NDF60N360U1, NDD60N360U1

N-Channel Power MOSFET 600 V, 360 mΩ

Features

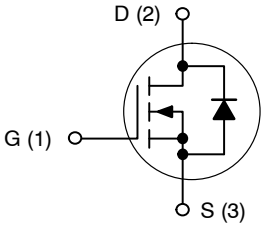
- 100% Avalanche Tested
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

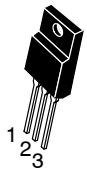
ON Semiconductor®

http://onsemi.com

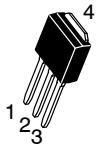
$V_{(BR)DSS}$	$R_{DS(ON)}$ MAX
600 V	360 mΩ @ 10 V

N−Channel MOSFET

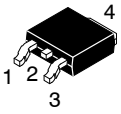




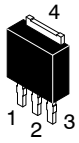
TO−220FP
CASE 221AH



IPAK
CASE 369D



DPAK
CASE 369C



IPAK
CASE 369AD

ABSOLUTE MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Parameter			Symbol	NDF	NDD	Unit
Drain−to−Source Voltage			V_{DSS}	600		V
Gate−to−Source Voltage			V_{GS}	±25		V
Continuous Drain Current $R_{\theta JC}$	Steady State	T_C = 25°C	I_D	13 (Note 1)	11	A
		T_C = 100°C		8.1 (Note 1)	6.9	
Power Dissipation − $R_{\theta JC}$	Steady State	T_C = 25°C	P_D	30	114	W
Pulsed Drain Current	t_p = 10 μs		I_{DM}	51	44	A
Operating Junction and Storage Temperature			T_J, T_{STG}	−55 to +150		°C
Source Current (Body Diode)			I_S	13	11	A
Single Pulse Drain−to−Source Avalanche Energy			EAS	64		mJ
RMS Isolation Voltage (t = 0.3 sec., R.H. ≤ 30%, T_A = 25°C) (Figure 15)			V_{ISO}	4500	−	V
Peak Diode Recovery (Note 2)			dv/dt	15		V/ns
Lead Temperature for Soldering Leads			T_L	260		°C

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. Limited by maximum junction temperature
2. $I_{SD} \le 11$ A, di/dt ≤ 400 A/μs, $V_{DS\ peak} \le V_{(BR)DSS}$, V_{DD} = 80% $V_{(BR)DSS}$

THERMAL RESISTANCE

Parameter		Symbol	Value	Unit
Junction−to−Case (Drain)	NDF60N360U1	$R_{\theta JC}$	4.1	°C/W
	NDD60N360U1		1.1	
Junction−to−Ambient Steady State		$R_{\theta JA}$		°C/W
(Note 3)	NDF60N360U1		50	
(Note 4)	NDD60N360U1		47	
(Note 3)	NDD60N360U1−1		98	
(Note 3)	NDD60N360U1−35G		95	

3. Insertion mounted
4. Surface mounted on FR4 board using 1″ sq. pad size (Cu area = 1.127 in sq [2 oz] including traces)

MARKING AND ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 3 of this data sheet.

