NCV8674

Very Low I$_q$ Low Dropout Linear Regulator

The NCV8674 is a precision 5.0 V fixed output, low dropout integrated voltage regulator with an output current capability of 350 mA. Careful management of light load current consumption, combined with a low leakage process, achieve a typical quiescent current of 30 μA.

The output voltage is accurate within ±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
- ±2.0% Output Accuracy, Over Full Temperature Range
- 40 μA Maximum Quiescent Current at I$_{OUT}$ = 100 μA
- 600 mV Maximum Dropout Voltage at 350 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
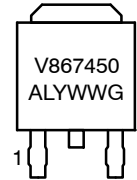- EMC Compliant
- This is a Pb−Free Device

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MARKING DIAGRAMS
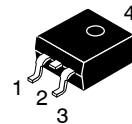
D²PAK
DS SUFFIX
CASE 936

V867450
ALYWWG

A	= Assembly Location
L	= Wafer Lot
Y	= Year
WW	= Work Week
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 8 of this data sheet.
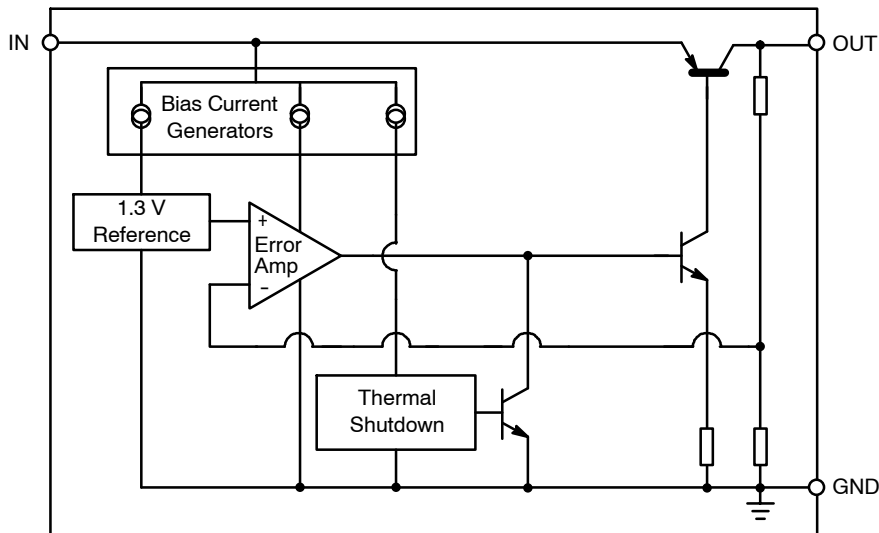
NCV8674

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.
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	Min	Max	Unit
Junction−to−Ambient	$R_{\theta JA}$	–	40	°C/W
Junction−to−Case	$R_{\theta JC}$	–	4.0	°C/W

2. 1 oz., 100 mm^2 copper area.

LEAD SOLDERING TEMPERATURE & MSL

Rating	Symbol	Min	Max	Unit
Lead Temperature Soldering Reflow (SMD Styles Only), Lead Free (Note 3)	T_{sld}	–	265 pk	°C
Moisture Sensitivity Level	MSL		1	–

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

ELECTRICAL CHARACTERISTICS (V_{IN} = 13.5 V, Tj = −40°C to +150°C, unless otherwise noted.)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Voltage	V_{OUT}	0.1 mA ≤ I_{OUT} ≤ 350 mA (Note 4) 6.0 V ≤ V_{IN} ≤ 28 V	4.900	5.000	5.100	V
Line Regulation	ΔV_{OUT} vs. V_{IN}	I_{OUT} = 5.0 mA 6.0 V ≤ V_{IN} ≤ 28 V	−25	5.0	+25	mV
Load Regulation	ΔV_{OUT} vs. I_{OUT}	1.0 mA ≤ I_{OUT} ≤ 350 mA (Note 4)	−35	5.0	+35	mV
Dropout Voltage	V_{IN}−V_{OUT}	I_Q = 100 mA (Notes 4 & 5) I_Q = 350 mA (Notes 4 & 5)	– –	175 300	500 600	mV
Quiescent Current	I_q	I_{OUT} = 100 μA T_J = 25°C T_J = −40°C to +85°C	– –	27 30	35 38	μA
Active Ground Current	$I_{G(ON)}$	I_{OUT} = 50 mA (Note 4) I_{OUT} = 350 mA (Note 4)	– –	1.1 18	3 27	mA
Power Supply Rejection	PSRR	V_{RIPPLE} = 0.5 V_{P-P}, F = 100 Hz	–	67	–	dB
Output Capacitor for Stability	C_{OUT} ESR	I_{OUT} = 0.1 mA to 350 mA (Note 4)	22 –	– –	– 7.0	μF Ω

