NCV8184

Micropower 70 mA Low Dropout Tracking Regulator/Line Driver

The NCV8184 is a monolithic integrated low dropout tracking voltage regulator designed to provide an adjustable buffered output voltage that closely tracks (±5.0 mV) the reference input.

The part can be used in automotive applications with remote sensors, or any situation where it is necessary to isolate the output of your regulator.

The NCV8184 also enables the user to bestow a quick upgrade to their module when added current is needed, and the existing regulator cannot provide.

The versatility of this part also enables it to be used as a high−side driver.

Features

- 70 mA Source Capability
- Output Tracks within ±5.0 mV
- Low Input Voltage Tracking Performance (Works Down to V_{REF} = 2.1 V)
- Low Dropout (0.35 V Typ. @ 50 mA)
- Low Quiescent Current
- Thermal Shutdown
- Wide Operating Range
- Internally Fused Leads in SO−8 Package
- NCV Prefix, for Automotive and Other Applications Requiring Site and Change Control

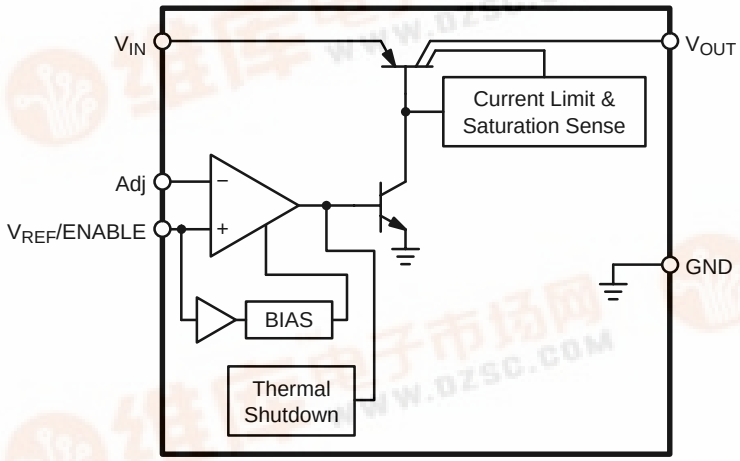

Figure 1. Block Diagram

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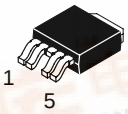
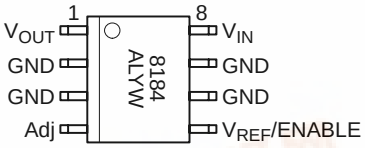
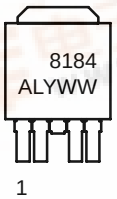
SO−8
D SUFFIX
CASE 751



DPAK
5−LEAD
DT SUFFIX
CASE 175AA

PIN CONNECTIONS AND MARKING DIAGRAM





Pin 1. V_{IN}
2. V_{OUT}
Tab, 3. GND
4. Adj
5. V_{REF}/ENABLE

A = Assembly Location
L = Wafer Lot
Y = Year
WW, W = Work Week

ORDERING INFORMATION

Device	Package	Shipping†
NCV8184D	SO−8	95 Units/Rail
NCV8184DR2	SO−8	2500 Tape & Reel
NCV8184DT	DPAK	50 Units/Rail
NCV8184DTRK	DPAK	2500 Tape & Reel

†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.

MAXIMUM RATINGS

Rating		Value	Unit
Storage Temperature		−65 to 150	°C
Supply Voltage Range (continuous)		−15 to 42	V
Supply Voltage Operating Range		4.0 to 42	V
Peak Transient Voltage (V_{IN} = 14 V, Load Dump Transient = 28 V)		42	V
Voltage Range (V_{OUT}, Adj)		−3.0 to 42	V
Voltage Range (V_{REF}/ENABLE)		−0.3 to 42	V
Maximum Junction Temperature		150	°C
ESD Capability	Human Body Model Machine Model	2.5 200	kV V
Lead Temperature Soldering:	Reflow: (SMD styles only) (Note 1)	240 peak (Note 2)	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. 60 second maximum above 183°C.
2. −5°C / +0°C Allowable Conditions

THERMAL CHARACTERISTICS

See Package Thermal Data Section (Page 8)

ELECTRICAL CHARACTERISTICS (V_{IN} = 14 V; V_{REF}/ENABLE > 2.1 V; −40°C < T_J < +125°C; C_{OUT} = 1.0 μF; I_{OUT} = 1.0 mA; Adj = V_{OUT}; $C_{OUT-ESR}$ = 1.0 Ω, unless otherwise specified.)

Parameter	Test Conditions	Min	Typ	Max	Unit
Regular Output					
V_{REF}/ENABLE − V_{OUT} V_{OUT} Tracking Error	6.0 V ≤ V_{IN} ≤ 26 V, 100 μA ≤ I_{OUT} ≤ 50 mA 2.1 V ≤ V_{REF}/ENABLE ≤ (V_{IN} − 600 mV) V_{IN} = 12 V, I_{OUT} = 5.0 mA, V_{REF}/ENABLE = 5.0 V	−10 −5.0	− −	10 5.0	mV mV
Dropout Voltage (V_{IN} − V_{OUT})	I_{OUT} = 100 μA I_{OUT} = 5.0 mA I_{OUT} = 50 mA	− − −	100 250 350	150 500 600	mV mV mV
Line Regulation	6.0 V ≤ V_{IN} ≤ 26 V, V_{REF}/ENABLE = 5.0 V	−	−	10	mV
Load Regulation	100 μA ≤ I_{OUT} ≤ 50 mA, V_{REF}/ENABLE = 5.0 V	−	−	10	mV
Adj Input Bias Current	V_{REF}/ENABLE = 5.0 V	−	0.2	1.0	μA
Current Limit	V_{IN} = 14 V, V_{REF}/ENABLE = 5.0 V, V_{OUT} = 90% of Adj	70	−	400	mA
Quiescent Current (I_{IN} − I_{OUT})	V_{IN} = 12 V, I_{OUT} = 50 mA V_{IN} = 12 V, I_{OUT} = 100 μA V_{IN} = 12 V, V_{REF}/ENABLE = 0 V	− − −	5.0 50 −	7.0 70 20	mA μA μA
Ripple Rejection	f = 120 Hz, I_{OUT} = 50 mA, 6.0 V ≤ V_{IN} ≤ 26 V	60	−	−	dB
Thermal Shutdown	Guaranteed by Design	150	180	210	°C
V_{REF}/ENABLE					
Enable Voltage	−	0.8	−	2.1	V
Input Bias Current	V_{REF}/ENABLE = 5.0 V	−	0.2	1.0	μA

PACKAGE PIN DESCRIPTION

Package Lead Number		Lead Symbol	Function
SO−8	DPAK, 5−LEAD		
8	1	V_{IN}	Battery supply input voltage.
1	2	V_{OUT}	Regulated output.
2, 3, 6, 7	Tab, 3	GND	Ground.
4	4	Adj	Adjust lead, noninverting input.
5	5	V_{REF}/ENABLE	Reference voltage and ENABLE input.