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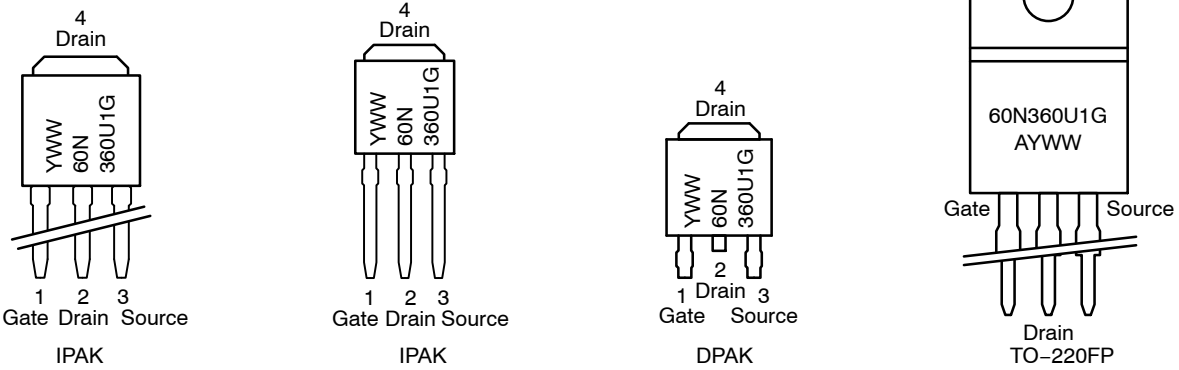
ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions		Min	Typ	Max	Unit
OFF CHARACTERISTICS							
Drain−to−Source Breakdown Voltage	$V_{(BR)DSS}$	V_{GS} = 0 V, I_D = 1 mA		600			V
Drain−to−Source Breakdown Voltage Temperature Coefficient	$V_{(BR)DSS}/T_J$	Reference to 25°C, I_D = 1 mA			560		mV/°C
Drain−to−Source Leakage Current	I_{DSS}	V_{DS} = 600 V, V_{GS} = 0 V	T_J = 25°C			1	μA
			T_J = 125°C			100	
Gate−to−Source Leakage Current	I_{GSS}	V_{GS} = ±25 V				±100	nA
ON CHARACTERISTICS (Note 5)							
Gate Threshold Voltage	$V_{GS(TH)}$	V_{DS} = V_{GS}, I_D = 250 μA		2	3.2	4	V
Negative Threshold Temperature Coefficient	$V_{GS(TH)}/T_J$	Reference to 25°C, I_D = 250 μA			8.6		mV/°C
Static Drain-to-Source On Resistance	$R_{DS(on)}$	V_{GS} = 10 V, I_D = 5.5 A			320	360	mΩ
Forward Transconductance	g_{FS}	V_{DS} = 15 V, I_D = 5.5 A			10		S
DYNAMIC CHARACTERISTICS							
Input Capacitance	C_{iss}	V_{DS} = 50 V, V_{GS} = 0 V, f = 1 MHz			790		pF
Output Capacitance	C_{oss}				47		
Reverse Transfer Capacitance	C_{rss}				3.0		
Effective output capacitance, energy related (Note 7)	$C_{o(er)}$	V_{GS} = 0 V, V_{DS} = 0 to 480 V			38.9		
Effective output capacitance, time related (Note 8)	$C_{o(tr)}$	I_D = constant, V_{GS} = 0 V, V_{DS} = 0 to 480 V			135		
Total Gate Charge	Q_g	V_{DS} = 300 V, I_D = 13 A, V_{GS} = 10 V			26		nC
Gate-to-Source Charge	Q_{gs}				4.7		
Gate-to-Drain Charge	Q_{gd}				12.9		
Plateau Voltage	V_{GP}				5.6		V
Gate Resistance	R_g				4.5		Ω
RESISTIVE SWITCHING CHARACTERISTICS (Note 6)							
Turn-on Delay Time	$t_{d(on)}$	V_{DD} = 300 V, I_D = 13 A, V_{GS} = 10 V, R_G = 0 Ω			10		ns
Rise Time	t_r				20		
Turn-off Delay Time	$t_{d(off)}$				26		
Fall Time	t_f				22		
SOURCE−DRAIN DIODE CHARACTERISTICS							
Diode Forward Voltage	V_{SD}	I_S = 13 A, V_{GS} = 0 V	T_J = 25°C		0.93	1.6	V
			T_J = 100°C		0.86		
Reverse Recovery Time	t_{rr}	V_{GS} = 0 V, V_{DD} = 30 V I_S = 13 A, d_i/d_t = 100 A/μs			303		ns
Charge Time	t_a				206		
Discharge Time	t_b				97		
Reverse Recovery Charge	Q_{rr}				3.6		μC

5. Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
6. Switching characteristics are independent of operating junction temperatures.
7. $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% $V_{(BR)DSS}$
8. $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% $V_{(BR)DSS}$

MARKING DIAGRAMS



A = Assembly Location
Y = Year
WW = Work Week
G = Pb−Free Package

ORDERING INFORMATION

Device	Package	Shipping†
NDF60N360U1G	TO−220FP (Pb-Free, Halogen-Free)	50 Units / Rail (In Development)
NDD60N360U1−1G	IPAK (Pb-Free, Halogen-Free)	75 Units / Rail
NDD60N360U1−35G	IPAK (Pb-Free, Halogen-Free)	75 Units / Rail
NDD60N360U1T4G	DPAK (Pb-Free, Halogen-Free)	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.