PROTECTION

Current Limit	$I_{OUT(LIM)}$	V_{OUT} = 4.5 V (5.0 V Version) (Note 4)	350	–	–	mA
Short Circuit Current Limit	$I_{OUT(SC)}$	V_{OUT} = 0 V (Note 4)	100	600	–	mA
Thermal Shutdown Threshold	T_{TSD}	(Note 6)	150	–	200	°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 V.
6. Not tested in production. Limits are guaranteed by design.
7. $V_{DO} = V_{IN} − V_{OUT}$. For output voltage set to < 4.5 V, V_{DO} will be constrained by the minimum input voltage.

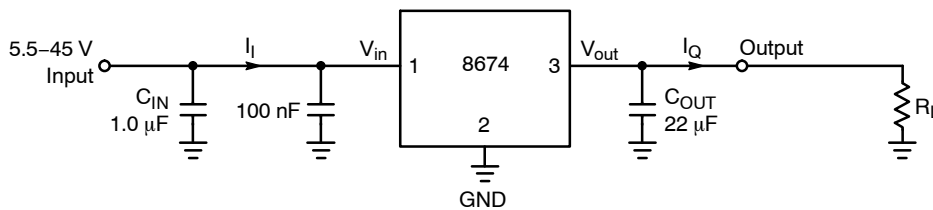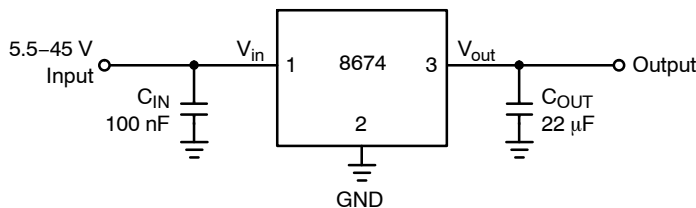**Figure 2. Measurement Circuit**

Figure 3. Applications Circuit

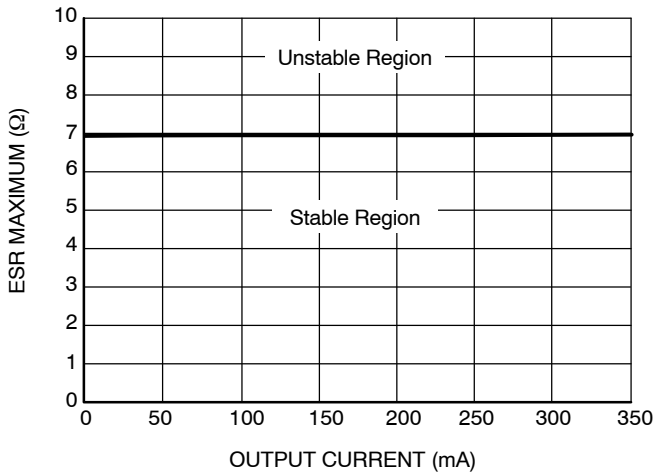# NCV8674

TYPICAL CHARACTERISTIC CURVES

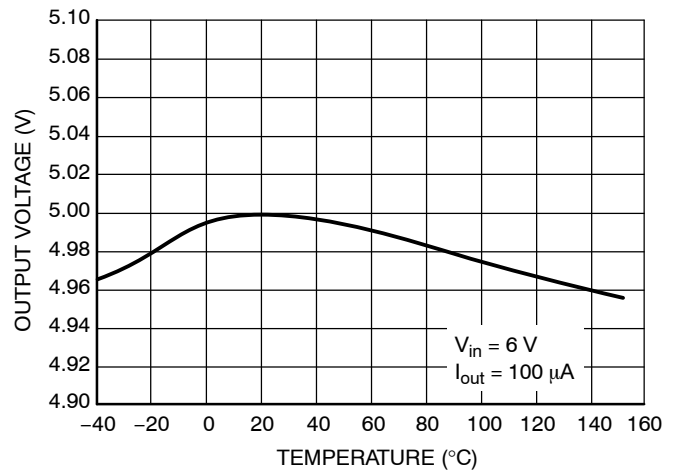**Figure 4. ESR Maximum vs. Output Current**

