

# NID9N05CL

## Power MOSFET 9 Amps, 52 Volts N-Channel, Logic Level, Clamped MOSFET w/ ESD Protection in a DPAK Package

### Benefits

- High Energy Capability for Inductive Loads
- Low Switching Noise Generation

### Features

- Diode Clamp Between Gate and Source
- ESD Protection - HBM 5000 V
- Active Over-Voltage Gate to Drain Clamp
- Scalable to Lower or Higher  $R_{DS(on)}$
- Internal Series Gate Resistance

### Applications

- Automotive and Industrial Markets:  
Solenoid Drivers, Lamp Drivers, Small Motor Drivers

### MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage Internally Clamped	$V_{DSS}$	52-59	Vdc
Gate-to-Source Voltage - Continuous	$V_{GS}$	$\pm 12$	Vdc
Drain Current - Continuous @ $T_A = 25^\circ\text{C}$ - Single Pulse ( $t_p = 10 \mu\text{s}$ )	$I_D$ $I_{DM}$	9.0 35	A
Total Power Dissipation @ $T_A = 25^\circ\text{C}$	$P_D$	28.8	W
Operating and Storage Temperature Range	$T_J, T_{stg}$	-55 to 175	$^\circ\text{C}$
Single Pulse Drain-to-Source Avalanche Energy - Starting $T_J = 125^\circ\text{C}$ ( $V_{DD} = 50 \text{ V}$ , $I_{D(pk)} = 1.5 \text{ A}$ , $V_{GS} = 10 \text{ V}$ , $R_G = 25 \Omega$ )	$E_{AS}$	160	mJ
Thermal Resistance - Junction-to-Case - Junction-to-Ambient (Note 1) - Junction-to-Ambient (Note 2)	$R_{\theta JC}$ $R_{\theta JA}$ $R_{\theta JA}$	5.2 72 100	$^\circ\text{C/W}$
Maximum Lead Temperature for Soldering Purposes, 1/8" from Case for 10 Sec.	$T_L$	260	$^\circ\text{C}$

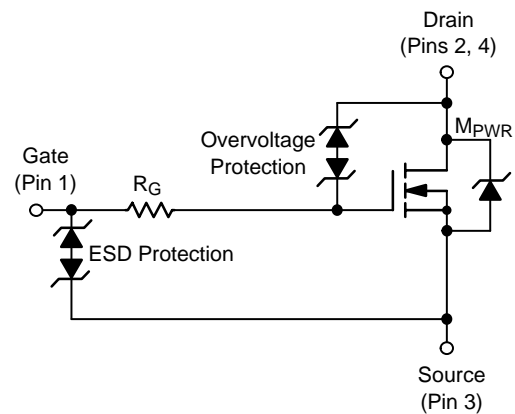
1. When surface mounted to an FR4 board using 1" pad size, (Cu area 1.127 in<sup>2</sup>)
2. When surface mounted to an FR4 board using minimum recommended pad size, (Cu area 0.412 in<sup>2</sup>)



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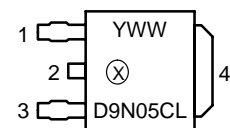
<http://onsemi.com>

**9 AMPERES**  
**52 V CLAMPED**  
 **$R_{DS(on)} = 90 \text{ m}\Omega$  (Typ.)**



**DPAK  
CASE 369A  
STYLE 2**

### MARKING DIAGRAM



D9N05CL = Device Code  
Y = Year  
WW = Work Week

1 = Gate  
2 = Drain  
3 = Source  
4 = Drain

### ORDERING INFORMATION

Device	Package	Shipping
NID9N05CLT4	DPAK	2500/Tape & Reel
NID9N05CL	DPAK	75 Units/Rail

# NID9N05CL

## MOSFET ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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### OFF CHARACTERISTICS