TYPICAL CHARACTERISTICS

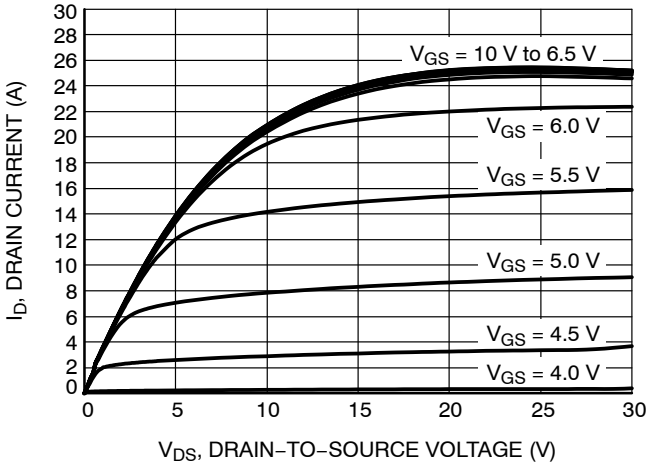


Figure 1. On−Region Characteristics

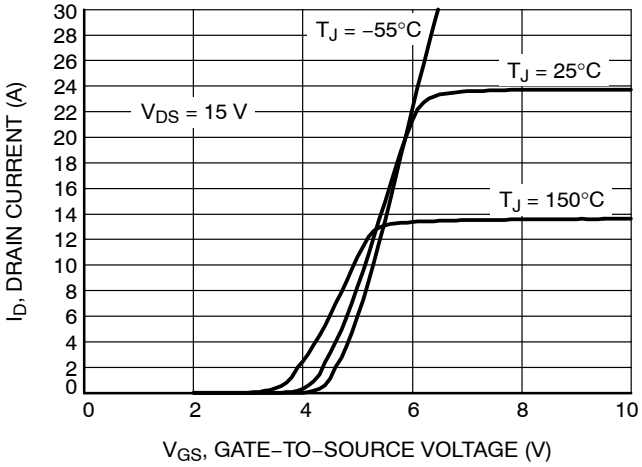


Figure 2. Transfer Characteristics

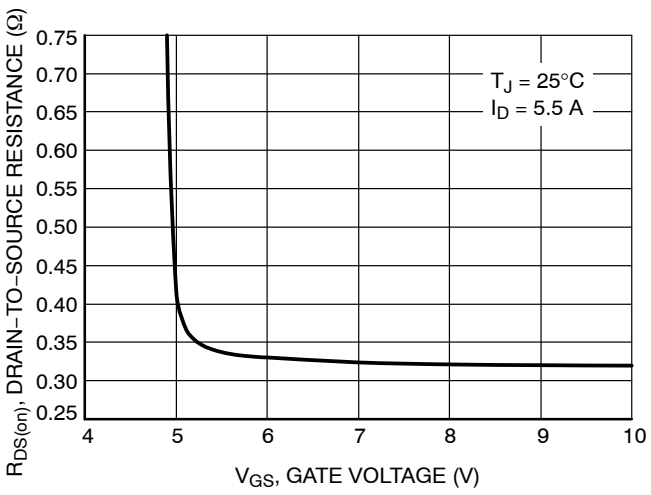


Figure 3. On−Resistance vs. Gate−to−Source Voltage

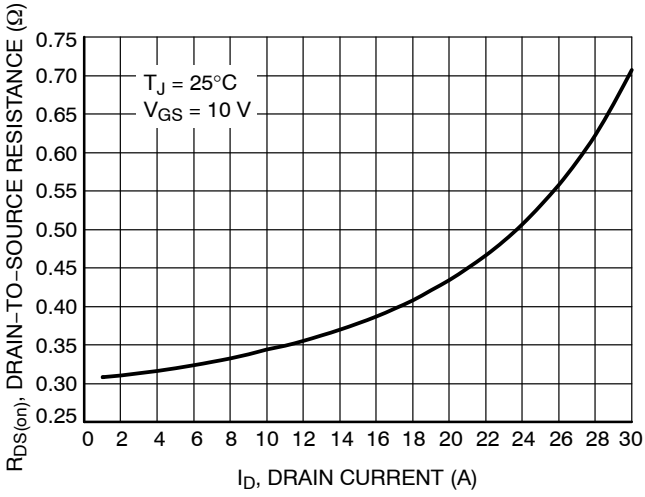


Figure 4. On−Resistance vs. Drain Current and Gate Voltage

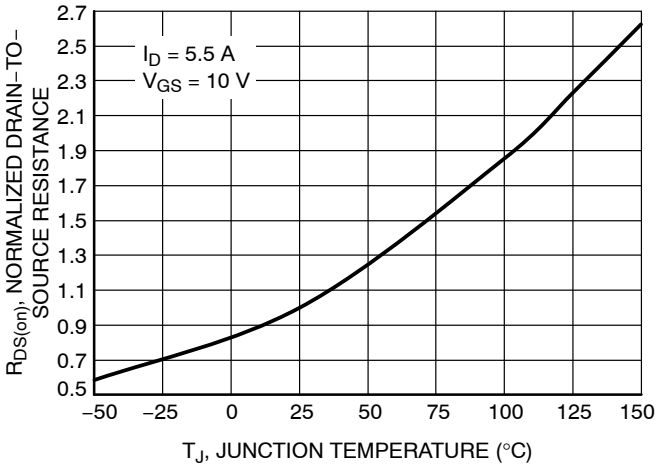


Figure 5. On−Resistance Variation with Temperature

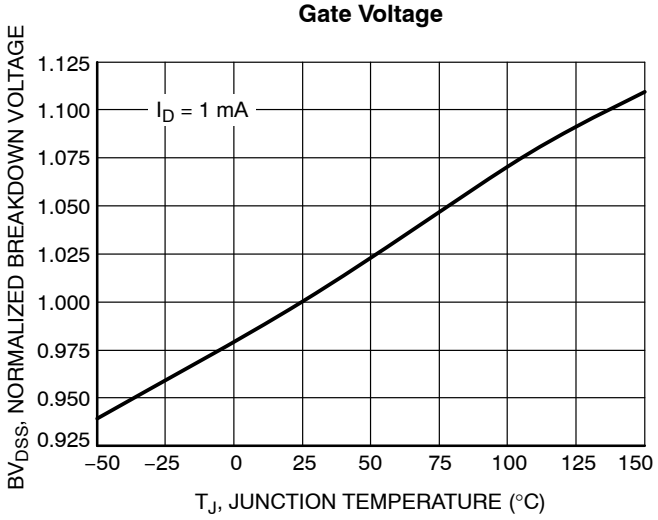