TYPICAL PERFORMANCE CHARACTERISTICS

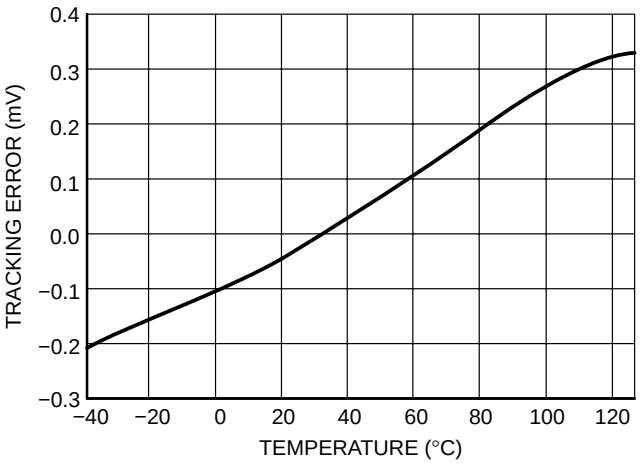


Figure 2. Tracking Error vs. Temperature

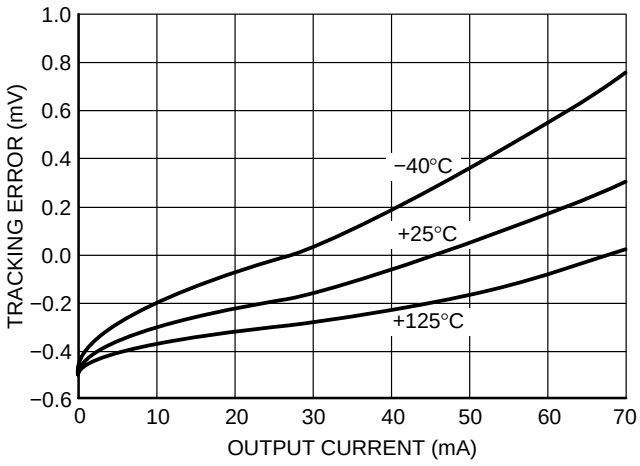


Figure 3. Tracking Error vs. Output Current

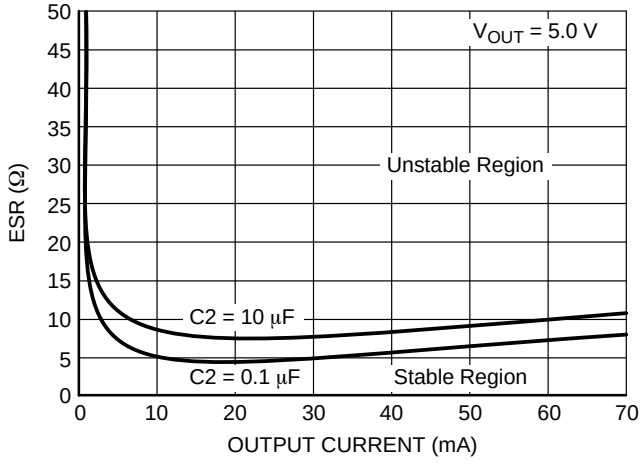


Figure 4. Output Stability with Capacitor Change

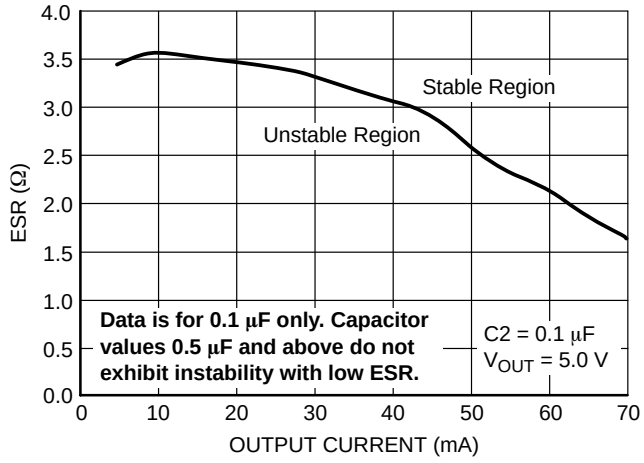


Figure 5. Output Stability with 0.1 μF at Low ESR

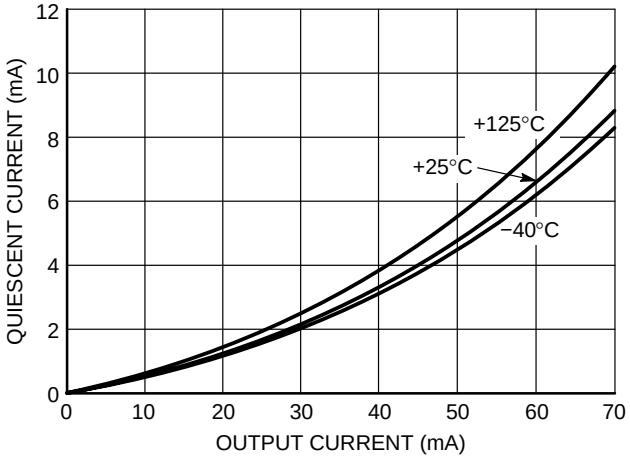


Figure 6. Quiescent Current vs. Output Current

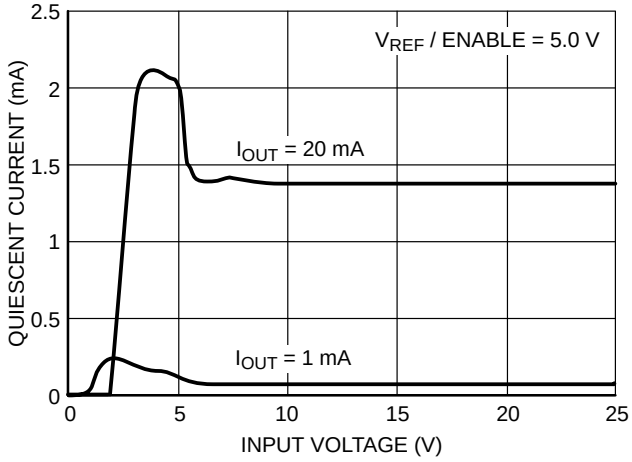


Figure 7. Quiescent Current vs. Input Voltage

TYPICAL PERFORMANCE CHARACTERISTICS

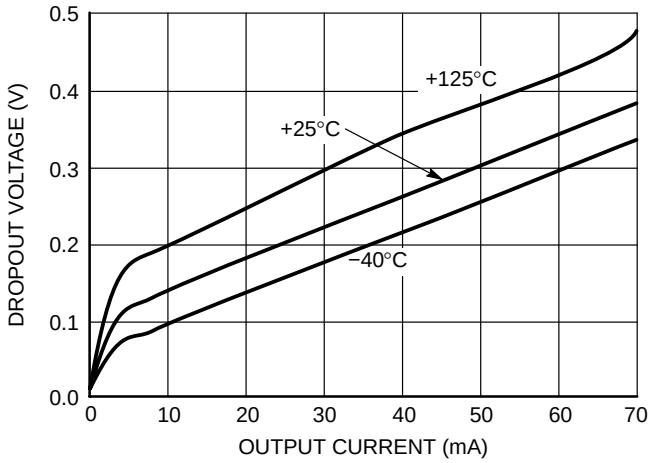


Figure 8. Dropout Voltage vs. Output Current

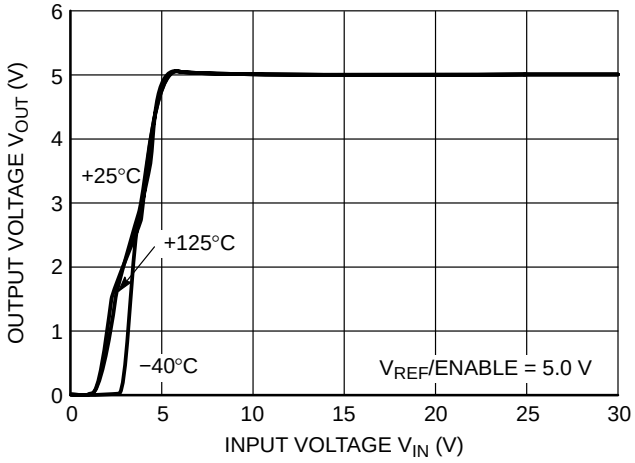


Figure 9. Output Voltage vs. Input Voltage

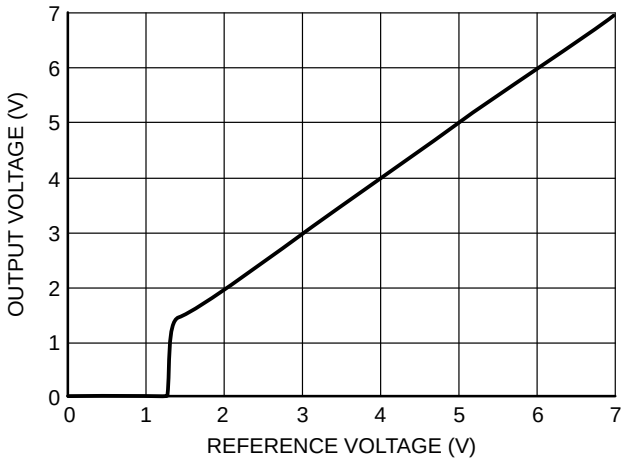


Figure 10. Output Voltage vs. Reference Voltage

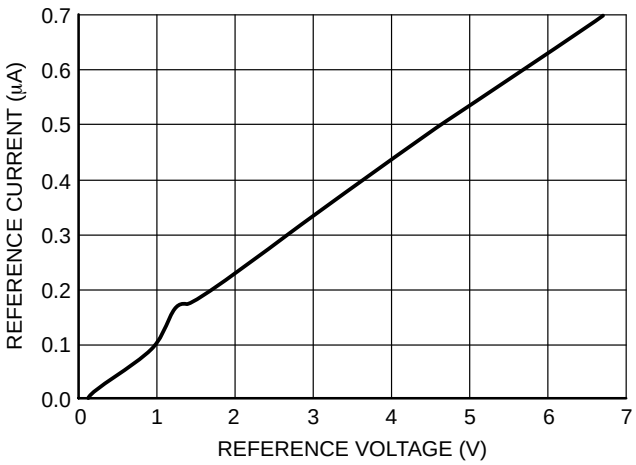


