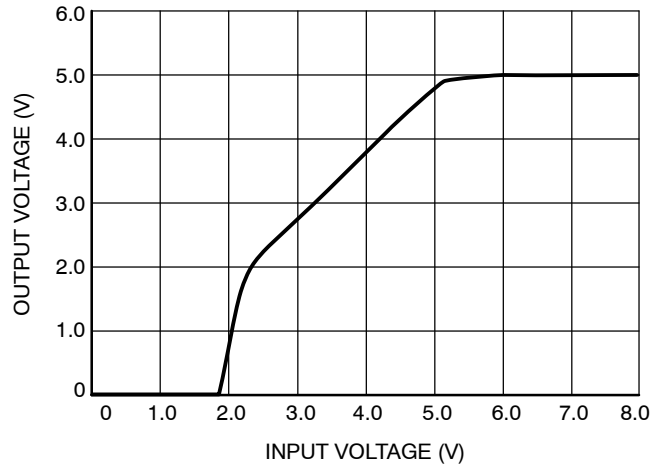


Figure 5. Output Voltage vs. Input Voltage

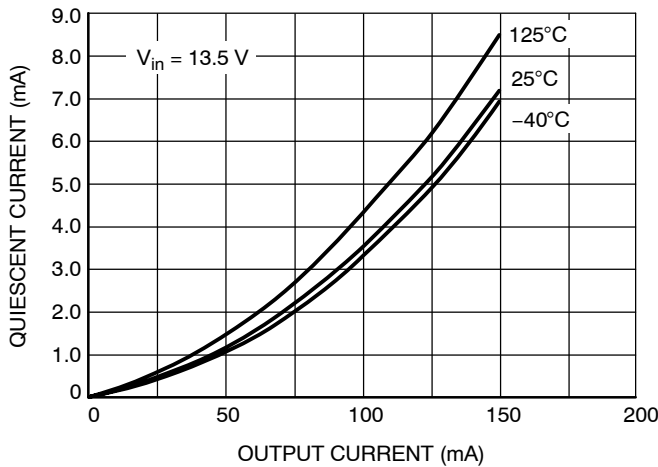


Figure 6. Current Consumption vs. Output Load

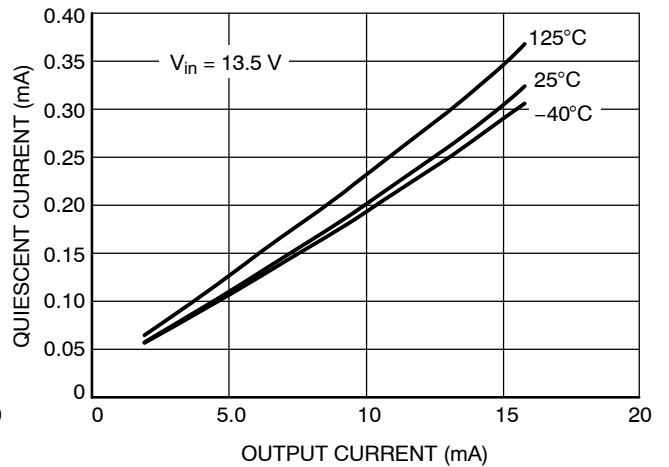


Figure 7. Current Consumption vs. Output Load (Low Load)