Figure 6. Breakdown Voltage Variation with Temperature

TYPICAL CHARACTERISTICS

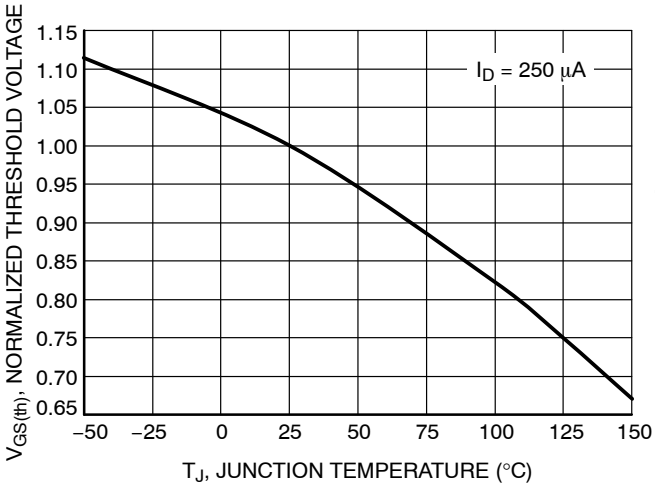


Figure 7. Threshold Voltage Variation with Temperature

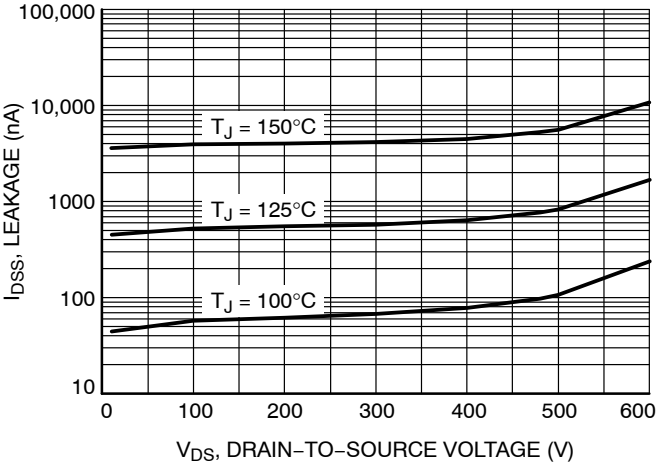


Figure 8. Drain−to−Source Leakage Current vs. Voltage

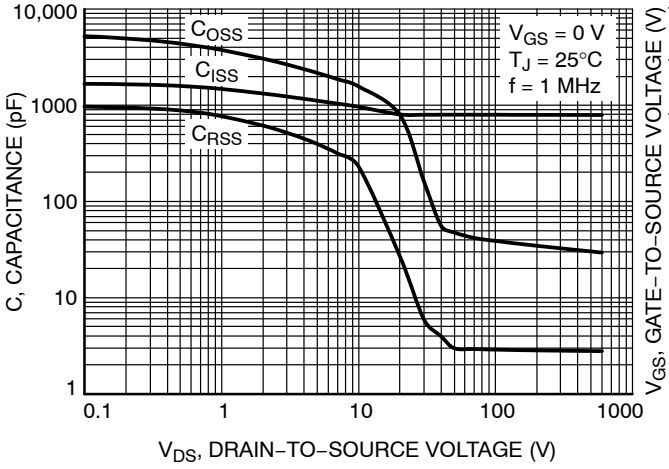


Figure 9. Capacitance Variation

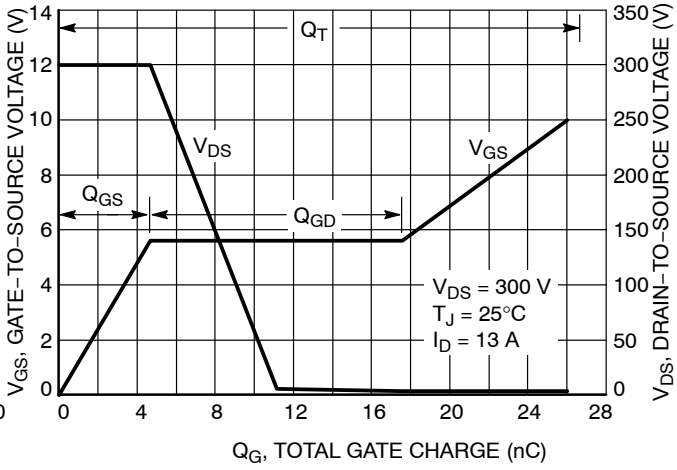


Figure 10. Gate−to−Source and Drain−to−Source Voltage vs. Total Charge

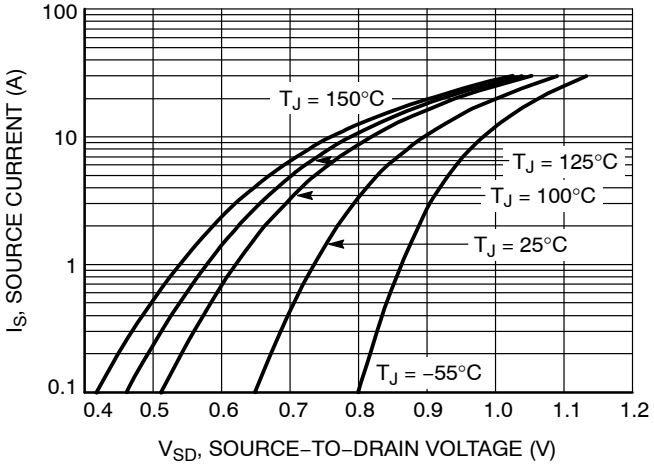


Figure 11. Diode Forward Voltage vs. Current