Figure 5. Output Voltage vs. Temperature
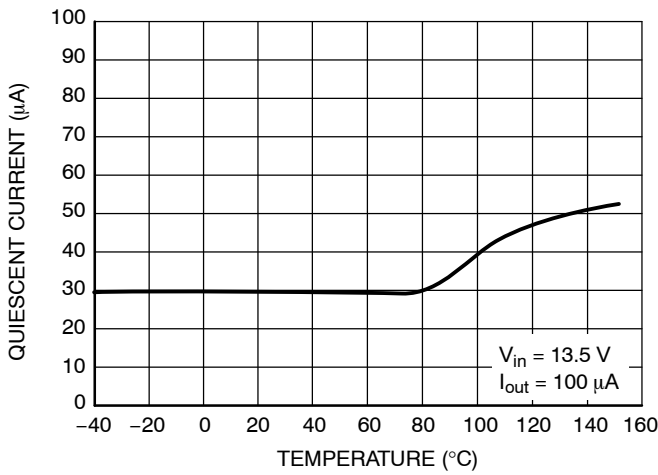

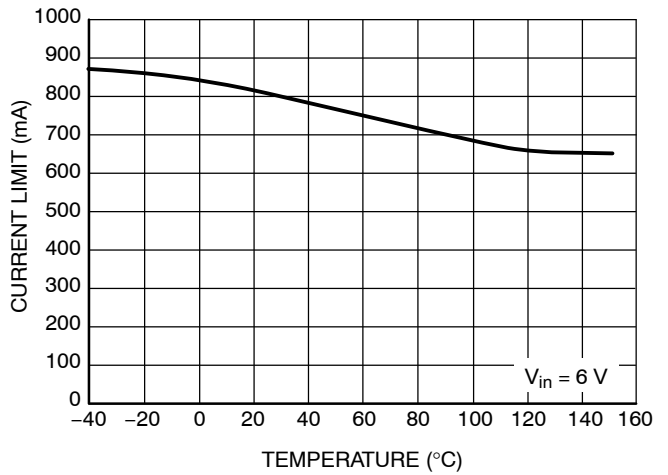**Figure 6. Quiescent Current vs. Temperature**

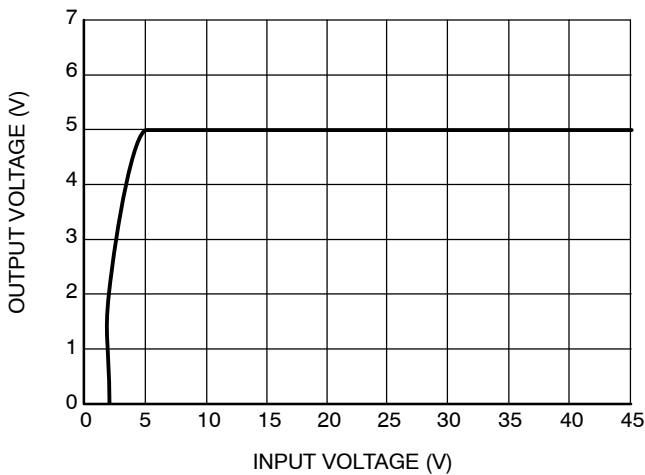**Figure 7. Current Limit vs. Temperature**

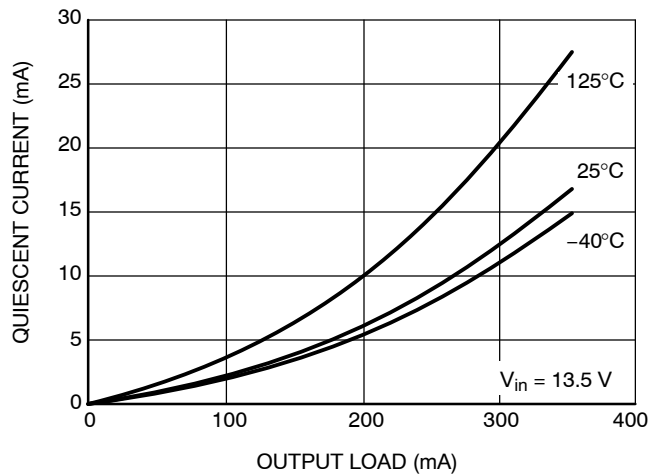
Figure 8. Output Voltage vs. Input Voltage