Figure 11. Reference Current vs. Reference Voltage

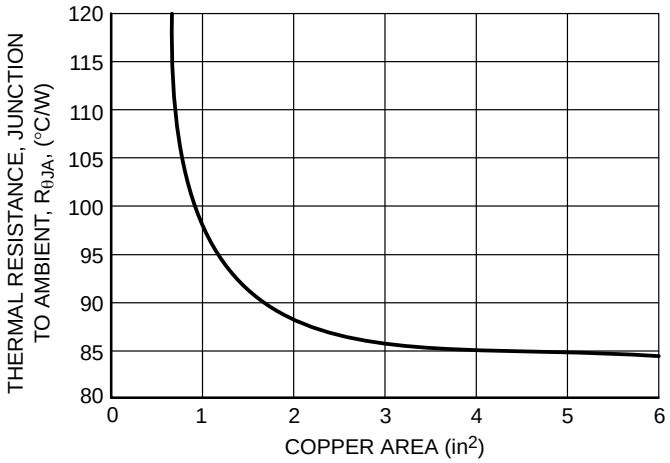


Figure 12. SO−8, θJA as a Function of the Pad Copper Area (2.0 oz. Cu Thickness), Board Material = 0.0625 G−10/R−4

CIRCUIT DESCRIPTION

ENABLE Function

By pulling the V_{REF}/ENABLE lead below 0.8 V, (see Figure 16 or Figure 17), the IC is disabled and enters a sleep state where the device draws less than 20 μA from supply. When the V_{REF}/ENABLE lead is greater than 2.1 V, V_{OUT} tracks the V_{REF}/ENABLE lead normally.

Output Voltage

The output is capable of supplying 70 mA to the load while configured as a similar (Figure 13), lower (Figure 15), or higher (Figure 14) voltage as the reference lead. The Adj lead acts as the inverting terminal of the op amp and the V_{REF} lead as the non−inverting.

The device can also be configured as a high−side driver as displayed in Figure 18.