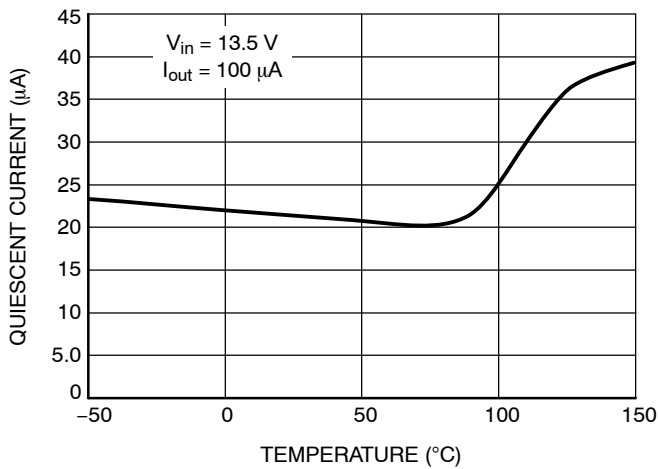


Figure 8. Quiescent Current vs. Temperature

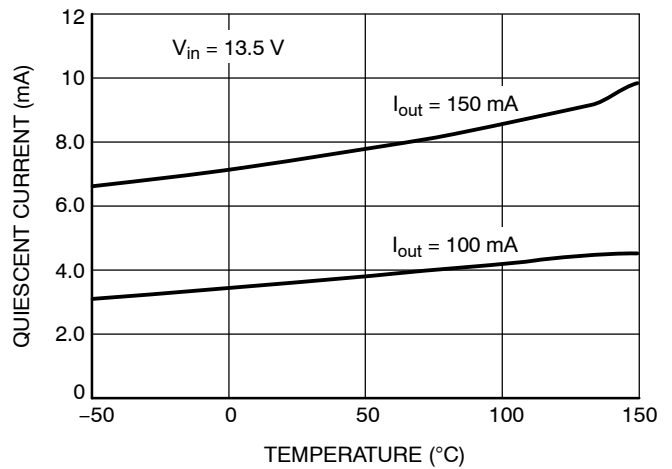


Figure 9. Quiescent Current vs. Temperature

NCV8664

Typical Curves

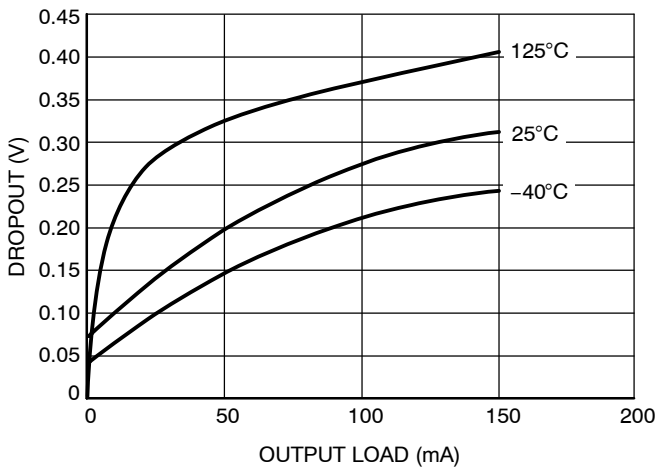


Figure 10. Dropout Voltage vs. Output Load

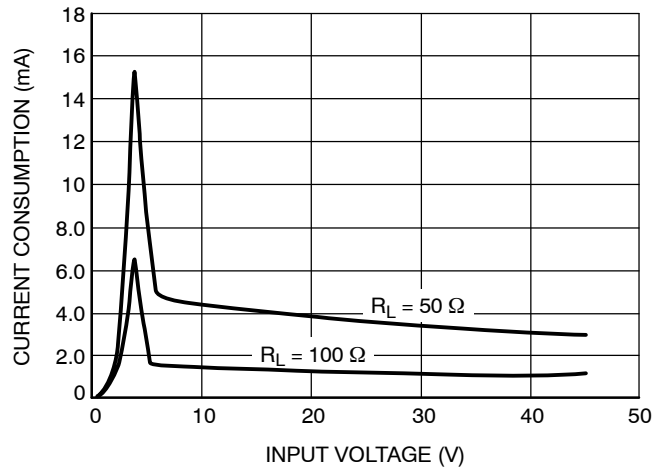


Figure 11. Current Consumption vs. Input Voltage

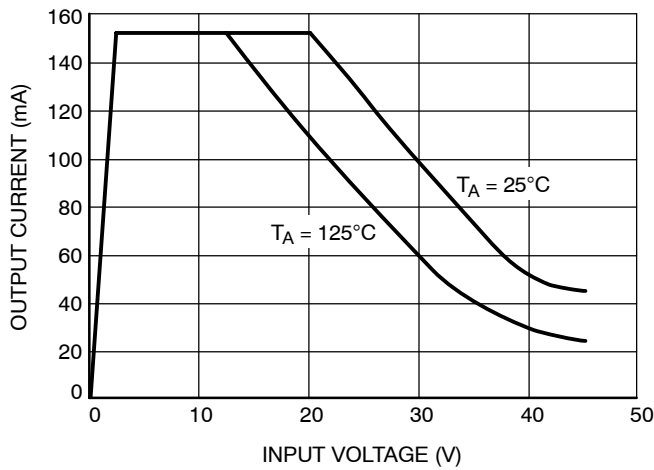


Figure 12. Output Current vs. Input Voltage

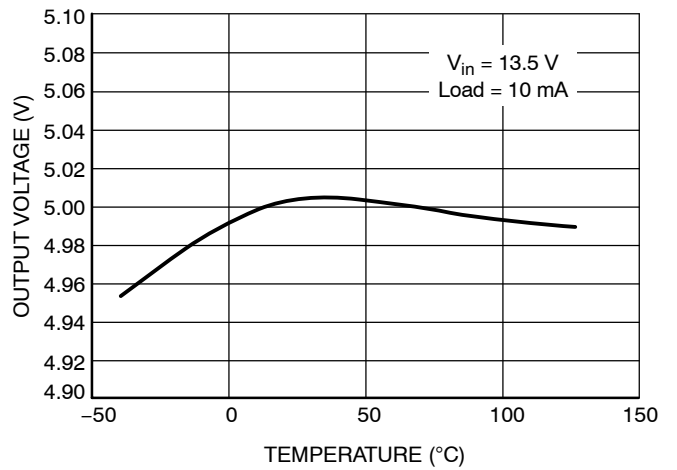


Figure 13. Output Voltage vs. Temperature

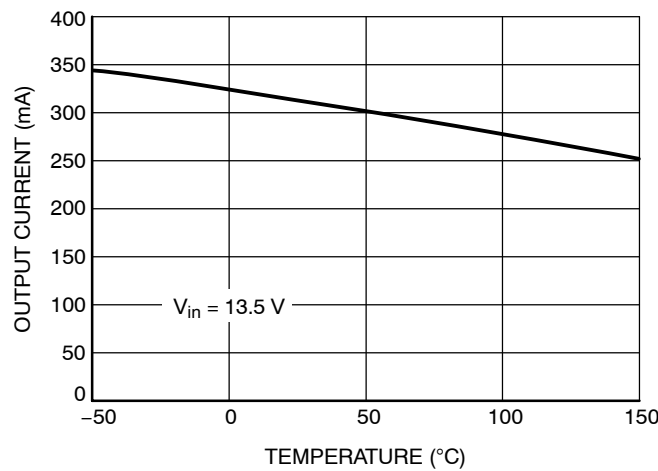


Figure 14. Current Limit vs. Temperature

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Circuit Description

The NCV8664 is a precision trimmed 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 μA . 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.

Regulator Stability Considerations

The input capacitor C_{IN1} 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 Ω in series with C_{IN2} . 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°C to -40°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 $C_{\text{OUT}} \geq 10 \mu\text{F}$ and an $\text{ESR} \leq 9 \Omega$ 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:

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

Where:

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

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

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

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

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

The value of $R_{\theta\text{JA}}$ can then be compared with those in the package section of the data sheet. Those packages with $R_{\theta\text{JA}}$'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

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 $R_{\theta\text{JA}}$:

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

Where:

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

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

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

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

Like $R_{\theta\text{JA}}$, it too is a function of package type. $R_{\theta\text{CS}}$ and $R_{\theta\text{SA}}$ 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.