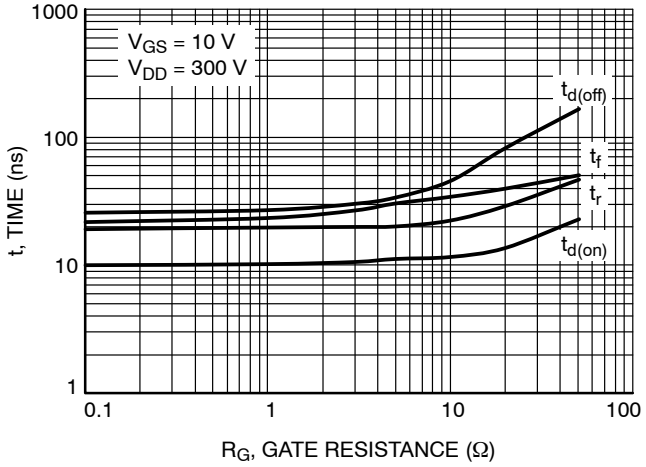


Figure 12. Resistive Switching Time Variation vs. Gate Resistance

TYPICAL CHARACTERISTICS

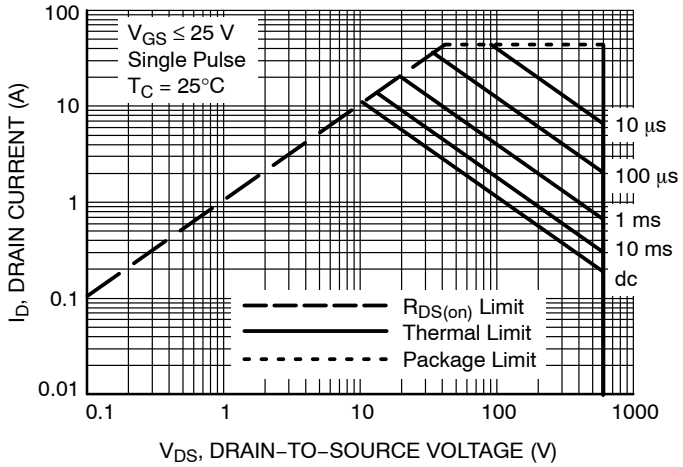


Figure 13. Maximum Rated Forward Biased Safe Operating Area NDD60N360U1

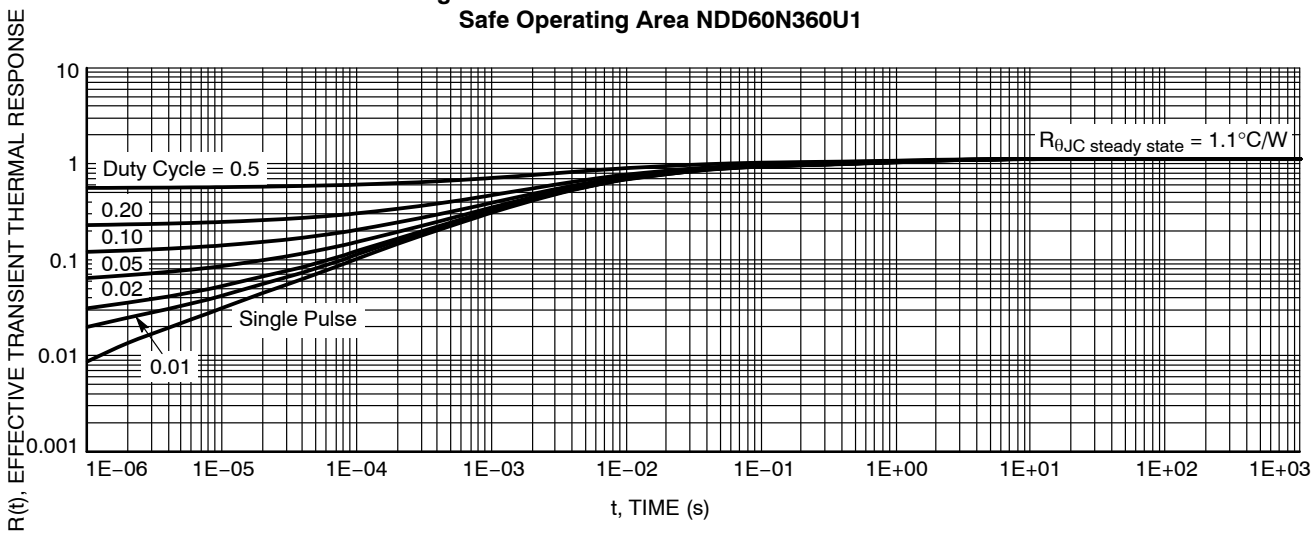


Figure 14. Thermal Impedance (Junction−to−Case) for NDD60N360U1

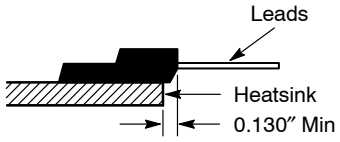


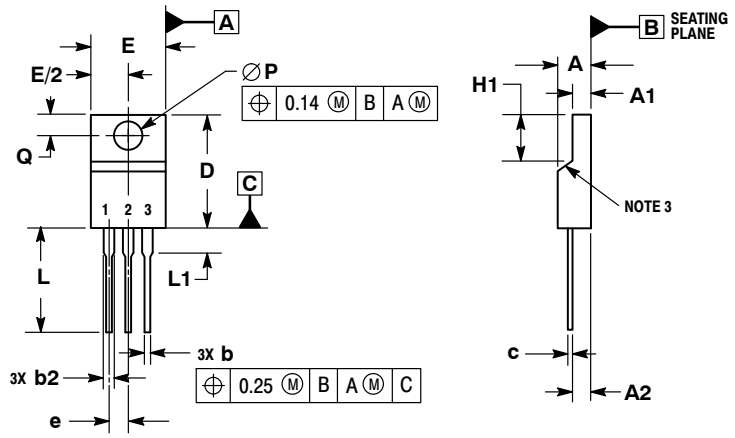
Figure 15. Mounting Position for Isolation Test

