

NTD4404N

Power MOSFET 85 Amps, 24 Volts N-Channel DPAK

Features

- Planar HD3e Process for Fast Switching Performance
- Low $R_{DS(on)}$ to Minimize Conduction Loss
- Low C_{iss} to Minimize Driver Loss
- Low Gate Charge
- Pb-Free Packages are Available

MAXIMUM RATINGS ($T_J = 25^\circ\text{C}$ Unless otherwise specified)

Parameter	Symbol	Value	Unit
Drain-to-Source Voltage	V_{DSS}	24	V_{dc}
Gate-to-Source Voltage – Continuous	V_{GS}	± 20	V_{dc}
Thermal Resistance – Junction-to-Case	$R_{\theta JC}$	1.6	$^\circ\text{C/W}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$	P_D	78.1	W
Drain Current	I_D	85	A
– Continuous @ $T_C = 25^\circ\text{C}$, Limited by Package	I_D	32	A
– Continuous @ $T_A = 25^\circ\text{C}$, Limited by Wires	I_{DM}	96	A
– Single Pulse ($t_p \leq 10 \mu\text{s}$)			
Thermal Resistance, Junction-to-Ambient (Note 1)	$R_{\theta JA}$	52	$^\circ\text{C/W}$
Total Power Dissipation @ $T_A = 25^\circ\text{C}$	P_D	2.4	W
Drain Current – Continuous @ $T_A = 25^\circ\text{C}$	I_D	16	A
Thermal Resistance, Junction-to-Ambient (Note 2)	$R_{\theta JA}$	100	$^\circ\text{C/W}$
Total Power Dissipation @ $T_A = 25^\circ\text{C}$	P_D	1.25	W
Drain Current – Continuous @ $T_A = 25^\circ\text{C}$	I_D	12	A
Operating and Storage Temperature Range	T_J, T_{stg}	-55 to 150	$^\circ\text{C}$
Single Pulse Drain-to-Source Avalanche Energy – Starting $T_J = 25^\circ\text{C}$ ($V_{DD} = 23 V_{dc}$, $V_{GS} = 10 V_{dc}$, $I_L = 13.4 A_{pk}$, $L = 1 \text{ mH}$, $R_G = 25 \Omega$)	E_{AS}	90	mJ
Maximum Lead Temperature for Soldering Purposes, 1/8 in from Case for 10 Seconds	T_L	260	$^\circ\text{C}$

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. When surface mounted to an FR4 board using 1 inch pad size, (Cu Area 1.127 in²).
2. When surface mounted to an FR4 board using minimum recommended pad size, (Cu Area 0.412 in²).



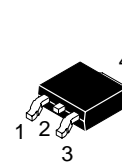
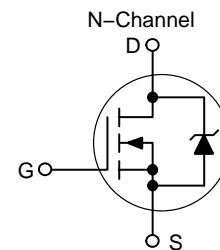
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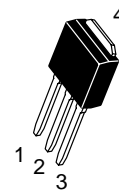
85 AMPERES, 24 VOLTS

$R_{DS(on)} = 4.23 \text{ m}\Omega$ (Min)

$R_{DS(on)} = 5.17 \text{ m}\Omega$ (Max)

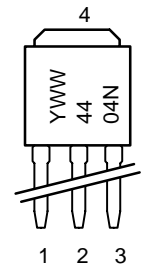
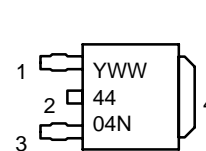


**DPAK
CASE 369C
STYLE 2**



**Straight Lead DPAK-3
CASE 369D
STYLE 2**

MARKING DIAGRAMS & PIN ASSIGNMENTS



- 1 Gate
- 2 Drain
- 3 Source
- 4 Drain

Y = Year
WW = Work Week
4404N = Specific Device Code

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

NTD4404N

ELECTRICAL CHARACTERISTICS (T_J = 25°C Unless otherwise specified)