Figure 9. Quiescent Current vs. Output Load
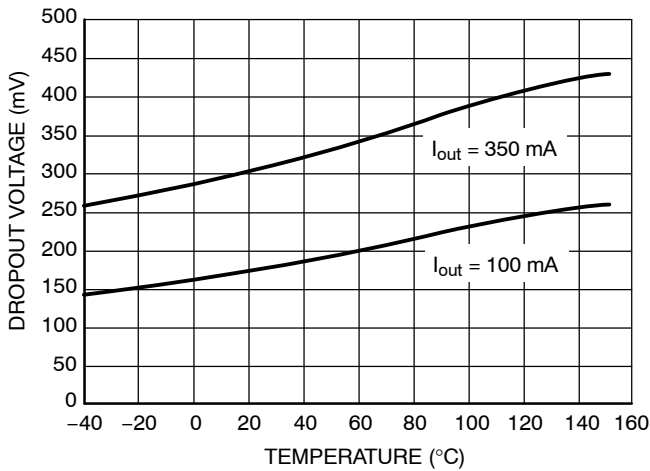
TYPICAL CHARACTERISTIC CURVES

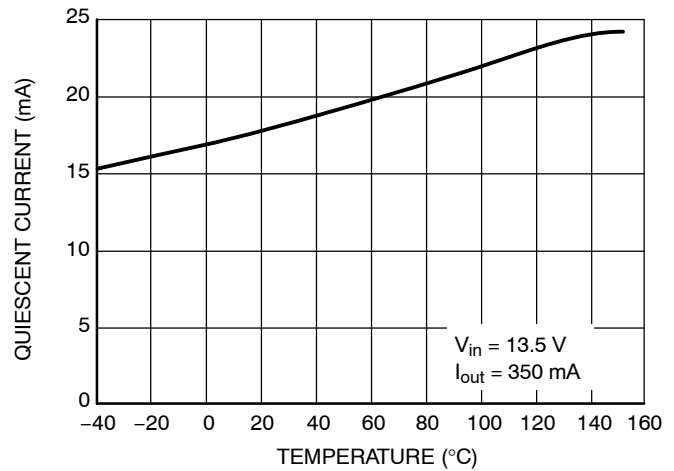**Figure 10. Dropout Voltage vs. Temperature**

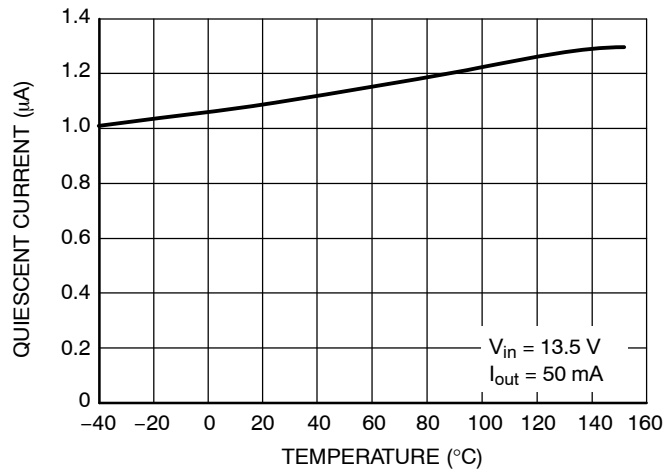**Figure 11. Quiescent Current vs. Temperature – 350 mA Load**