Measurement made between leads and heatsink with all leads shorted together.

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

PACKAGE DIMENSIONS

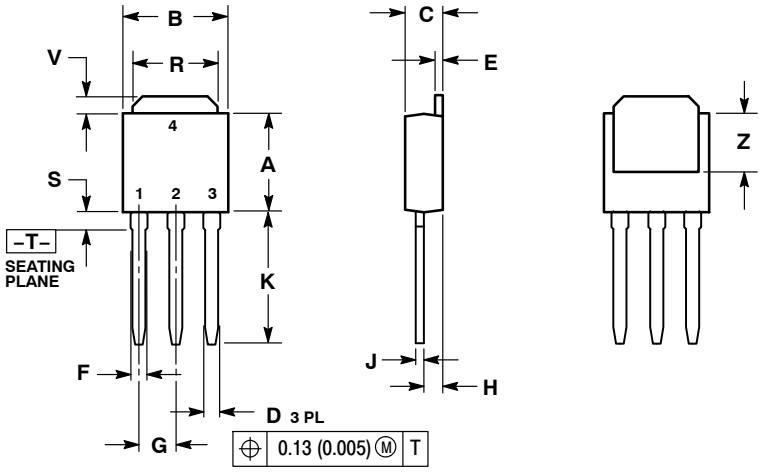
TO−220 FULLPACK, 3−LEAD
CASE 221AH
ISSUE E



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR UNCONTROLLED IN THIS AREA.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH AND GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.13 PER SIDE. THESE DIMENSIONS ARE TO BE MEASURED AT OUTERMOST EXTREME OF THE PLASTIC BODY.