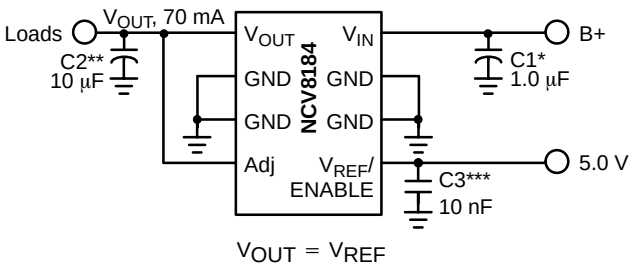


Figure 13. Tracking Regulator at the Same Voltage

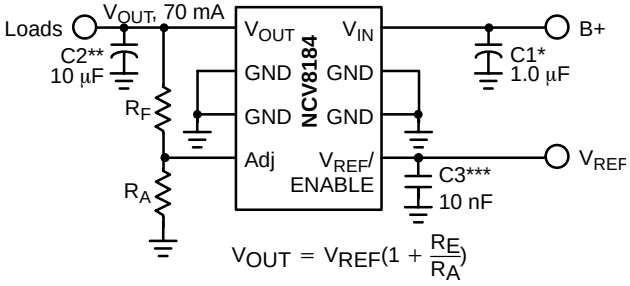


Figure 14. Tracking Regulator at Higher Voltages

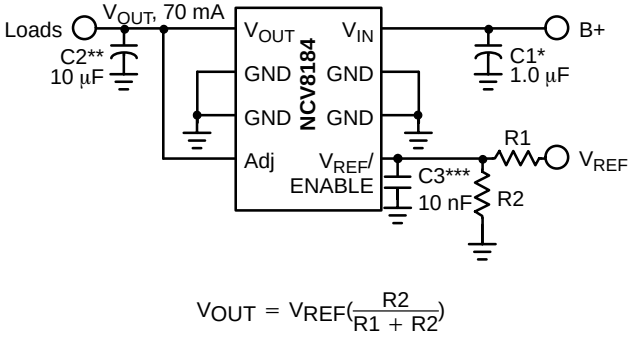


Figure 15. Tracking Regulator at Lower Voltages

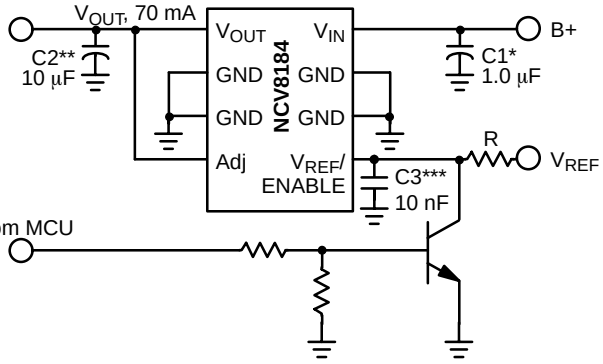


Figure 16. Tracking Regulator with ENABLE Circuit

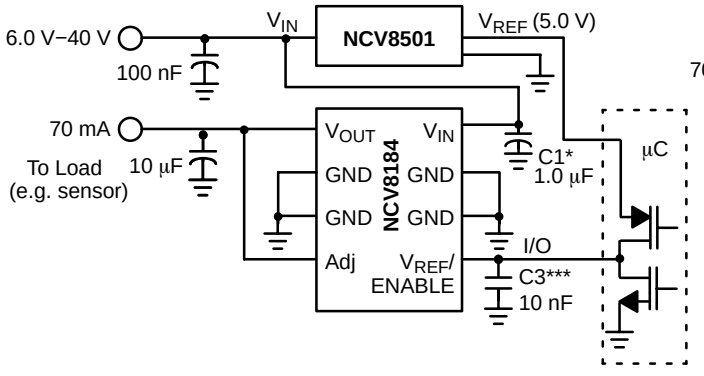


Figure 17. Alternative ENABLE Circuit

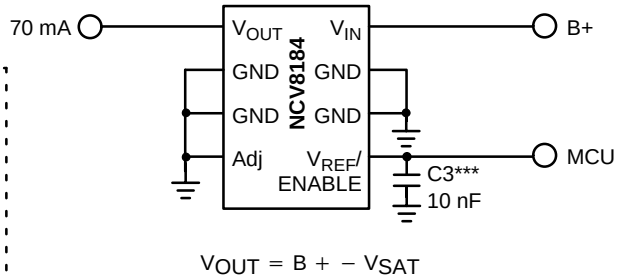


Figure 18. High−Side Driver

* C1 is required if the regulator is far from the power source filter.
** C2 is required for stability.
*** C3 is recommended for EMC susceptibility

APPLICATION NOTES

V_{OUT} Short to Battery

The NCV8184 will survive a short to battery when hooked up the conventional way as shown in Figure 19. No damage to the part will occur. The part also endures a short to battery when powered by an isolated supply at a lower voltage as in Figure 20. In this case the NCV8184 supply input voltage is set at 7 V when a short to battery (14 V typical) occurs on V_{OUT} which normally runs at 5 V. The current into the device (ammeter in Figure 20) will draw additional current as displayed in Figure 21.

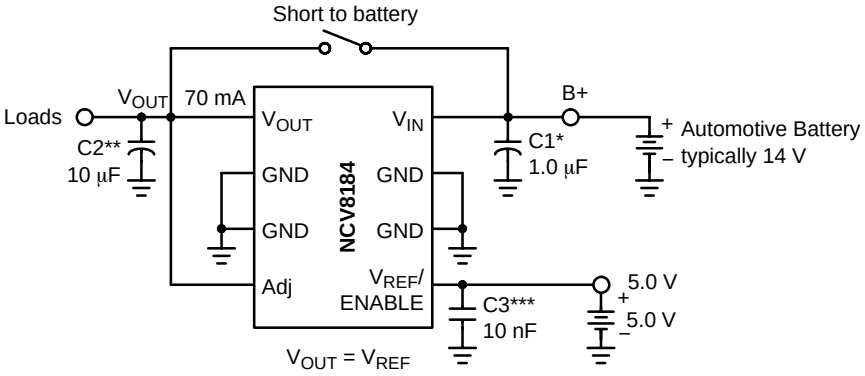
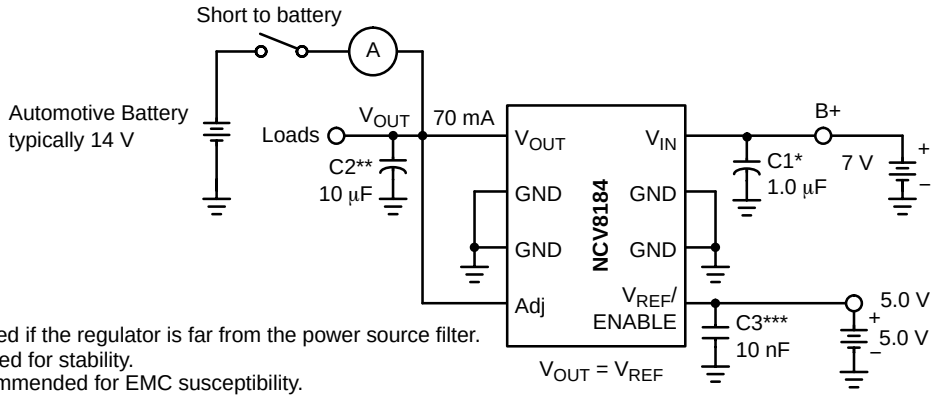


Figure 19.



* C1 is required if the regulator is far from the power source filter.
** C2 is required for stability.
*** C3 is recommended for EMC susceptibility.

Figure 20.

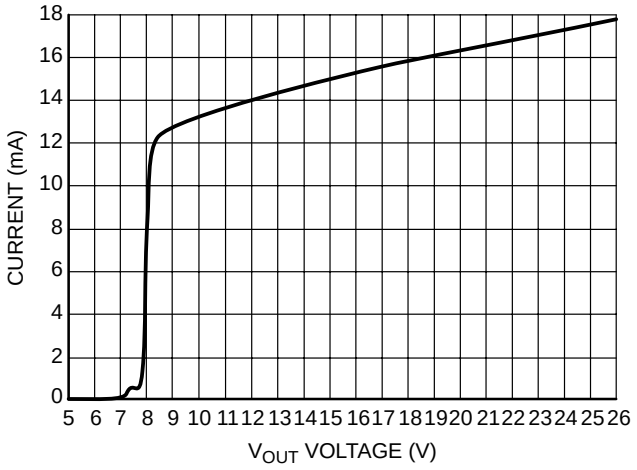


Figure 21. V_{OUT} Short to Battery

Switched Application

The NCV8184 has been designed for use in systems where the reference voltage on the V_{REF}/ENABLE pin is continuously on. Typically, the current into the V_{REF}/ENABLE pin will be less than 1.0 μA when the voltage on the V_{IN} pin (usually the ignition line) has been switched out (V_{IN} can be at high impedance or at ground.) Reference Figure 22.