Drain-to-Source Breakdown Voltage (Note 3) ( $V_{GS} = 0 \text{ Vdc}$ , $I_D = 1.0 \text{ mAdc}$ ) Temperature Coefficient (Negative)	$V_{(BR)DSS}$	52 -	55 -10	59 -	Vdc mV/ $^\circ\text{C}$
Zero Gate Voltage Drain Current ( $V_{DS} = 40 \text{ Vdc}$ , $V_{GS} = 0 \text{ Vdc}$ ) ( $V_{DS} = 40 \text{ Vdc}$ , $V_{GS} = 0 \text{ Vdc}$ , $T_J = 125^\circ\text{C}$ )	$I_{DSS}$	- -	- -	10 25	$\mu\text{Adc}$
Gate-Body Leakage Current ( $V_{GS} = \pm 8 \text{ Vdc}$ , $V_{DS} = 0 \text{ Vdc}$ ) ( $V_{GS} = \pm 14 \text{ Vdc}$ , $V_{DS} = 0 \text{ Vdc}$ )	$I_{GSS}$	- -	- $\pm 22$	$\pm 10$ -	$\mu\text{Adc}$

### ON CHARACTERISTICS (Note 3)

Gate Threshold Voltage (Note 3) ( $V_{DS} = V_{GS}$ , $I_D = 100 \mu\text{Adc}$ ) Threshold Temperature Coefficient (Negative)	$V_{GS(th)}$	1.3 -	1.75 -4.5	2.5 -	Vdc mV/ $^\circ\text{C}$
Static Drain-to-Source On-Resistance (Note 3) ( $V_{GS} = 4.0 \text{ Vdc}$ , $I_D = 1.5 \text{ Adc}$ ) ( $V_{GS} = 3.5 \text{ Vdc}$ , $I_D = 0.6 \text{ Adc}$ ) ( $V_{GS} = 3.0 \text{ Vdc}$ , $I_D = 0.2 \text{ Adc}$ ) ( $V_{GS} = 12 \text{ Vdc}$ , $I_D = 9.0 \text{ Adc}$ ) ( $V_{GS} = 12 \text{ Vdc}$ , $I_D = 12 \text{ Adc}$ )	$R_{DS(on)}$	- - - 70 67	153 175 - 90 95	181 364 1210 - -	m $\Omega$
Forward Transconductance (Note 3) ( $V_{DS} = 15 \text{ Vdc}$ , $I_D = 9.0 \text{ Adc}$ )	$g_{FS}$	-	24	-	Mhos

### DYNAMIC CHARACTERISTICS

Input Capacitance	$(V_{DS} = 40 \text{ Vdc}, V_{GS} = 0 \text{ V}, f = 10 \text{ kHz})$	$C_{iss}$	-	155	250	pF
Output Capacitance		$C_{oss}$	-	60	100	
Transfer Capacitance		$C_{rss}$	-	25	40	
Input Capacitance	$(V_{DS} = 25 \text{ Vdc}, V_{GS} = 0 \text{ V}, f = 10 \text{ kHz})$	$C_{iss}$	-	175	-	pF
Output Capacitance		$C_{oss}$	-	70	-	
Transfer Capacitance		$C_{rss}$	-	30	-	

3. Pulse Test: Pulse Width  $\leq 300 \mu\text{s}$ , Duty Cycle  $\leq 2\%$ .
4. Switching characteristics are independent of operating junction temperatures.

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## MOSFET ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
<b>SWITCHING CHARACTERISTICS (Note 4)</b>					
Turn-On Delay Time	$t_{d(on)}$	-	130	200	ns
Rise Time	$t_r$	-	500	750	
Turn-Off Delay Time	$t_{d(off)}$	-	1300	2000	
Fall Time	$t_f$	-	1150	1850	
Turn-On Delay Time	$t_{d(on)}$	-	200	-	ns
Rise Time	$t_r$	-	500	-	
Turn-Off Delay Time	$t_{d(off)}$	-	2500	-	
Fall Time	$t_f$	-	1800	-	
Turn-On Delay Time	$t_{d(on)}$	-	120	-	ns
Rise Time	$t_r$	-	275	-	
Turn-Off Delay Time	$t_{d(off)}$	-	1600	-	
Fall Time	$t_f$	-	1100	-	
Gate Charge	$Q_T$	-	4.5	7.0	nC
	$Q_1$	-	1.2	-	
	$Q_2$	-	2.7	-	
Gate Charge	$Q_T$	-	3.6	-	nC
	$Q_1$	-	1.0	-	
	$Q_2$	-	2.0	-	