Characteristics	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-to-Source Breakdown Voltage (Note 3) (V _{GS} = 0 V _{dc} , I _D = 250 μA _{dc}) Temperature Coefficient (Positive)	V _{(br)DSS}	24 –	28 20.5	– –	V _{dc} mV/°C
Zero Gate Voltage Drain Current (V _{DS} = 20 V _{dc} , V _{GS} = 0 V _{dc}) (V _{DS} = 20 V _{dc} , V _{GS} = 0 V _{dc} , T _J = 150°C)	I _{DSS}	– –	– –	1.5 10	μA _{dc}
Gate-Body Leakage Current (V _{GS} = ±20 V _{dc} , V _{DS} = 0 V _{dc})	I _{GSS}	–	–	±100	nA _{dc}

ON CHARACTERISTICS (Note 3)

Gate Threshold Voltage (Note 3) (V _{DS} = V _{GS} , I _D = 250 μA _{dc}) Threshold Temperature Coefficient (Negative)	V _{GS(th)}	1.0 –	1.5 4.0	2.0 –	V _{dc} mV/°C
Static Drain-to-Source On-Resistance (Note 3) (V _{GS} = 10 V _{dc} , I _D = 20 A _{dc})	R _{DS(on)}	4.23	–	5.17	mΩ
Forward Transconductance (Note 3) (V _{DS} = 10 V _{dc} , I _D = 15 A _{dc})	g _{FS}	–	38	–	Mhos

DYNAMIC CHARACTERISTICS

Input Capacitance	(V _{DS} = 20 V _{dc} , V _{GS} = 0 V, f = 1 MHz)	C _{iss}	–	2050	–	pF
Output Capacitance		C _{oss}	–	871	–	
Transfer Capacitance		C _{rss}	–	359	–	

SWITCHING CHARACTERISTICS (Note 4)

Turn-On Delay Time	(V _{GS} = 10 V _{dc} , V _{DD} = 10 V _{dc} , I _D = 30 A _{dc} , R _G = 3 Ω)	t _{d(on)}	–	6.3	–	ns
Rise Time		t _r	–	77	–	
Turn-Off Delay Time		t _{d(off)}	–	25	–	
Fall Time		t _f	–	12	–	
Gate Charge	(V _{GS} = 5 V _{dc} , I _D = 10 A _{dc} , V _{DS} = 10 V _{dc}) (Note 3)	Q _T	–	17.7	–	nC
		Q ₁	–	2.6	–	
		Q ₂	–	7.1	–	

SOURCE-DRAIN DIODE CHARACTERISTICS

Forward On-Voltage	(I _S = 10 A _{dc} , V _{GS} = 0 V _{dc}) (Note 3) (I _S = 10 A _{dc} , V _{GS} = 0 V _{dc} , T _J = 125°C)	V _{SD}	– –	0.78 0.63	1.0 –	V _{dc}
Reverse Recovery Time		(I _S = 20 A _{dc} , V _{GS} = 0 V _{dc} , di _S /dt = 100 A/μs) (Note 3)	t _{rr}	–	37.5	–
	t _a		–	16.8	–	
	t _b		–	20.7	–	
Reverse Recovery Stored Charge		Q _{RR}	–	0.027	–	μC

3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

4. Switching characteristics are independent of operating junction temperatures.

ORDERING INFORMATION

Device	Package	Shipping [†]
NTD4404N	DPAK	75 Units / Rail
NTD4404NG	DPAK (Pb-Free)	75 Units / Rail
NTD4404NT4	DPAK	2500 / Tape & Reel
NTD4404NT4G	DPAK (Pb-Free)	2500 / Tape & Reel
NTD4404N1	DPAK-3, Straight Lead	75 Units / Rail
NTD4404N1G	DPAK-3, Straight Lead (Pb-Free)	75 Units / Rail

[†]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.