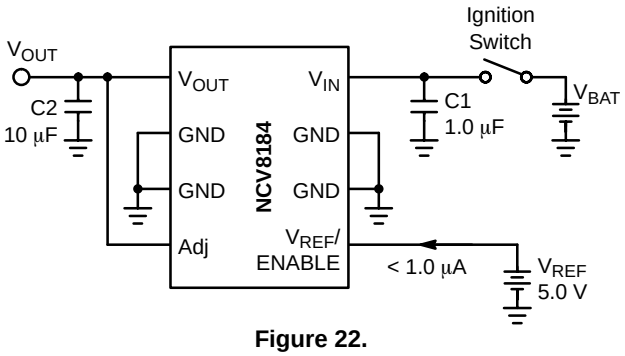


Figure 22.

External Capacitors

The output capacitor for the NCV8184 is required for stability. Without it, the regulator output will oscillate. Actual size and type may vary depending upon the application load and temperature range. Capacitor effective series resistance (ESR) is also a factor in the IC stability. Worst−case is determined at the minimum ambient temperature and maximum load expected.

The output capacitor can be increased in size to any desired value above the minimum. One possible purpose of this would be to maintain the output voltage during brief conditions of negative input transients that might be characteristic of a particular system.

The capacitor must also be rated at all ambient temperatures expected in the system. To maintain regulator stability down to −40°C, a capacitor rated at that temperature must be used.

More information on capacitor selection for SMART REGULATOR®s is available in the SMART REGULATOR application note, “Compensation for Linear Regulators,” document number SR003AN/D, available through our website at http://www.onsemi.com.

Calculating Power Dissipation in a Single Output Linear Regulator

The maximum power dissipation for a single output regulator (Figure 23) is:

$$P_{D(max)} = \{V_{IN(max)} - V_{OUT(min)}\} I_{OUT(max)} + V_{IN(max)} I_Q \quad \text{(eq. 1)}$$

where:

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

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

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

I_Q is the quiescent current the regulator consumes at $I_{OUT(max)}$.

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

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

The value of $R_{\theta JA}$ can then be compared with those in the Package Thermal Data 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.

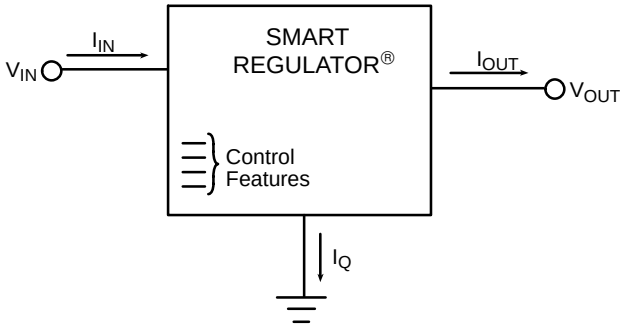


Figure 23. Single Output Regulator with Key Performance Parameters Labeled

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 $R_{\theta JA}$:

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

where:

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

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

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

$R_{\theta JC}$ appears in the package section of the data sheet. Like $R_{\theta JA}$, it 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 heat sink data sheets of heatsink manufacturers.

PACKAGE THERMAL DATA

Parameter	Test Conditions Typical Value		Units
SO−8 Package	**Min−Pad Board (Figure 24)**	**1.0 in Pad Board (Figure 25)**	
Junction−to−Case top (Ψ−JT, Ψ_{JT})	39	32	°C/W
Junction−to−Pin 8 (Ψ−JL8, Ψ_{JL8})	63	58	°C/W
Junction−to−Ambient ($R_{\theta JA}$, θ_{JA})	121	98	°C/W
DPAK 5−Pin Package	**0.5 in^2 Spreader Board (Figure 26)**	**1.0 in^2 Spreader Board (Figure 27)**	
Junction−to−Board (Ψ−JB, Ψ_{JB})	15	15	°C/W
Junction−to−Pin 3 (tab) (Ψ−JL3, Ψ_{JL3})	16	16	°C/W
Junction−to−Ambient ($R_{\theta JA}$, θ_{JA})	100	69	°C/W