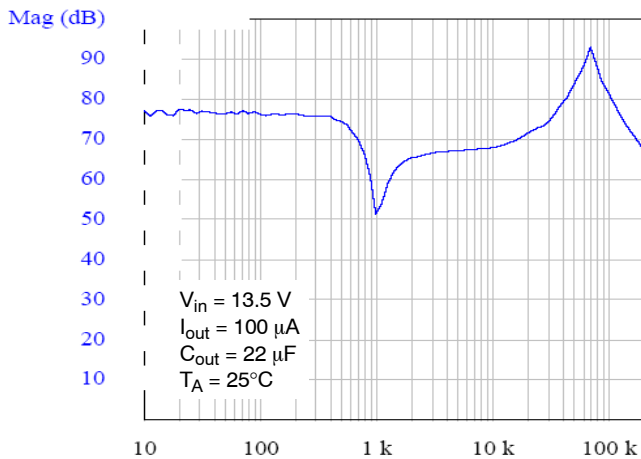**Figure 12. Quiescent Current vs. Temperature – 50 mA Load**
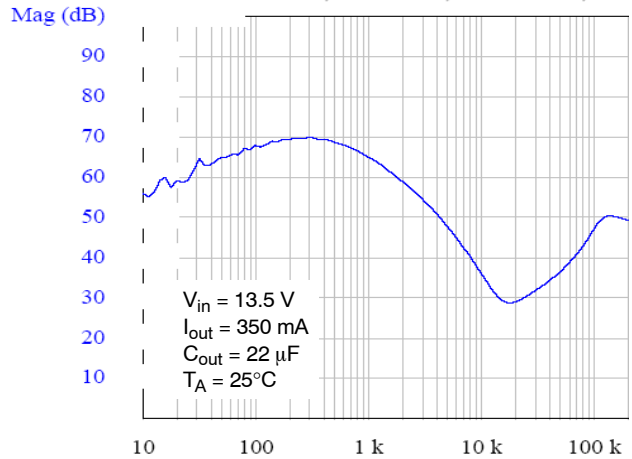
Figure 13. Power Supply Rejection – 100 μA

Figure 14. Power Supply Rejection – 350 mA

Circuit Description

The NCV8674 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 30 μA. The device has current capability of 350 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 NCV8674 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 Ω 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°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 $C_{OUT} \geq 22 \, \mu F$ and ESR ≤ 7.0 Ω, within the operating temperature range. Actual limits are shown in a graph in the Typical Characteristics section.

Calculating Power Dissipation in a Single Output Linear Regulator

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

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

Where:

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

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

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

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

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

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

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 $R_{\theta JA}$:

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

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.

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

The maximum power dissipation for a single output regulator (Figure 15) is:

$$P_{D(max)} = [V_{I(max)} - V_{OUT(min)}] I_{OUT(max)} \qquad (1)$$
$$+ V_{I(max)} I_q$$

where

$V_{I(max)}$ is the maximum input voltage,

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

$I_{OUT(max)}$ is the maximum output current for the application,

I_q is the quiescent current the regulator consumes at $I_{Q(max)}$.

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

$$R_{\theta JA} = \frac{150°C - T_A}{P_D} \qquad (2)$$

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 NO TAG 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 heatsink will be required.
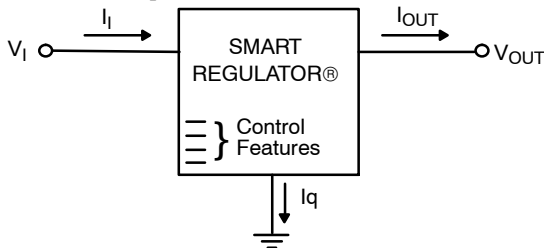

**Figure 15. Single Output Regulator with Key
Performance Parameters Labeled**

Heatsinks

A heatsink 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 $R_{\theta JA}$:

$$R_{\theta JA} = R_{\theta JC} + R_{\theta CS} + R_{\theta SA} \qquad (3)$$

where

$R_{\theta JC}$ is the junction−to−case thermal resistance,

$R_{\theta CS}$ is the case−to−heatsink thermal resistance,

$R_{\theta SA}$ is the heatsink−to−ambient thermal resistance.

$R_{\theta JC}$ 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, heatsink and the interface between them. These values appear in heatsink data sheets of heatsink manufacturers.