NTD4404N

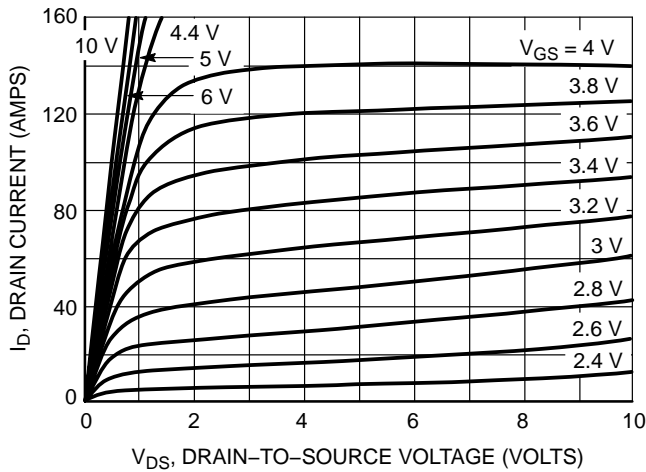


Figure 1. On-Region Characteristics

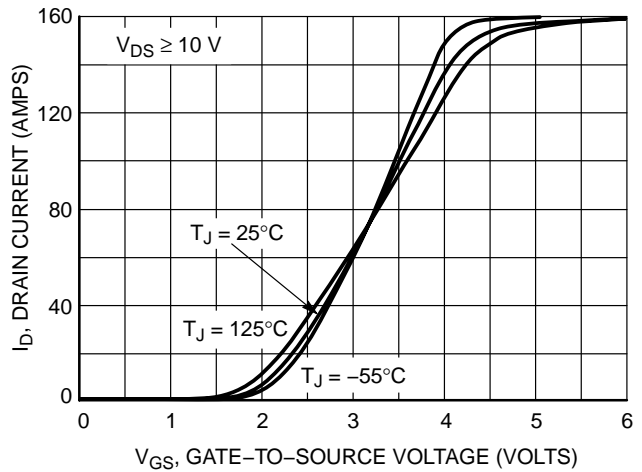


Figure 2. Transfer Characteristics

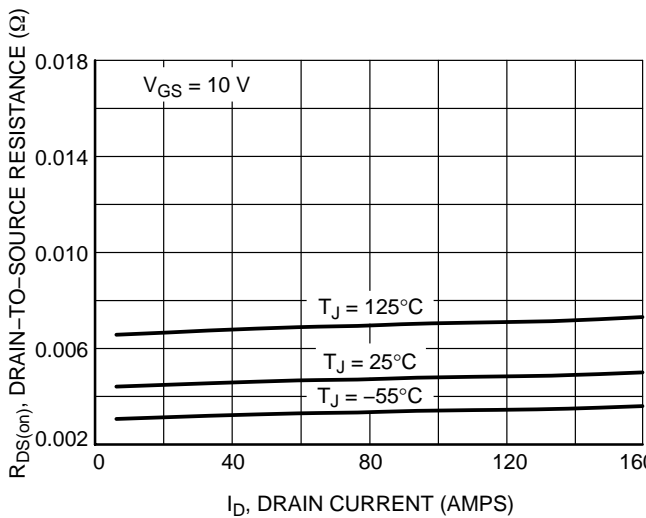


Figure 3. On-Resistance versus Drain Current and Temperature

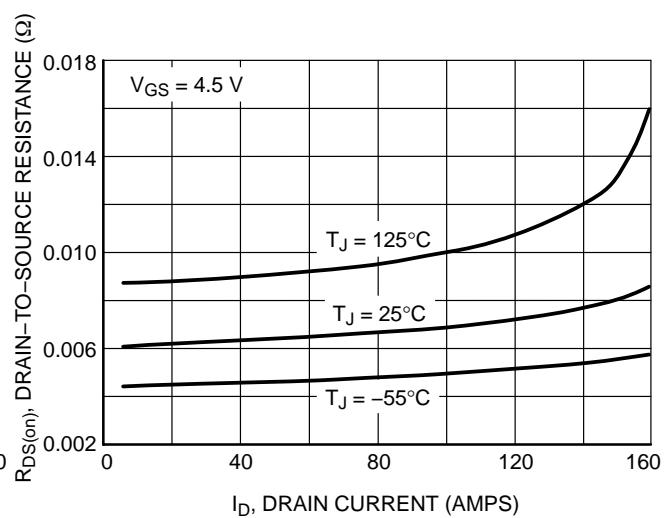


Figure 4. On-Resistance versus Drain Current and Temperature

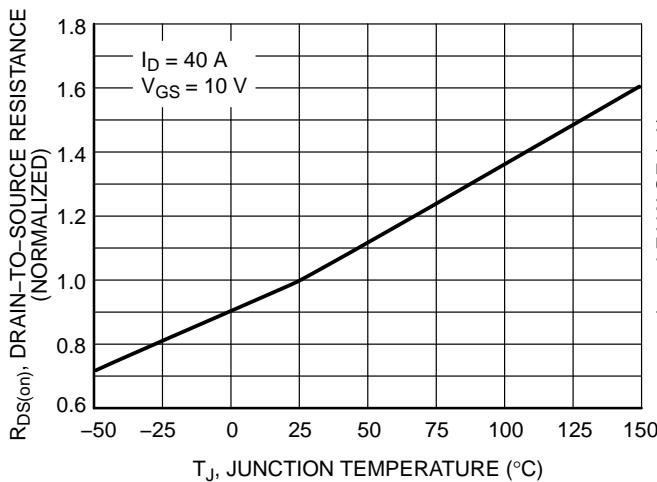


Figure 5. On-Resistance Variation with Temperature

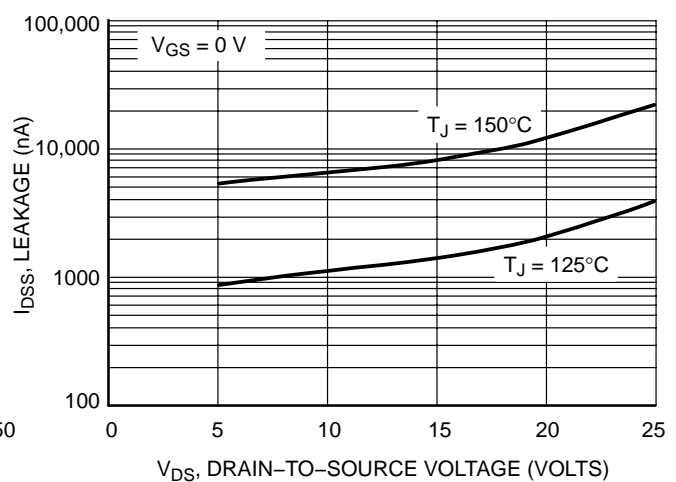


Figure 6. Drain-to-Source Leakage Current versus Voltage

POWER MOSFET SWITCHING

Switching behavior is most easily modeled and predicted by recognizing that the power MOSFET is charge controlled. The lengths of various switching intervals (Δt) are determined by how fast the FET input capacitance can be charged by current from the generator.

The published capacitance data is difficult to use for calculating rise and fall because drain-gate capacitance varies greatly with applied voltage. Accordingly, gate charge data is used. In most cases, a satisfactory estimate of average input current ($I_{G(AV)}$) can be made from a rudimentary analysis of the drive circuit so that

$$t = Q/I_{G(AV)}$$

During the rise and fall time interval when switching a resistive load, V_{GS} remains virtually constant at a level known as the plateau voltage, V_{SGP} . Therefore, rise and fall times may be approximated by the following:

$$t_r = Q_2 \times R_G / (V_{GG} - V_{SGP})$$

$$t_f = Q_2 \times R_G / V_{SGP}$$

where

V_{GG} = the gate drive voltage, which varies from zero to V_{GG}

R_G = the gate drive resistance

and Q_2 and V_{SGP} are read from the gate charge curve.

During the turn-on and turn-off delay times, gate current is not constant. The simplest calculation uses appropriate values from the capacitance curves in a standard equation for voltage change in an RC network. The equations are:

$$t_{d(on)} = R_G C_{iss} \ln [V_{GG}/(V_{GG} - V_{SGP})]$$

$$t_{d(off)} = R_G C_{iss} \ln (V_{GG}/V_{SGP})$$

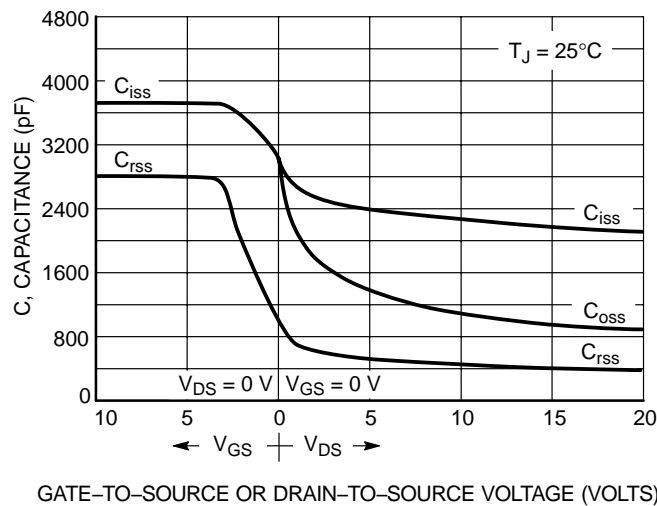


Figure 7. Capacitance Variation

The capacitance (C_{iss}) is read from the capacitance curve at a voltage corresponding to the off-state condition when calculating $t_{d(on)}$ and is read at a voltage corresponding to the on-state when calculating $t_{d(off)}$.

At high switching speeds, parasitic circuit elements complicate the analysis. The inductance of the MOSFET source lead, inside the package and in the circuit wiring which is common to both the drain and gate current paths, produces a voltage at the source which reduces the gate drive current. The voltage is determined by $L di/dt$, but since di/dt is a function of drain current, the mathematical solution is complex. The MOSFET output capacitance also complicates the mathematics. And finally, MOSFETs have finite internal gate resistance which effectively adds to the resistance of the driving source, but the internal resistance is difficult to measure and, consequently, is not specified.

The resistive switching time variation versus gate resistance (Figure 9) shows how typical switching performance is affected by the parasitic circuit elements. If the parasitics were not present, the slope of the curves would maintain a value of unity regardless of the switching speed. The circuit used to obtain the data is constructed to minimize common inductance in the drain and gate circuit loops and is believed readily achievable with board mounted components. Most power electronic loads are inductive; the data in the figure is taken with a resistive load, which approximates an optimally snubbed inductive load. Power MOSFETs may be safely operated into an inductive load; however, snubbing reduces switching losses.