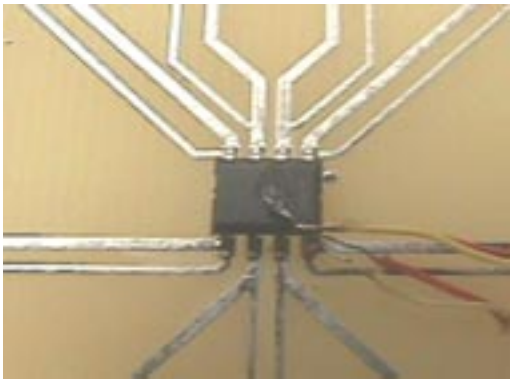


Figure 24. 2.0 oz. copper, 40 mil traces

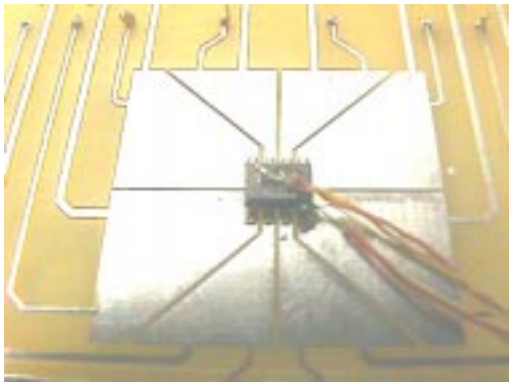


Figure 25. 1.0 oz. copper, approx. 1/8 in^2 per lead, 1.0 in^2 total

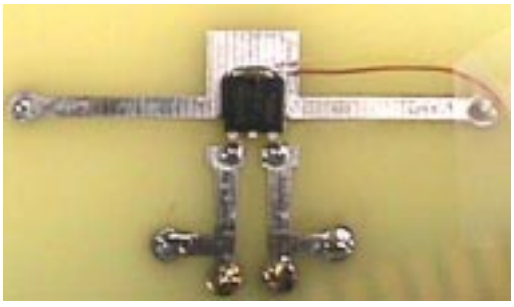


Figure 26. 1.0 oz. copper, 0.3 in^2 drain pad, 0.5 in^2 including traces

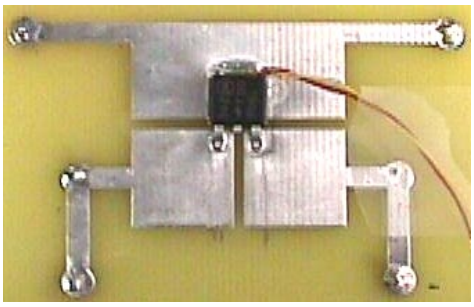


Figure 27. 2.0 oz. copper, 0.5 in^2 drain pad, 1.0 in^2 including traces

Table 1. SO−8 Thermal RC Network Models*

Board Type			Min−Pad	1.0 inch Pad		Min−Pad	1.0 inch Pad	
(SPICE Deck Format)			Cauer Network			Foster Network		
			Min	1.0 inch	Units	Tau	Tau	Units
C_C1	**Junction**	**Gnd**	**7.06879E−7**	**7.06879E−7**	W−s/C	**2.99E−7**	**2.99E−7**	sec
C_C2	**node1**	**Gnd**	**3.34499E−6**	**3.34499E−6**	W−s/C	**4.40E−6**	**4.40E−6**	sec
C_C3	**node2**	**Gnd**	**1.00350E−5**	**1.00350E−5**	W−s/C	**4.48E−5**	**4.48E−5**	sec
C_C4	**node3**	**Gnd**	**3.68358E−5**	**3.68358E−5**	W−s/C	**2.46E−4**	**2.46E−4**	sec
C_C5	**node4**	**Gnd**	**4.29554E−4**	**4.29554E−4**	W−s/C	**4.72E−3**	**4.72E−3**	sec
C_C6	**node5**	**Gnd**	**7.20791E−3**	**7.20791E−3**	W−s/C	**7.18E−2**	**7.25E−2**	sec
C_C7	node6	Gnd	3.52182E−2	3.76156E−2	W−s/C	1.61E+0	1.31E+0	sec
C_C8	node7	Gnd	7.16622E−1	1.33747E+0	W−s/C	2.08E+1	1.62E+1	sec
C_C9	node8	Gnd	6.57830E+0	3.97588E+0	W−s/C	1.33E+2	1.08E+2	sec
			Min	**1.0 inch**		**R's**	**R's**	
R_R1	**Junction**	**node1**	**5.17805E−1**	**5.1780E−1**	°C/W	**0.34137**	**0.34137**	°C/W
R_R2	**node1**	**node2**	**1.55341E+0**	**1.5534E+0**	°C/W	**0.83581**	**0.83581**	°C/W
R_R3	**node2**	**node3**	**4.66024E+0**	**4.6602E+0**	°C/W	**2.36526**	**2.36526**	°C/W
R_R4	**node3**	**node4**	**4.98386E+0**	**4.9838E+0**	°C/W	**6.76959**	**6.76960**	°C/W
R_R5	**node4**	**node5**	**1.04570E+1**	**1.0457E+1**	°C/W	**10.39190**	**10.39200**	°C/W
R_R6	**node5**	**node6**	**1.14509E+1**	**1.1450E+1**	°C/W	**8.68648**	**8.81855**	°C/W
R_R7	node6	node7	3.94880E+1	2.9500E+1	°C/W	38.62760	31.37390	°C/W
R_R8	node7	node8	3.10554E+1	1.6877E+1	°C/W	27.65780	8.93175	°C/W
R_R9	node8	node9	1.77562E+1	1.8812E+1	°C/W	26.24690	28.98470	°C/W

Table 2. DPAK 5−Lead Thermal RC Network Models*

Drain Copper Area (1 oz thick)			100 mm^2	653 mm^2		100 mm^2	653 mm^2	
(SPICE Deck Format)			Cauer Network			Foster Network		
			100 mm^2	653 mm^2	Units	Tau	Tau	Units
C_C1	**Junction**	**Gnd**	**1.51E−06**	**1.51E−06**	W−s/C	**1.00E−06**	**1.00E−06**	sec
C_C2	**node1**	**Gnd**	**6.00E−06**	**5.91E−06**	W−s/C	**1.00E−05**	**1.00E−05**	sec
C_C3	**node2**	**Gnd**	**1.90E−05**	**1.81E−05**	W−s/C	**1.00E−04**	**1.00E−04**	sec
C_C4	**node3**	**Gnd**	**1.05E−04**	**9.59E−05**	W−s/C	**7.00E−04**	**6.00E−04**	sec
C_C5	**node4**	**Gnd**	**2.98E−03**	**3.21E−03**	W−s/C	**1.03E−02**	**1.03E−02**	sec
C_C6	node5	Gnd	2.37E−02	7.87E−02	W−s/C	1.71E−01	1.71E−01	sec
C_C7	node6	Gnd	4.95E−02	7.88E−02	W−s/C	1.17E+00	1.17E+00	sec
C_C8	node7	Gnd	2.32E−01	1.03E+00	W−s/C	7.63E+00	7.63E+00	sec
C_C9	node8	Gnd	6.95E−01	1.58E+00	W−s/C	3.93E+01	3.93E+01	sec
C_C10	node9	Gnd	6.91E+00	1.16E+01	W−s/C	1.42E+02	1.42E+02	sec
			100 mm^2	**653 mm^2**		**R's**	**R's**	
R_R1	**Junction**	**node1**	**0.845**	**0.850**	°C/W	**0.507**	**0.507**	°C/W
R_R2	**node1**	**node2**	**1.886**	**1.933**	°C/W	**1.096**	**1.096**	°C/W
R_R3	**node2**	**node3**	**4.758**	**5.070**	°C/W	**3.467**	**3.467**	°C/W
R_R4	**node3**	**node4**	**5.336**	**4.862**	°C/W	**7.168**	**7.168**	°C/W
R_R5	**node4**	**node5**	**3.735**	**3.201**	°C/W	**3.394**	**3.394**	°C/W
R_R6	node5	node6	10.537	5.293	°C/W	4.000	0.720	°C/W
R_R7	node6	node7	19.583	6.828	°C/W	15.000	8.912	°C/W
R_R8	node7	node8	38.068	13.172	°C/W	20.000	3.636	°C/W
R_R9	node8	node9	43.000	16.466	°C/W	50.000	15.161	°C/W
R_R10	node9	gnd	16.884	8.868	°C/W	40.000	22.480	°C/W

*Bold face items in the tables above represent the package without the external thermal system.

The Cauer networks generally have physical significance and may be divided between nodes to separate thermal behavior due to one portion of the network from another. The Foster networks, though when sorted by time constant (as above) bear a rough correlation with the Cauer networks, are really only convenient mathematical models. Cauer networks can be easily implemented using circuit simulating tools, whereas Foster networks may be more easily implemented using mathematical tools (for instance, in a spreadsheet program), according to the following formula:

$$R(t) = \sum_{i=1}^{n} R_i \left(1 - e^{-t/tau_i}\right)$$

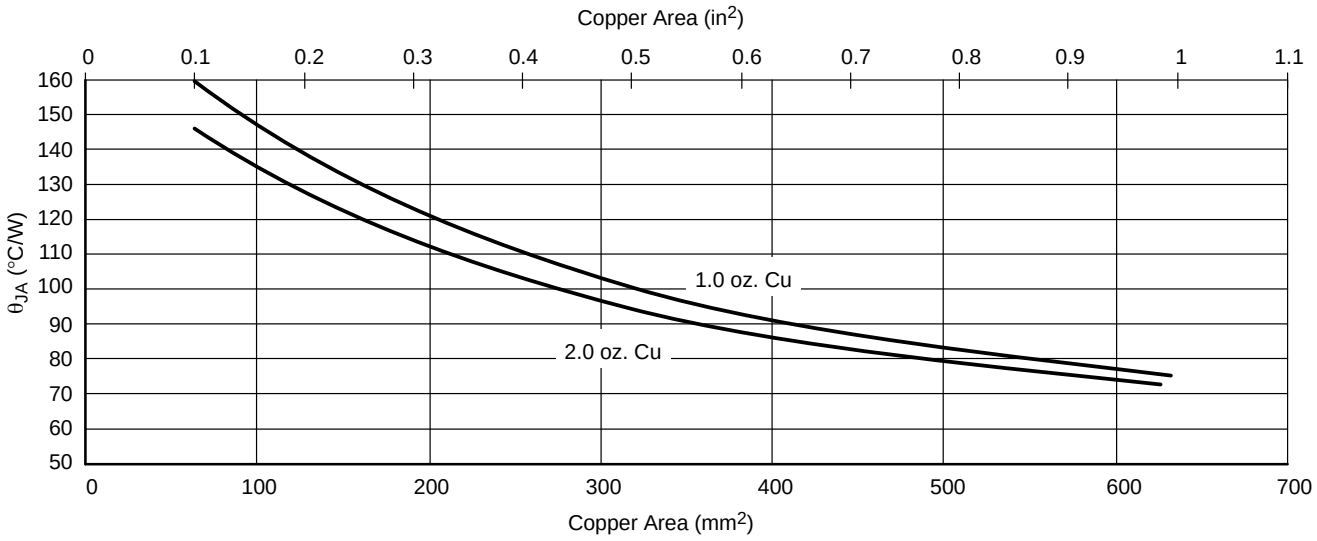


Figure 28. DPAK 5−Lead, θJA as a Function of the Pad Copper Area Including Traces, Board Material 0.62” Thick FR4