5. DIMENSION b2 DOES NOT INCLUDE DAMBAR PROTRUSION. LEAD WIDTH INCLUDING PROTRUSION SHALL NOT EXCEED 2.00.

	MILLIMETERS	
DIM	MIN	MAX
A	4.30	4.70
A1	2.50	2.90
A2	2.50	2.90
b	0.54	0.84
b2	1.10	1.40
c	0.49	0.79
D	14.70	15.30
E	9.70	10.30
e	2.54 BSC	
H1	6.70	7.10
L	12.70	14.73
L1	---	2.10
P	3.00	3.40
Q	2.80	3.20

IPAK
CASE 369D−01
ISSUE C



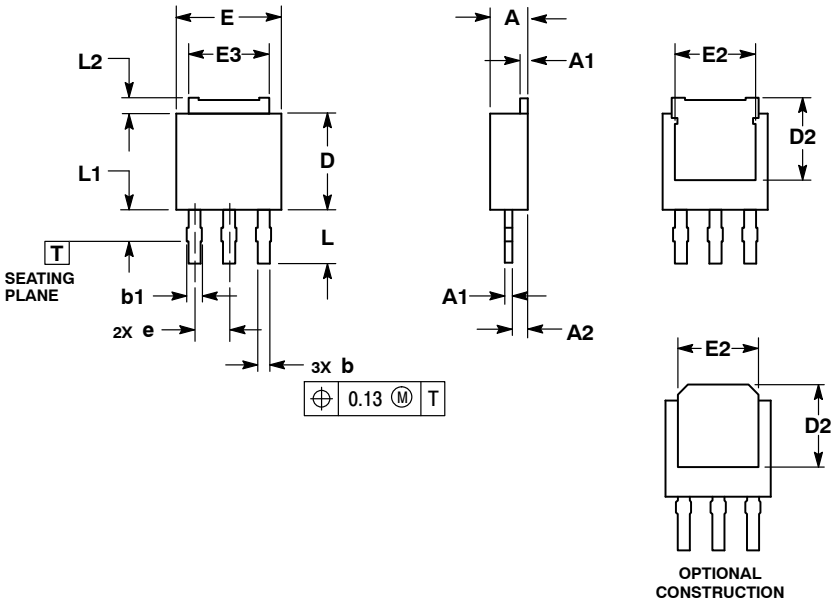
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.235	0.245	5.97	6.35
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:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