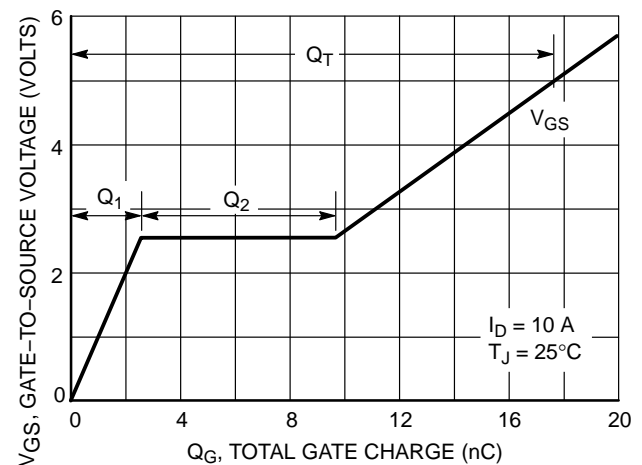


Figure 8. Gate-To-Source and Drain-To-Source Voltage versus Total Charge

DRAIN-TO-SOURCE DIODE CHARACTERISTICS

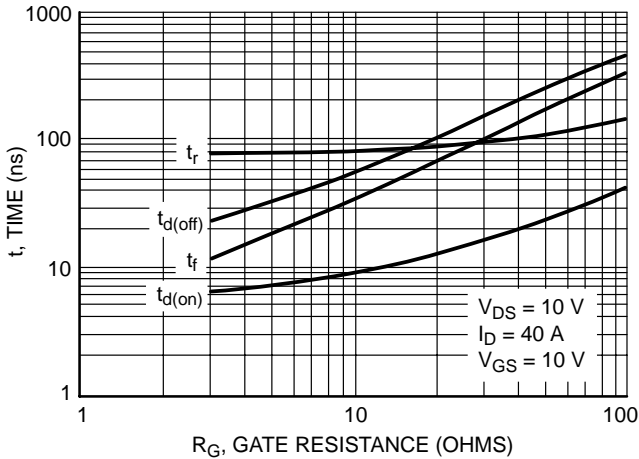


Figure 9. Resistive Switching Time Variation versus Gate Resistance

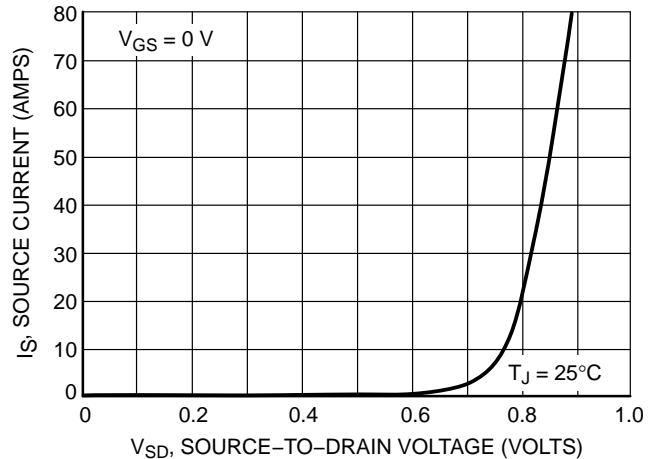


Figure 10. Diode Forward Voltage versus Current

SAFE OPERATING AREA

The Forward Biased Safe Operating Area curves define the maximum simultaneous drain-to-source voltage and drain current that a transistor can handle safely when it is forward biased. Curves are based upon maximum peak junction temperature and a case temperature (T_C) of 25°C . Peak repetitive pulsed power limits are determined by using the thermal response data in conjunction with the procedures discussed in AN569, “Transient Thermal Resistance – General Data and Its Use.”

Switching between the off-state and the on-state may traverse any load line provided neither rated peak current (I_{DM}) nor rated voltage (V_{DSS}) is exceeded and the transition time (t_r, t_f) do not exceed $10\text{ }\mu\text{s}$. In addition the total power averaged over a complete switching cycle must not exceed $(T_{J(MAX)} - T_C)/(R_{\theta JC})$.

A Power MOSFET designated E-FET can be safely used in switching circuits with unclamped inductive loads. For

reliable operation, the stored energy from circuit inductance dissipated in the transistor while in avalanche must be less than the rated limit and adjusted for operating conditions differing from those specified. Although industry practice is to rate in terms of energy, avalanche energy capability is not a constant. The energy rating decreases non-linearly with an increase of peak current in avalanche and peak junction temperature.

Although many E-FETs can withstand the stress of drain-to-source avalanche at currents up to rated pulsed current (I_{DM}), the energy rating is specified at rated continuous current (I_D), in accordance with industry custom. The energy rating must be derated for temperature as shown in the accompanying graph (Figure 12). Maximum energy at currents below rated continuous I_D can safely be assumed to equal the values indicated.

