

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

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 _{θJC}	Steady State	I _D	T _C = 25°C	13 (Note 1)	11	A
			T _C = 100°C	8.1 (Note 1)	6.9	
Power Dissipation – R _{θJC}	Steady State	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.

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

THERMAL RESISTANCE

Parameter	Symbol	Value	Unit
Junction-to-Case (Drain) NDF60N360U1 NDD60N360U1	R _{θJC}	4.1 1.1	°C/W
Junction-to-Ambient Steady State (Note 3) NDF60N360U1 (Note 4) NDD60N360U1 (Note 3) NDD60N360U1-1 (Note 3) NDD60N360U1-35G	R _{θJA}	50 47 98 95	°C/W

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

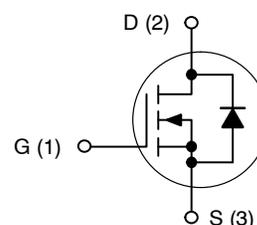


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V _{(BR)DSS}	R _{DS(ON)} MAX
600 V	360 mΩ @ 10 V

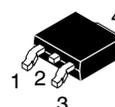
N-Channel MOSFET



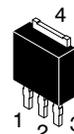
TO-220FP
CASE 221AH



IPAK
CASE 369D



DPAK
CASE 369C



IPAK
CASE 369AD

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
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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%.

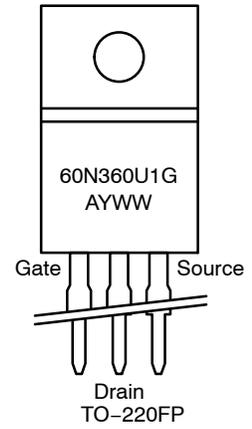
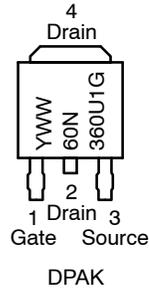
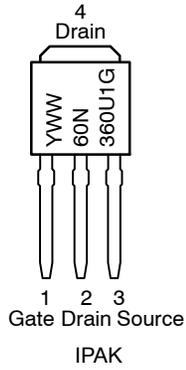
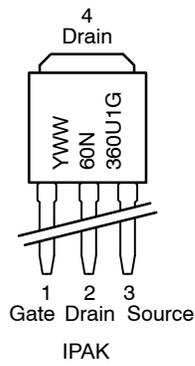
6. Switching characteristics are independent of operating junction temperatures.

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}

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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