Thermal, mounting, and heatsinking considerations are discussed in the ON Semiconductor application note AN1040/D.
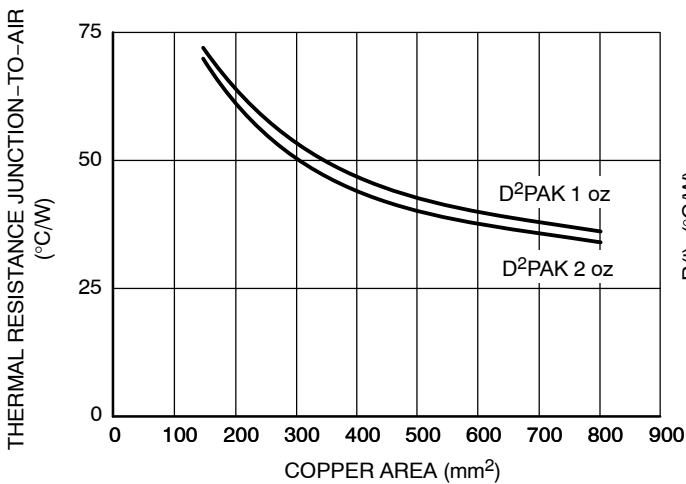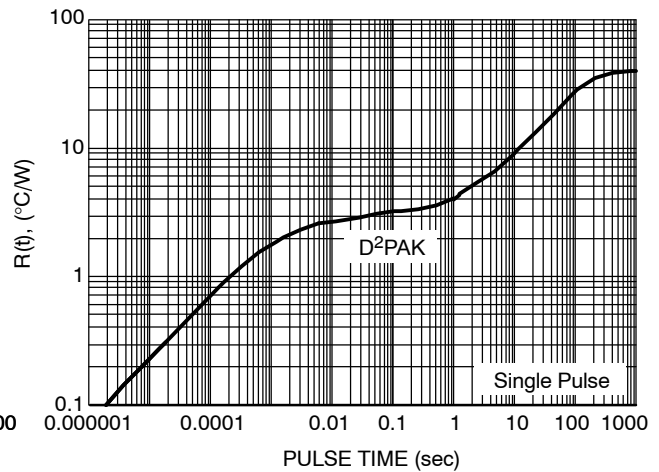

Figure 16.

**Figure 17. NCV8674 @ PCB Cu Area 650 mm^2
PCB Cu thk 1 oz**

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ORDERING INFORMATION

Device	Marking	Package	Shipping†
NCV8674DS50G	V867450	D²PAK (Pb−Free)	50 Units / Rail
NCV8674DS50R4G	V867450	D²PAK (Pb−Free)	800 / 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.

NCV8674

PACKAGE DIMENSIONS

D²PAK
CASE 936−03
ISSUE B
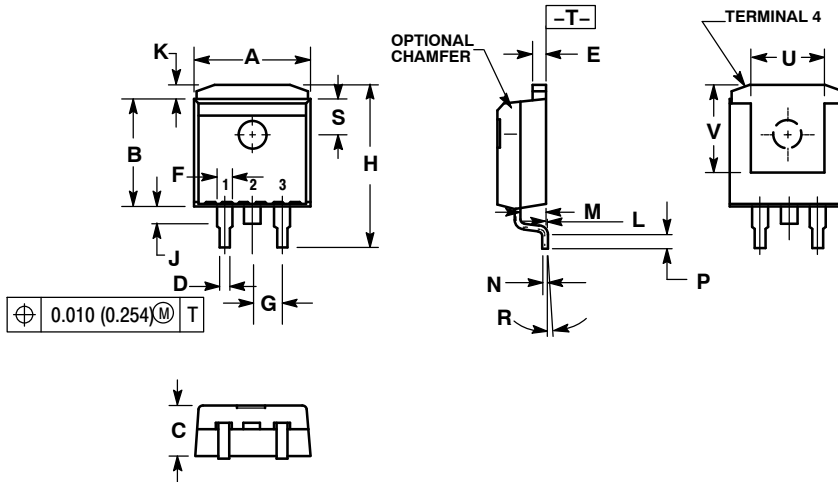
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.386	0.403	9.804	10.236
B	0.356	0.368	9.042	9.347
C	0.170	0.180	4.318	4.572
D	0.026	0.036	0.660	0.914
E	0.045	0.055	1.143	1.397
F	0.051 REF		1.295 REF	
G	0.100 BSC		2.540 BSC	
H	0.539	0.579	13.691	14.707
J	0.125 MAX		3.175 MAX	
K	0.050 REF		1.270 REF	
L	0.000	0.010	0.000	0.254
M	0.088	0.102	2.235	2.591
N	0.018	0.026	0.457	0.660
P	0.058	0.078	1.473	1.981
R	5° REF		5° REF	
S	0.116 REF		2.946 REF	
U	0.200 MIN		5.080 MIN	
V	0.250 MIN		6.350 MIN	

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
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Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

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For additional information, please contact your local Sales Representative

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