## SOURCE-DRAIN DIODE CHARACTERISTICS

Forward On-Voltage	( $I_S = 4.5 \text{ Adc}$ , $V_{GS} = 0 \text{ Vdc}$ ) (Note 3) ( $I_S = 4.0 \text{ Adc}$ , $V_{GS} = 0 \text{ Vdc}$ ) ( $I_S = 4.5 \text{ Adc}$ , $V_{GS} = 0 \text{ Vdc}$ , $T_J = 125^\circ\text{C}$ )	$V_{SD}$	- - -	0.86 0.845 0.725	1.2 - -	Vdc
Reverse Recovery Time	( $I_S = 4.5 \text{ Adc}$ , $V_{GS} = 0 \text{ Vdc}$ , $di_s/dt = 100 \text{ A}/\mu\text{s}$ ) (Note 3)	$t_{rr}$	-	700	-	ns
		$t_a$	-	200	-	
		$t_b$	-	500	-	
Reverse Recovery Stored Charge		$Q_{RR}$	-	6.5	-	$\mu\text{C}$

## ESD CHARACTERISTICS

Electro-Static Discharge Capability	Human Body Model (HBM)	ESD	5000	-	-	V
	Machine Model (MM)		500	-	-	

3. Pulse Test: Pulse Width  $\leq 300 \mu\text{s}$ , Duty Cycle  $\leq 2\%$ .
4. Switching characteristics are independent of operating junction temperatures.

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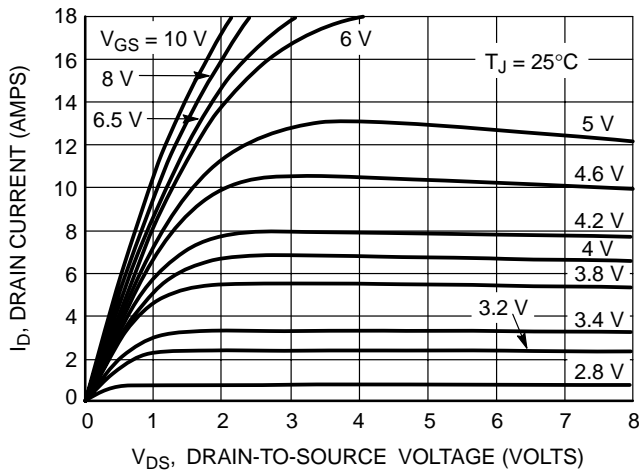