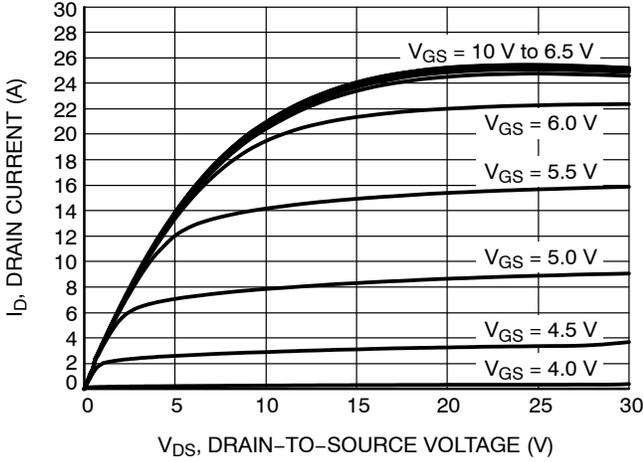


Figure 1. On-Region Characteristics

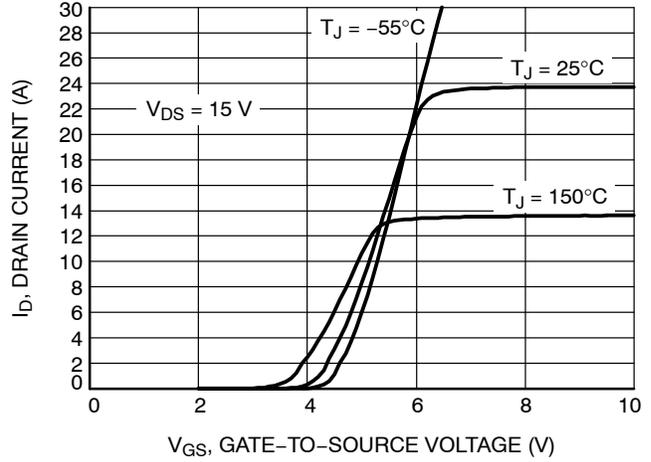


Figure 2. Transfer Characteristics

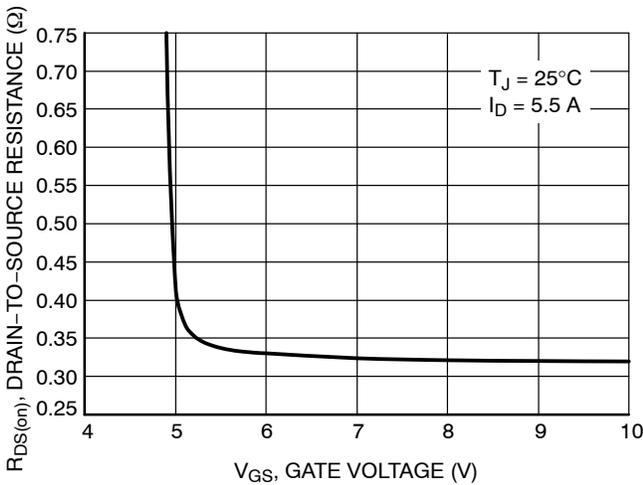


Figure 3. On-Resistance vs. Gate-to-Source Voltage

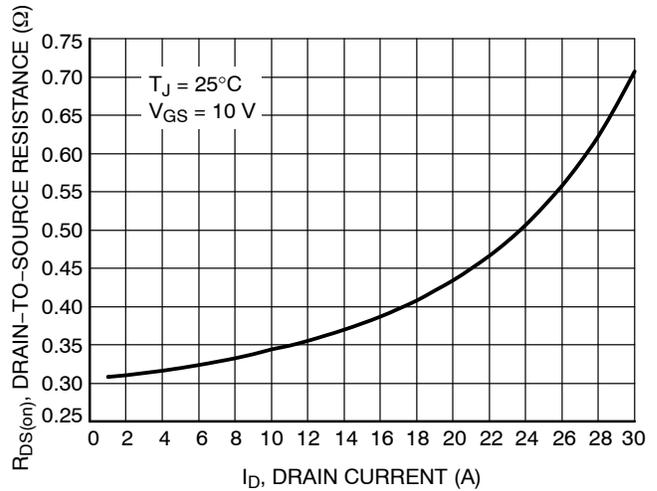


Figure 4. On-Resistance vs. Drain Current and Gate Voltage

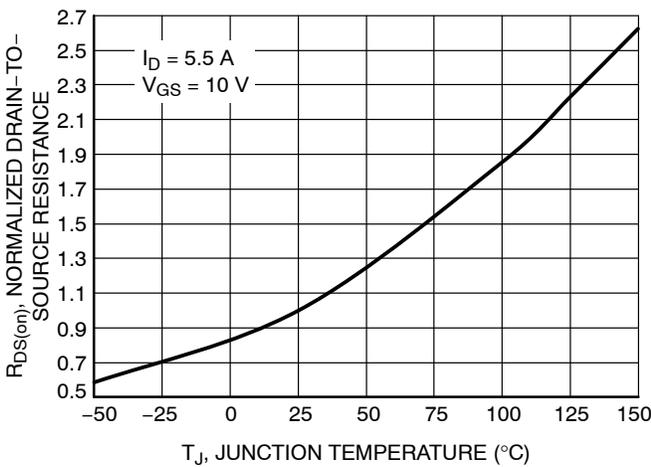


Figure 5. On-Resistance Variation with Temperature