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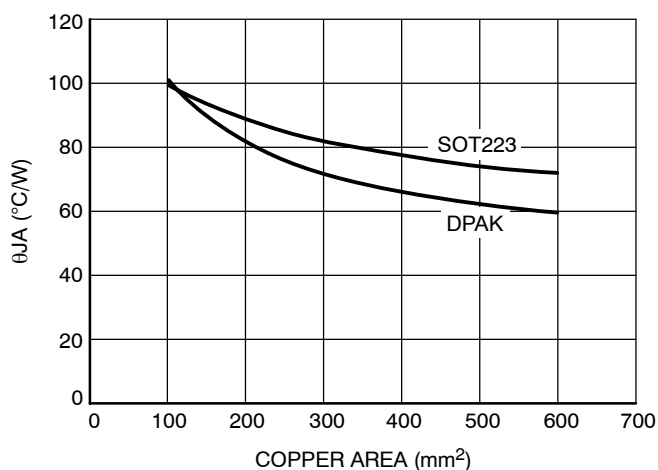


Figure 15. θ_{JA} vs. Copper Spreader Area

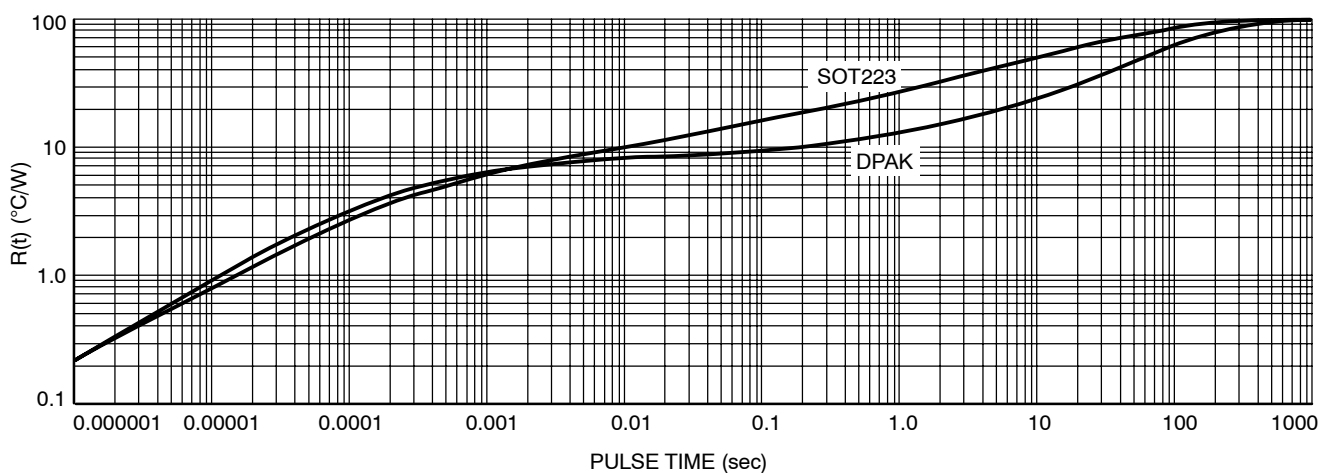


Figure 16. Single-Pulse Heating Curves

ORDERING INFORMATION

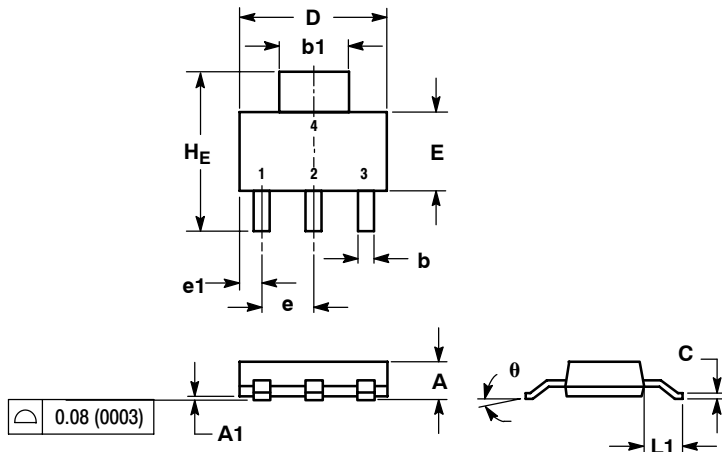
Device	Marking	Package	Shipping [†]
NCV8664DT50RKG	V66450G	DPAK	2500/Tape & Reel
NCV8664ST50T3G	V6645	SOT-223	4000/Tape & Reel

[†]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.