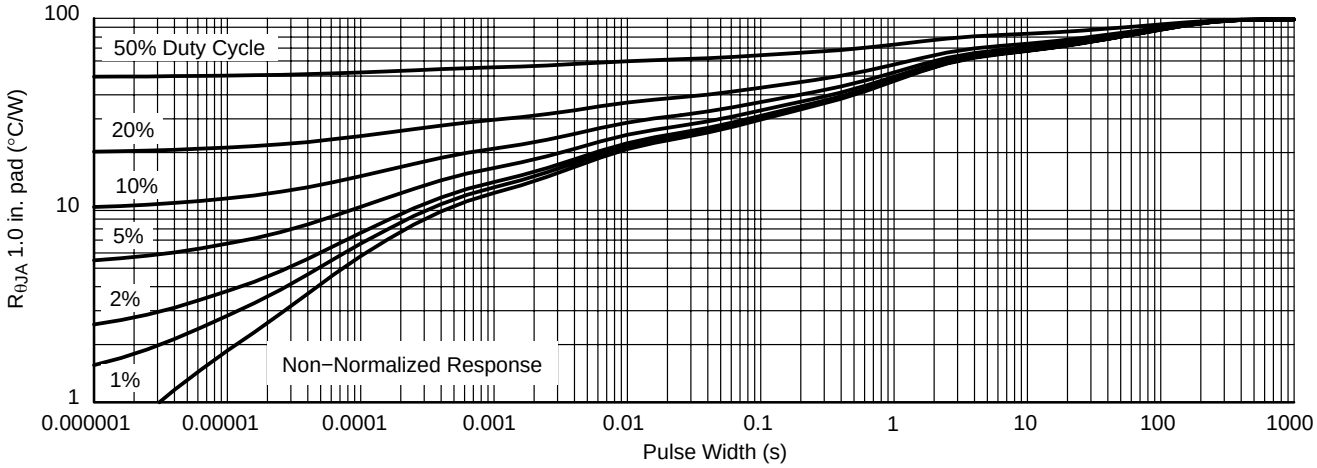


Figure 29. SO−8 Thermal Duty Cycle Curves on 1.0 in. Spreader Test Board

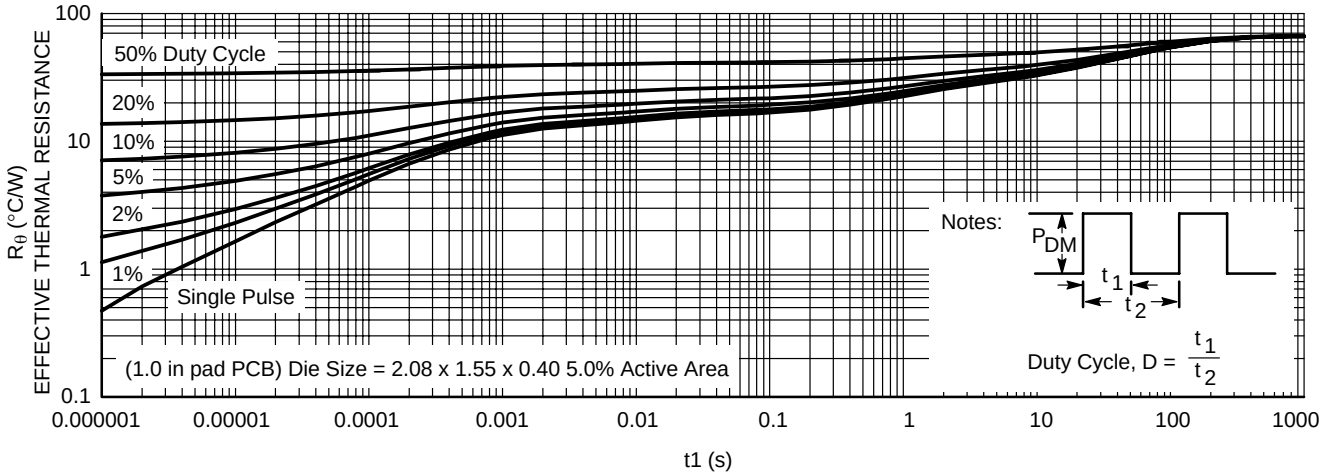


Figure 30. DPAK 5−Lead Thermal Duty Cycle Curves on 1.0 in. Spreader Test Board

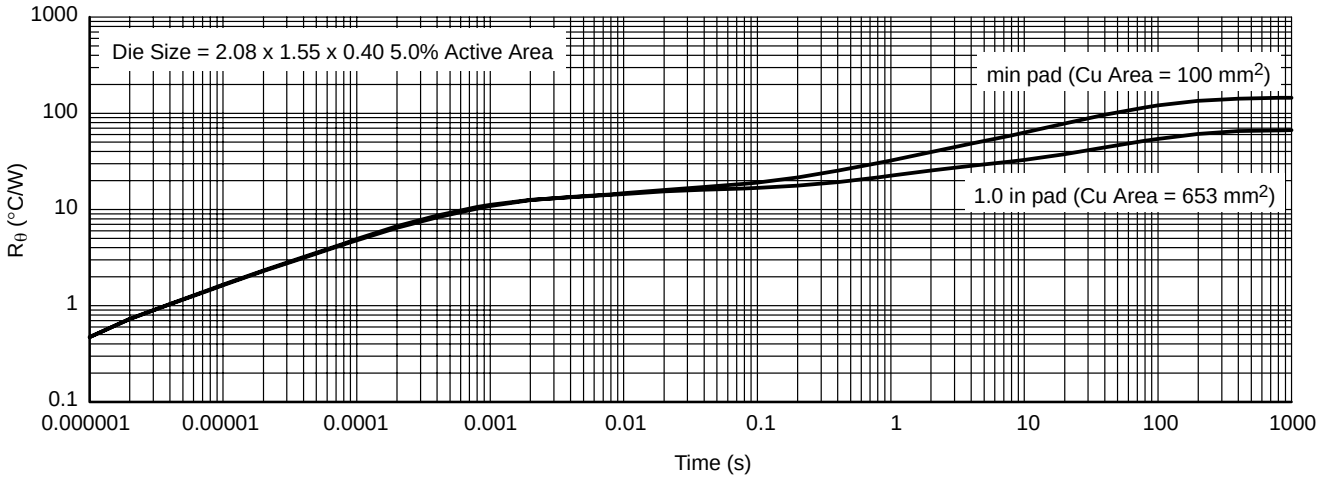


Figure 31. DPAK 5−Lead Thermal Transient Response on Typical Test Boards

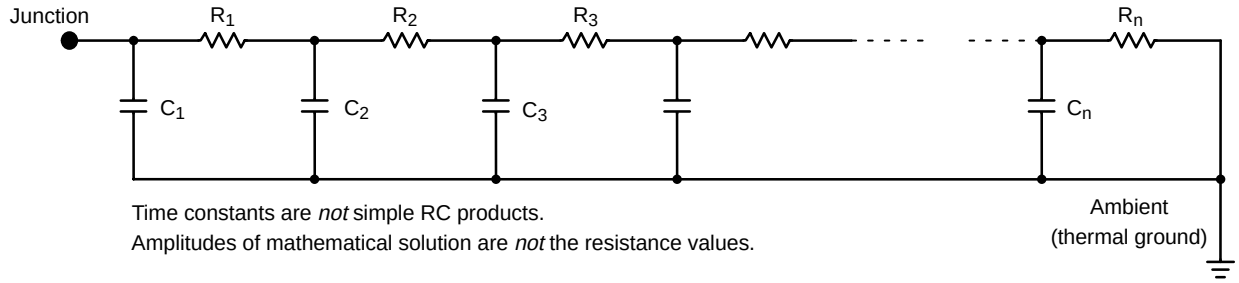


Figure 32. Grounded Capacitor Thermal Network (“Cauer” Ladder)

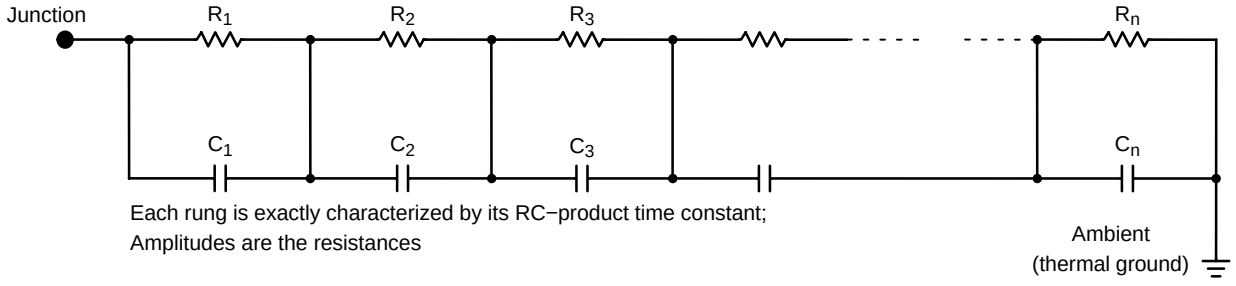
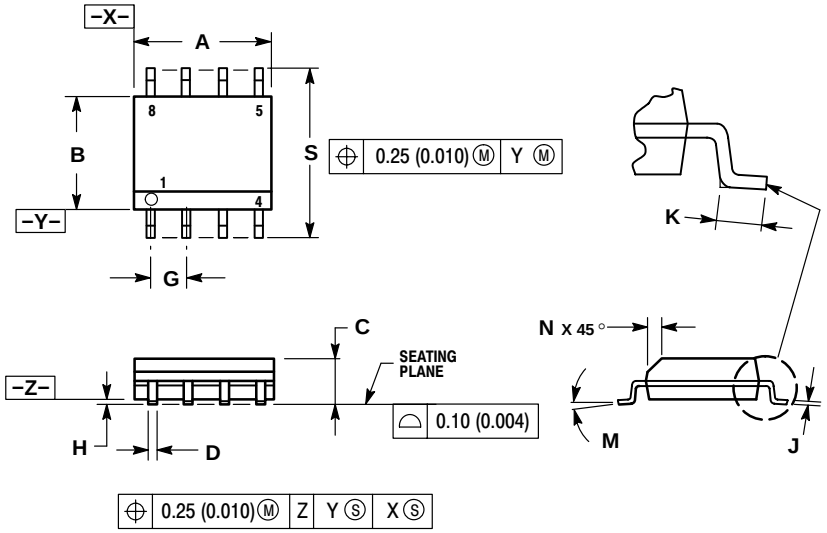


Figure 33. Non−Grounded Capacitor Thermal Ladder (“Foster” Ladder)

PACKAGE DIMENSIONS

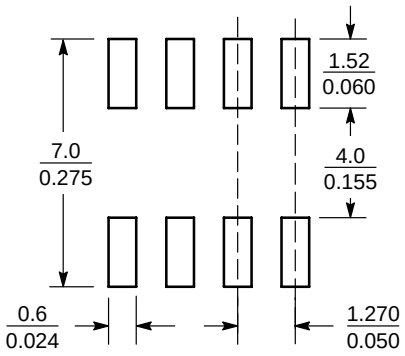
SO−8
D SUFFIX
CASE 751−07
ISSUE AB



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. 751−01 THRU 751−06 ARE OBSOLETE. NEW STANDAARD IS 751−07