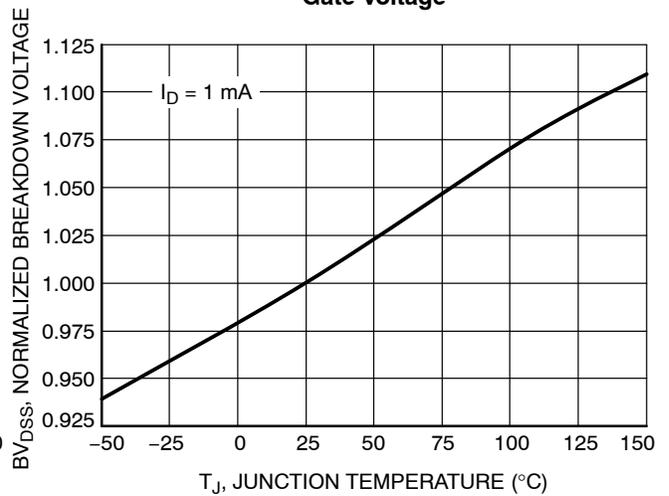


Figure 6. Breakdown Voltage Variation with Temperature

TYPICAL CHARACTERISTICS

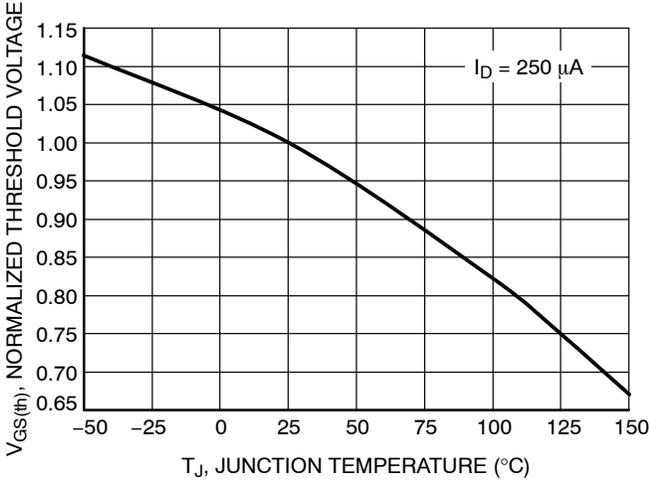


Figure 7. Threshold Voltage Variation with Temperature

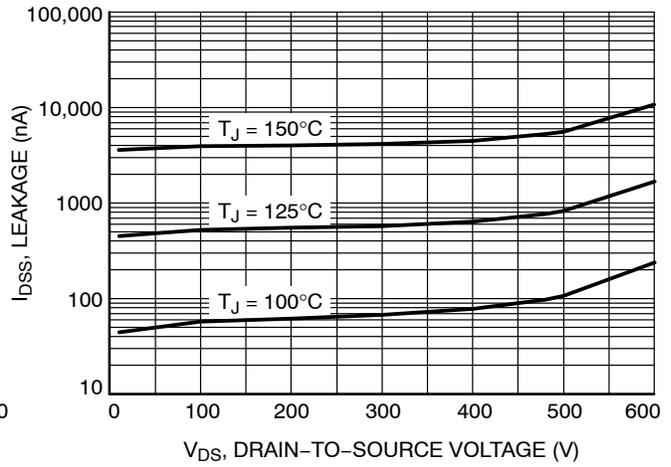


Figure 8. Drain-to-Source Leakage Current vs. Voltage

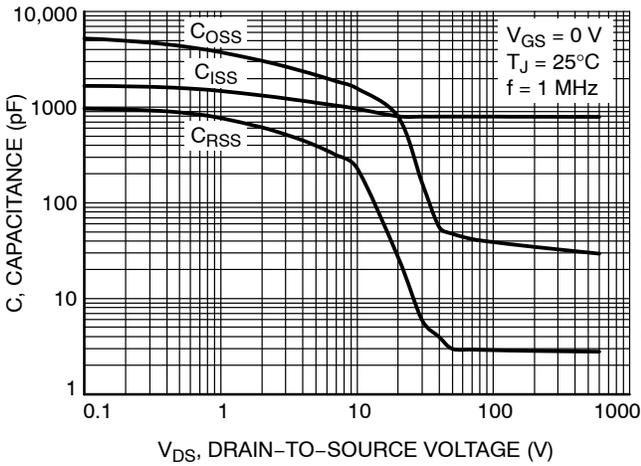


Figure 9. Capacitance Variation

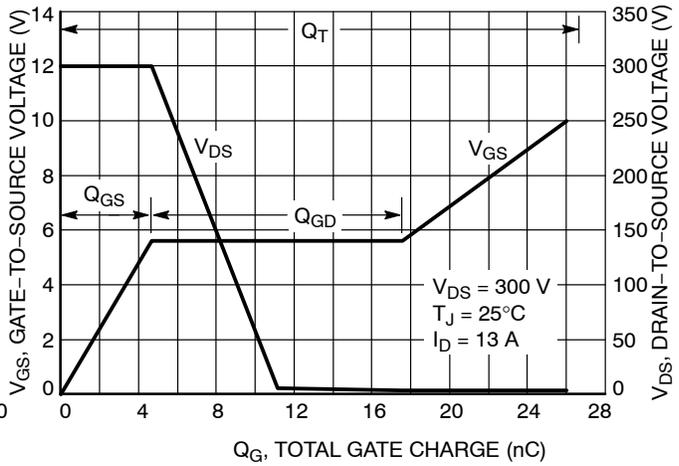