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PACKAGE DIMENSIONS

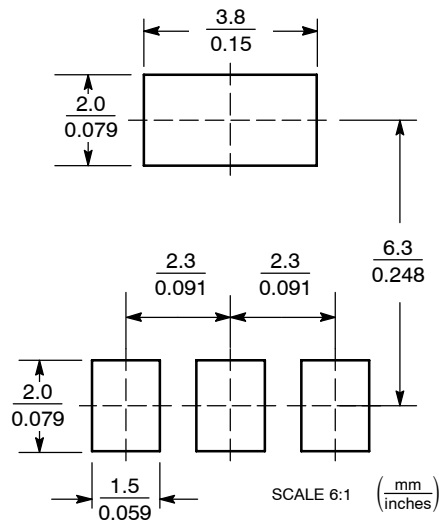
SOT-223 (TO-261)
ST SUFFIX
CASE 318E-04
ISSUE L



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.50	1.63	1.75	0.060	0.064	0.068
A1	0.02	0.06	0.10	0.001	0.002	0.004
b	0.60	0.75	0.89	0.024	0.030	0.035
b1	2.90	3.06	3.20	0.115	0.121	0.126
c	0.24	0.29	0.35	0.009	0.012	0.014
D	6.30	6.50	6.70	0.249	0.256	0.263
E	3.30	3.50	3.70	0.130	0.138	0.145
e	2.20	2.30	2.40	0.087	0.091	0.094
e1	0.85	0.94	1.05	0.033	0.037	0.041
L1	1.50	1.75	2.00	0.060	0.069	0.078
HE	6.70	7.00	7.30	0.264	0.276	0.287
θ	0°	-	10°	0°	-	10°

SOLDERING FOOTPRINT*



*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

NCV8664

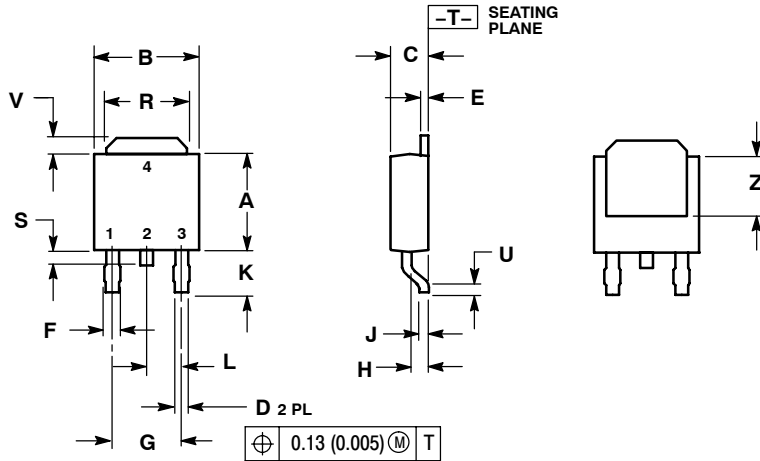
PACKAGE DIMENSIONS

DPAK (Single Gauge)

DT SUFFIX

CASE 369C

ISSUE O

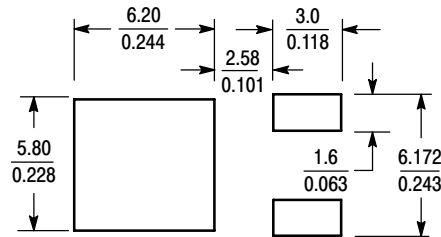


NOTES:


1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.245	5.97	6.22
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.018	0.023	0.46	0.58
F	0.037	0.045	0.94	1.14
G	0.180	BSC	4.58	BSC
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.090	BSC	2.29	BSC
R	0.180	0.215	4.57	5.45
S	0.025	0.040	0.63	1.01
U	0.020	---	0.51	---
V	0.035	0.050	0.89	1.27
Z	0.155	---	3.93	---

RECOMMENDED FOOTPRINT



SCALE 3:1 $\left(\frac{\text{mm}}{\text{inches}}\right)$

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