Figure 1. On-Region Characteristics

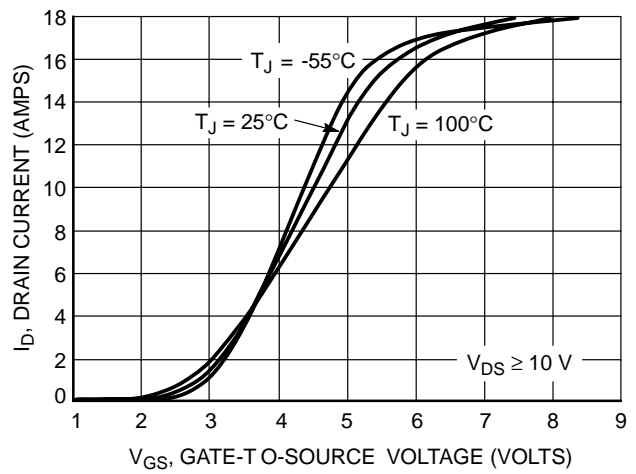


Figure 2. Transfer Characteristics

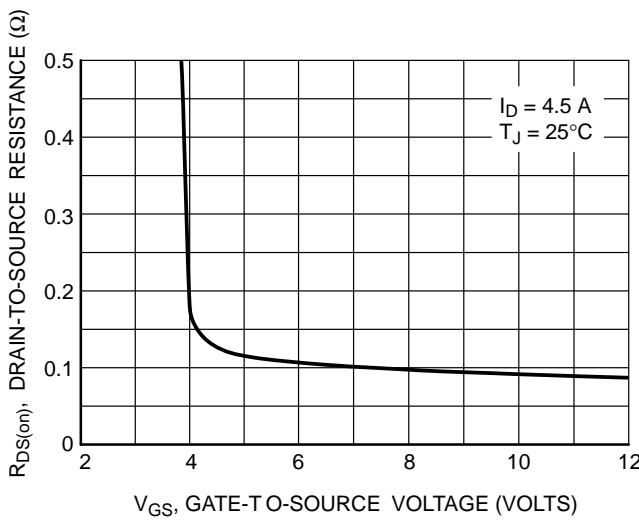


Figure 3. On-Resistance versus Gate-to-Source Voltage

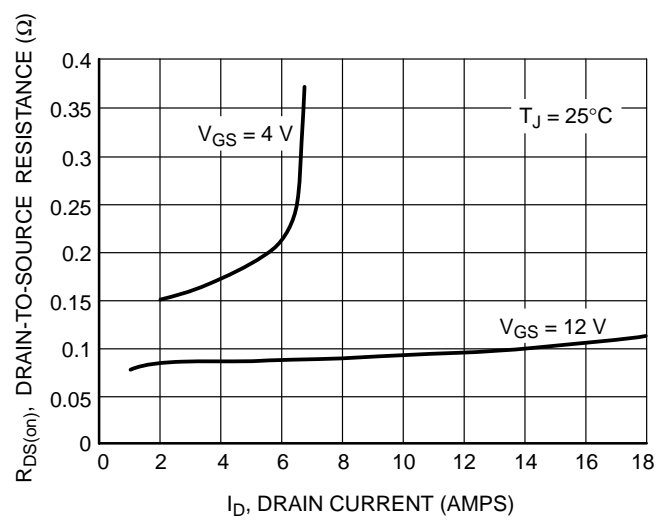


Figure 4. On-Resistance versus Drain Current and Gate Voltage

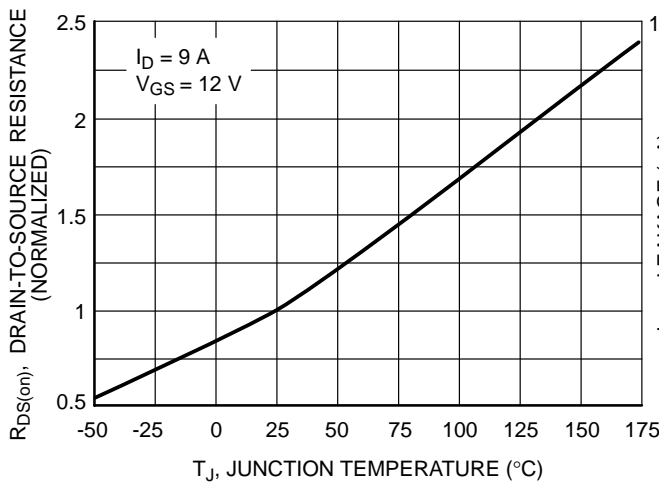


Figure 5. On-Resistance Variation with Temperature

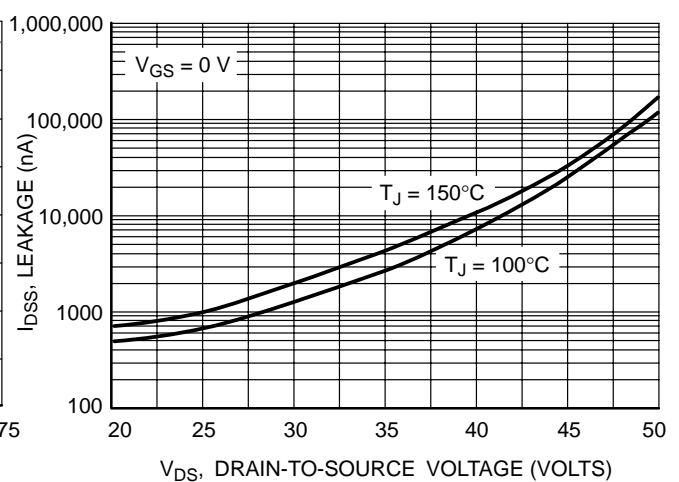


Figure 6. Drain-to-Source Leakage Current versus Voltage

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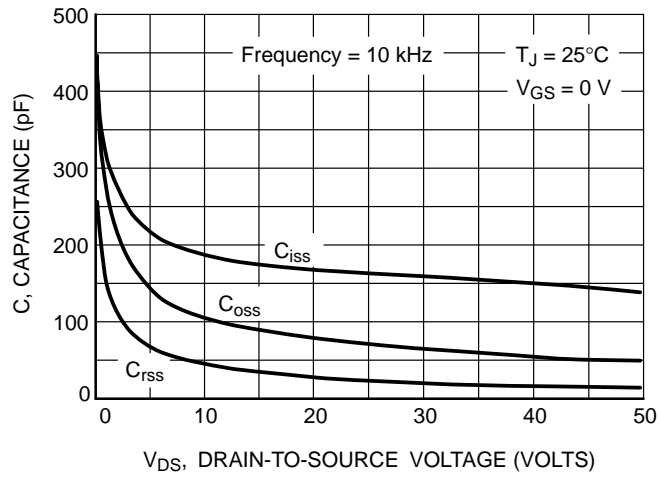