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

SOLDERING FOOTPRINT

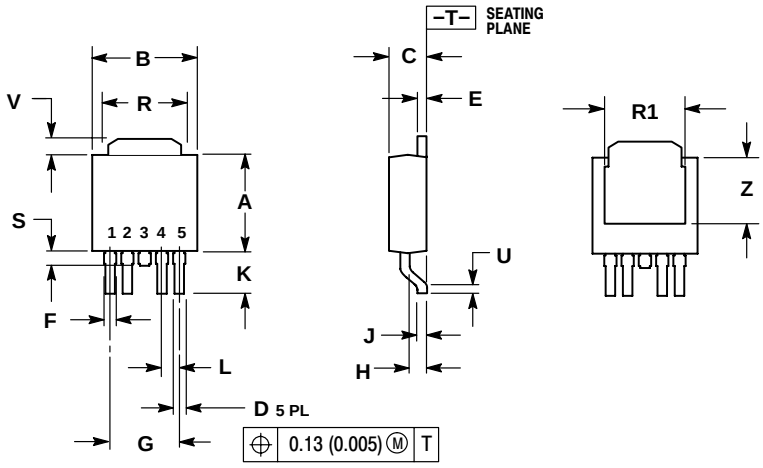


SCALE 6:1 $\left(\frac{\text{mm}}{\text{inches}}\right)$

NCV8184

PACKAGE DIMENSIONS

DPAK 5−LEAD CENTER LEAD CROP
DT SUFFIX
CASE 175AA−01
ISSUE O



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

	INCHES		MILLIMETERS	
DIM	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	0.020	0.028	0.51	0.71
E	0.018	0.023	0.46	0.58
F	0.024	0.032	0.61	0.81
G	0.180 BSC		4.56 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	0.045 BSC		1.14 BSC	
R	0.170	0.190	4.32	4.83
R1	0.185	0.210	4.70	5.33
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	0.170	3.93	4.32

Note: Pin 3 and the tab are internally connected

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