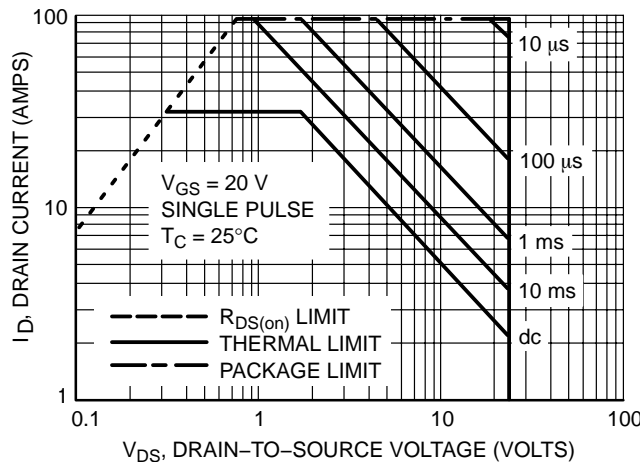


Figure 11. Maximum Rated Forward Biased Safe Operating Area

NTD4404N

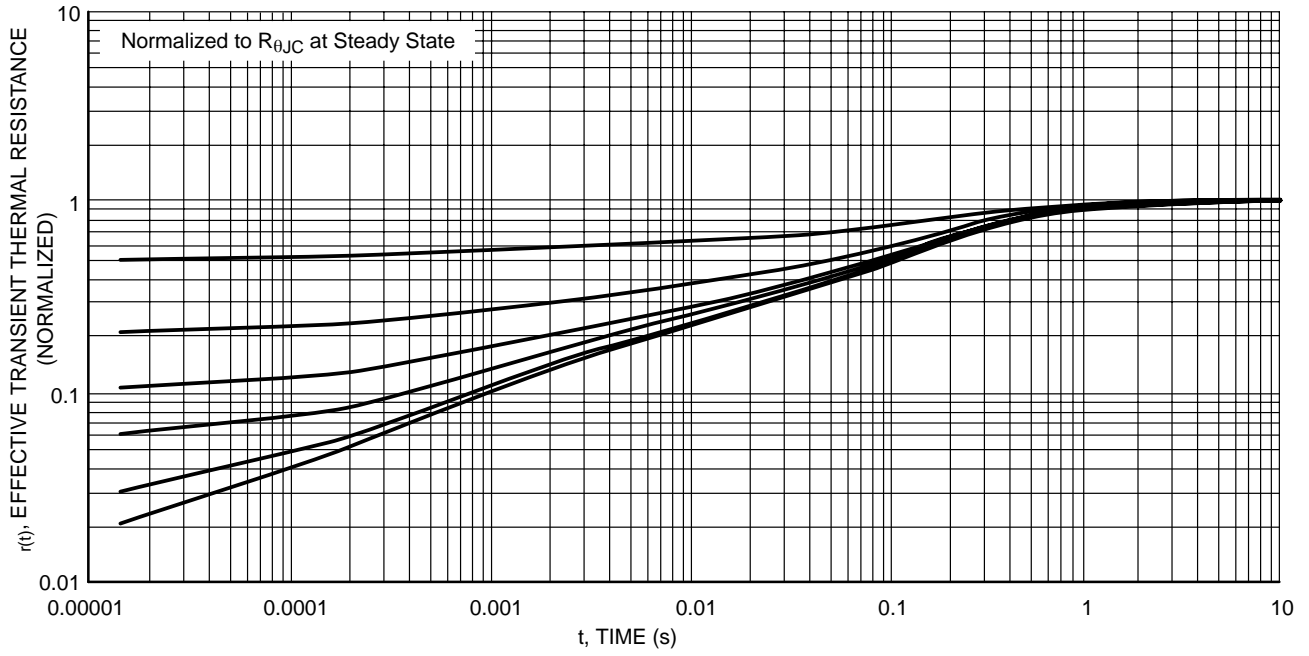


Figure 12. Thermal Response

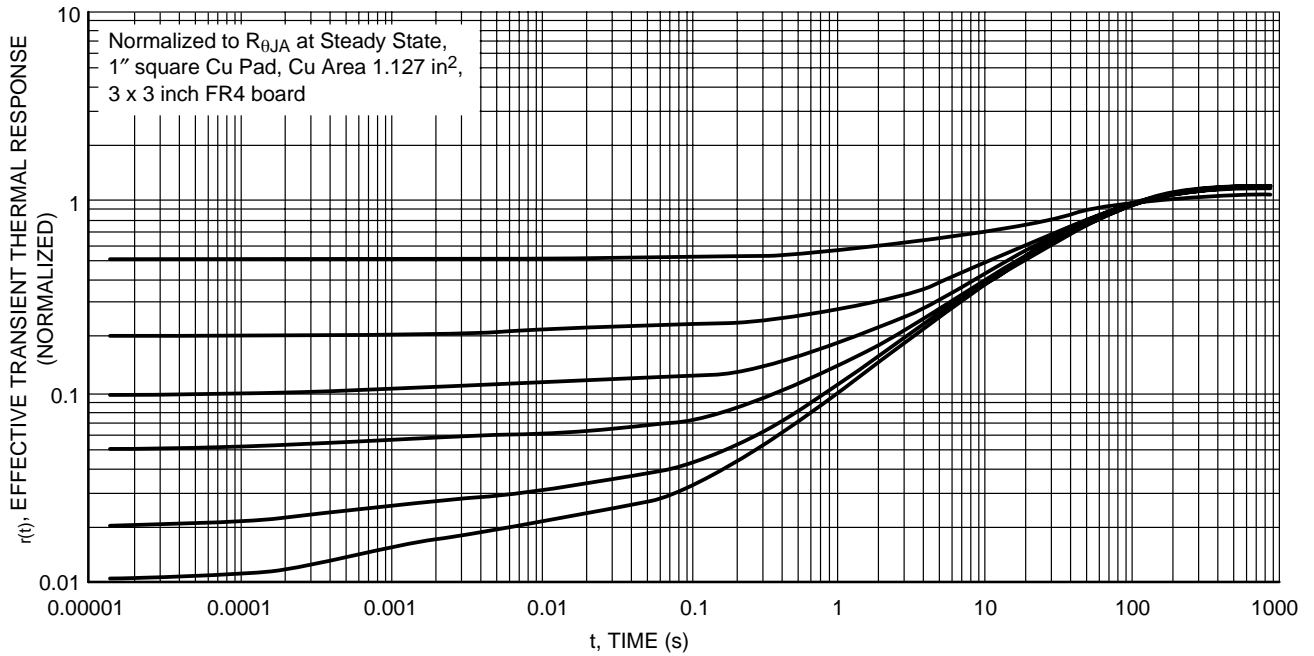
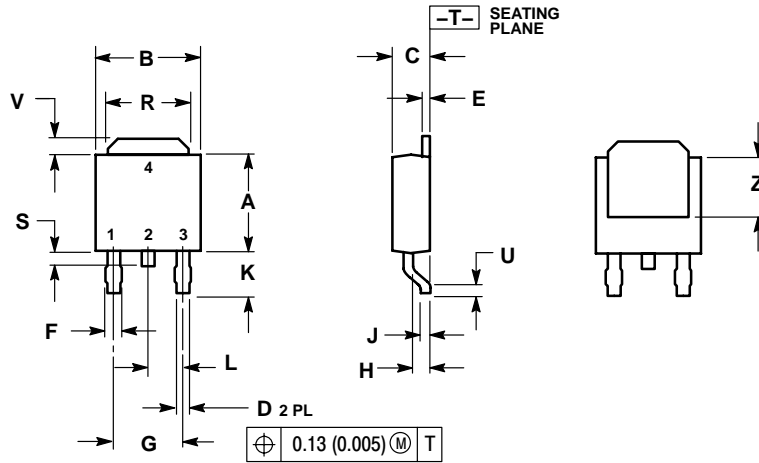