Figure 7. Capacitance Variation

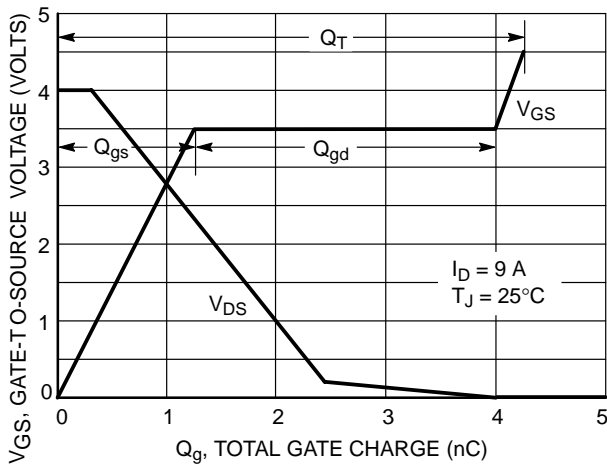


Figure 8. Gate-To-Source and Drain-To-Source Voltage versus Total Charge

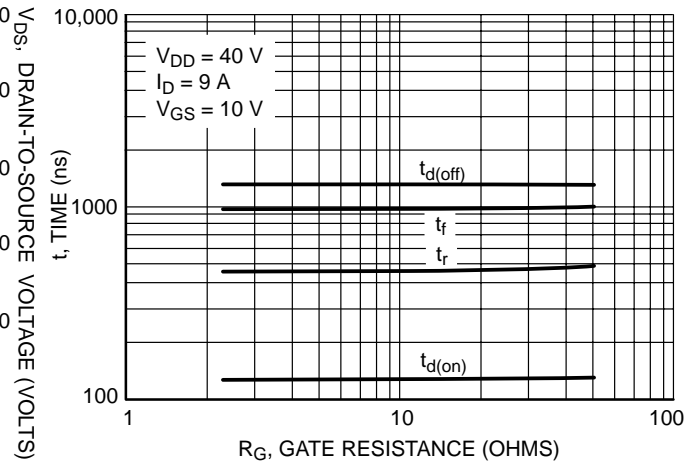


Figure 9. Resistive Switching Time Variation versus Gate Resistance

## DRAIN-TO-SOURCE DIODE CHARACTERISTICS

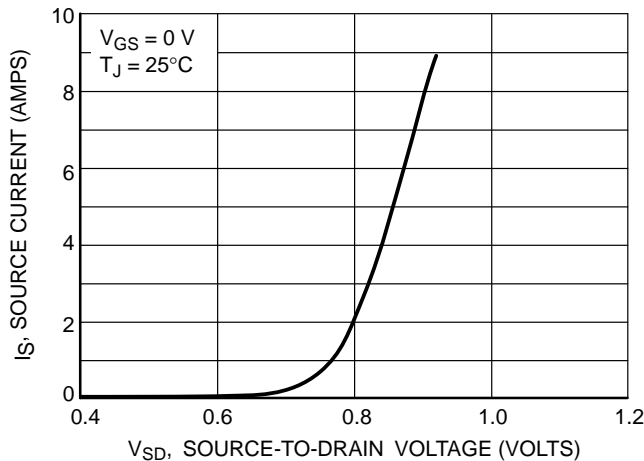


Figure 10. Diode Forward Voltage versus Current

## 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  $\mu$ 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.

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## SAFE OPERATING AREA

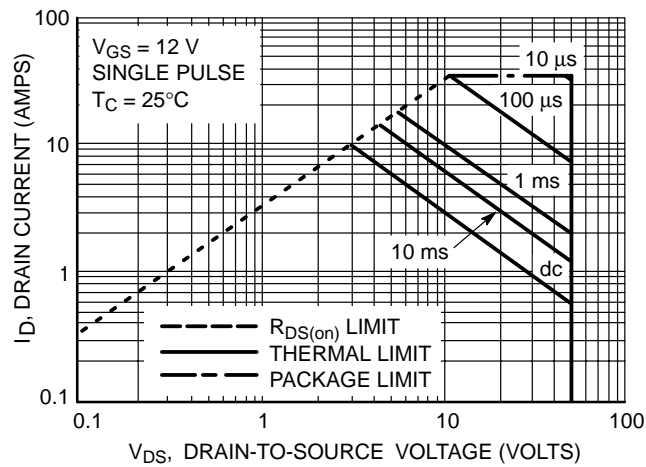


Figure 11. Maximum Rated Forward Biased Safe Operating Area