PACKAGE DIMENSIONS

3.5 MM IPAK, STRAIGHT LEAD
CASE 369AD
ISSUE B



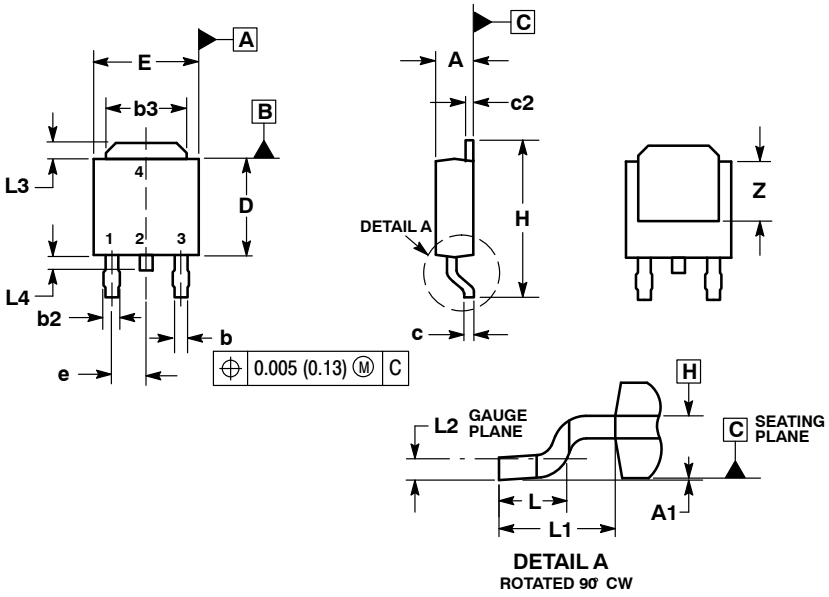
NOTES:
1.. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2.. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM TERMINAL TIP.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD GATE OR MOLD FLASH.

	MILLIMETERS	
DIM	MIN	MAX
A	2.19	2.38
A1	0.46	0.60
A2	0.87	1.10
b	0.69	0.89
b1	0.77	1.10
D	5.97	6.22
D2	4.80	---
E	6.35	6.73
E2	4.57	5.45
E3	4.45	5.46
e	2.28 BSC	
L	3.40	3.60
L1	---	2.10
L2	0.89	1.27

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

PACKAGE DIMENSIONS

DPAK (SINGLE GAUGE)
CASE 369C−01
ISSUE D

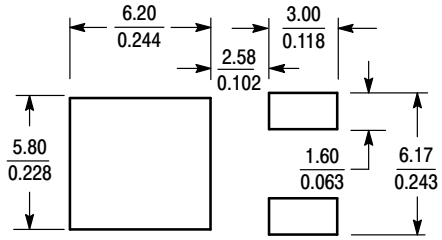


NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS b3, L3 and Z.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.006 INCHES PER SIDE.
5. DIMENSIONS D AND E ARE DETERMINED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
6. DATUMS A AND B ARE DETERMINED AT DATUM PLANE H.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.086	0.094	2.18	2.38
A1	0.000	0.005	0.00	0.13
b	0.025	0.035	0.63	0.89
b2	0.030	0.045	0.76	1.14
b3	0.180	0.215	4.57	5.46
c	0.018	0.024	0.46	0.61
c2	0.018	0.024	0.46	0.61
D	0.235	0.245	5.97	6.22
E	0.250	0.265	6.35	6.73
e	0.090 BSC		2.29 BSC	
H	0.370	0.410	9.40	10.41
L	0.055	0.070	1.40	1.78
L1	0.108 REF		2.74 REF	
L2	0.020 BSC		0.51 BSC	
L3	0.035	0.050	0.89	1.27
L4	−−−	0.040	−−−	1.01
Z	0.155	−−−	3.93	−−−

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

SOLDERING FOOTPRINT*



SCALE 3:1 (mm / inches)

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

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