Figure 13. Thermal Response

NTD4404N

PACKAGE DIMENSIONS

DPAK
CASE 369C
ISSUE O

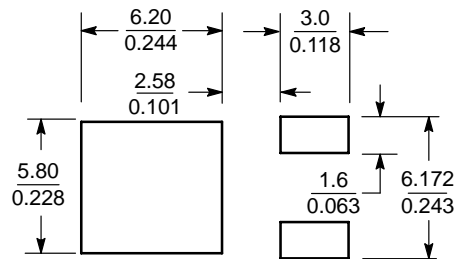


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

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	---

- STYLE 2:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

SOLDERING FOOTPRINT*



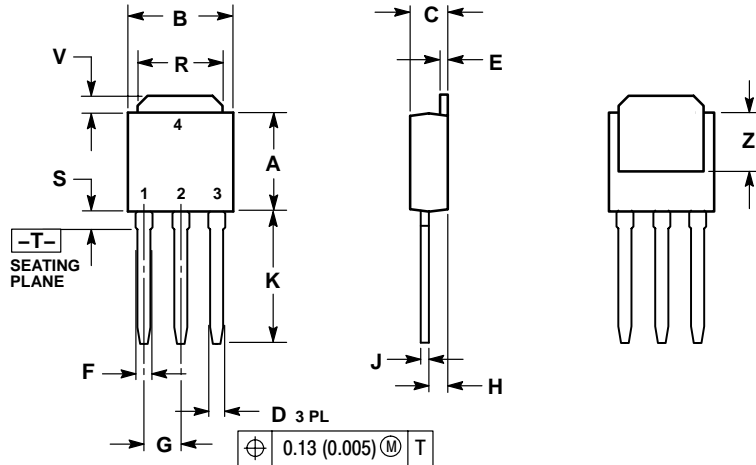
SCALE 3:1 $\left(\frac{\text{mm}}{\text{inches}}\right)$

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

NTD4404N

PACKAGE DIMENSIONS

DPAK-3
CASE 369D-01
ISSUE B



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	6.35
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	0.090 BSC		2.29 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.350	0.380	8.89	9.65
R	0.180	0.215	4.45	5.45
S	0.025	0.040	0.63	1.01
V	0.035	0.050	0.89	1.27
Z	0.155	---	3.93	---

STYLE 2:

1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

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