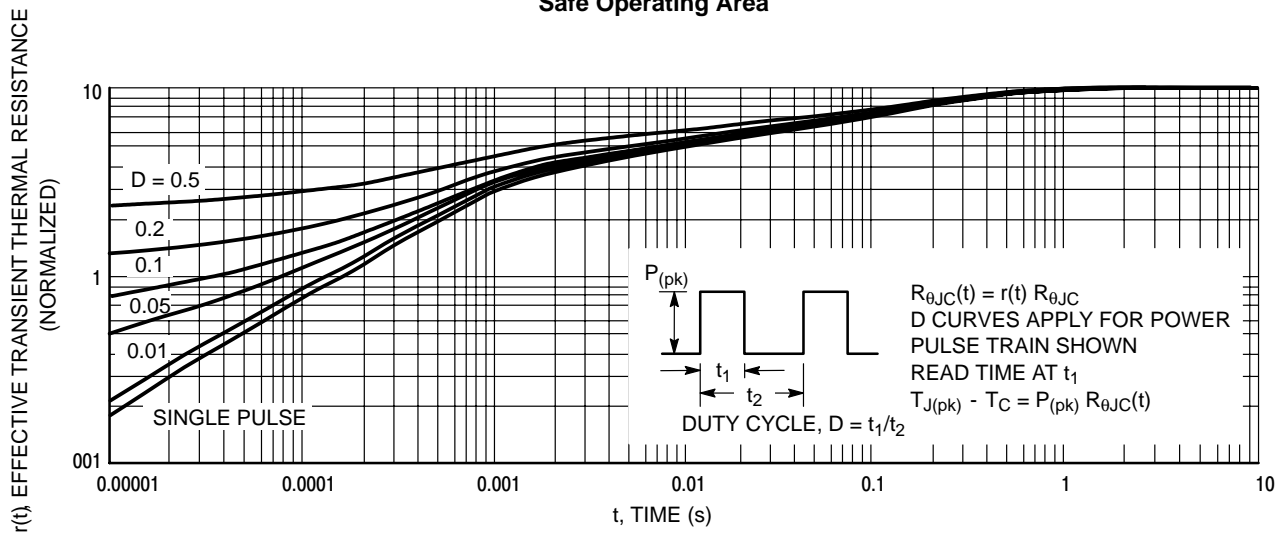
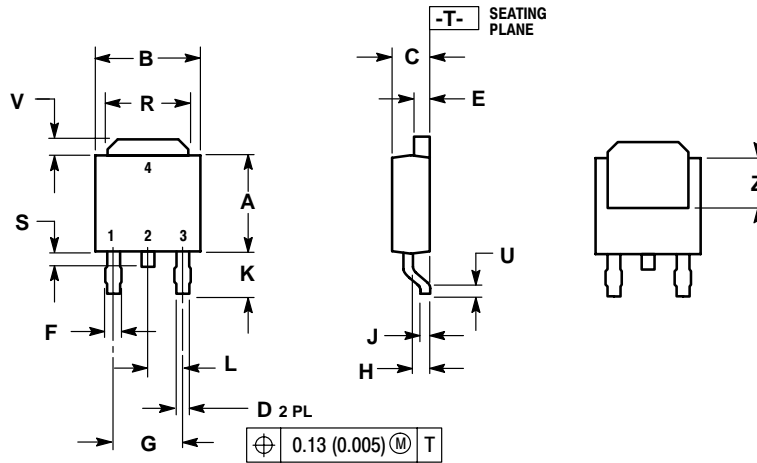


Figure 12. Thermal Response

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## PACKAGE DIMENSIONS


DPAK  
CASE 369A-13  
ISSUE AB



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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.250	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	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
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	0.175	0.215	4.45	5.46
S	0.020	0.050	0.51	1.27
U	0.020	---	0.51	---
V	0.030	0.050	0.77	1.27
Z	0.138	---	3.51	---

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

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