Figure 10. Gate-to-Source and Drain-to-Source Voltage vs. Total Charge

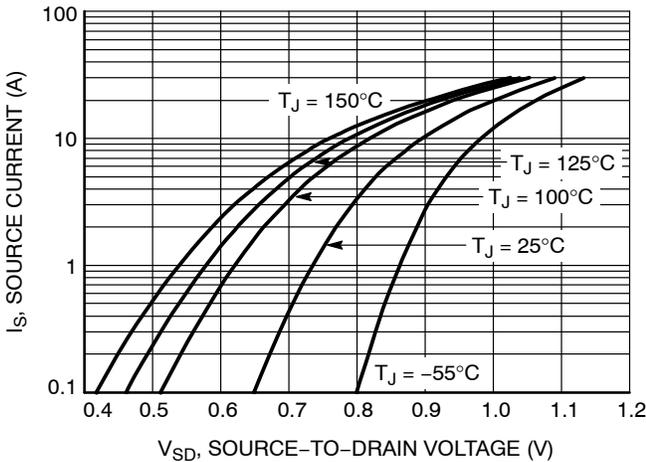


Figure 11. Diode Forward Voltage vs. Current

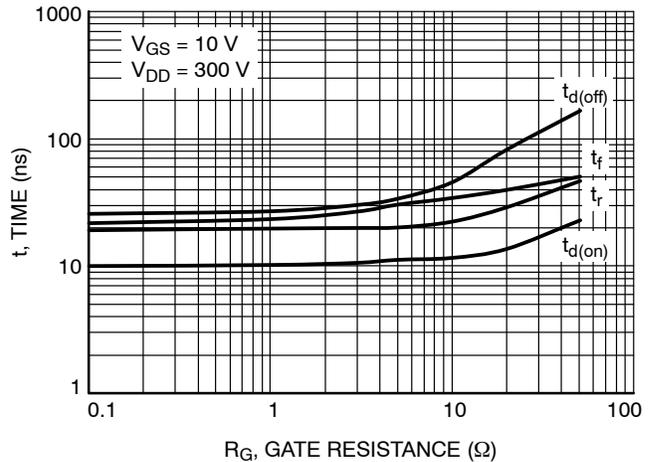


Figure 12. Resistive Switching Time Variation vs. Gate Resistance

NDF60N360U1, NDD60N360U1

TYPICAL CHARACTERISTICS

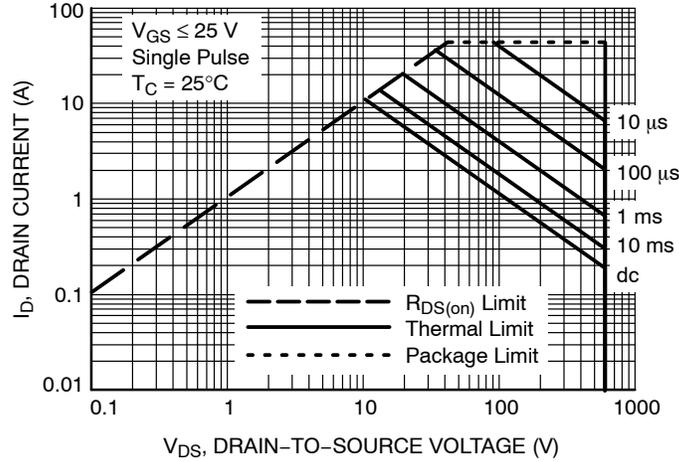


Figure 13. Maximum Rated Forward Biased Safe Operating Area NDD60N360U1

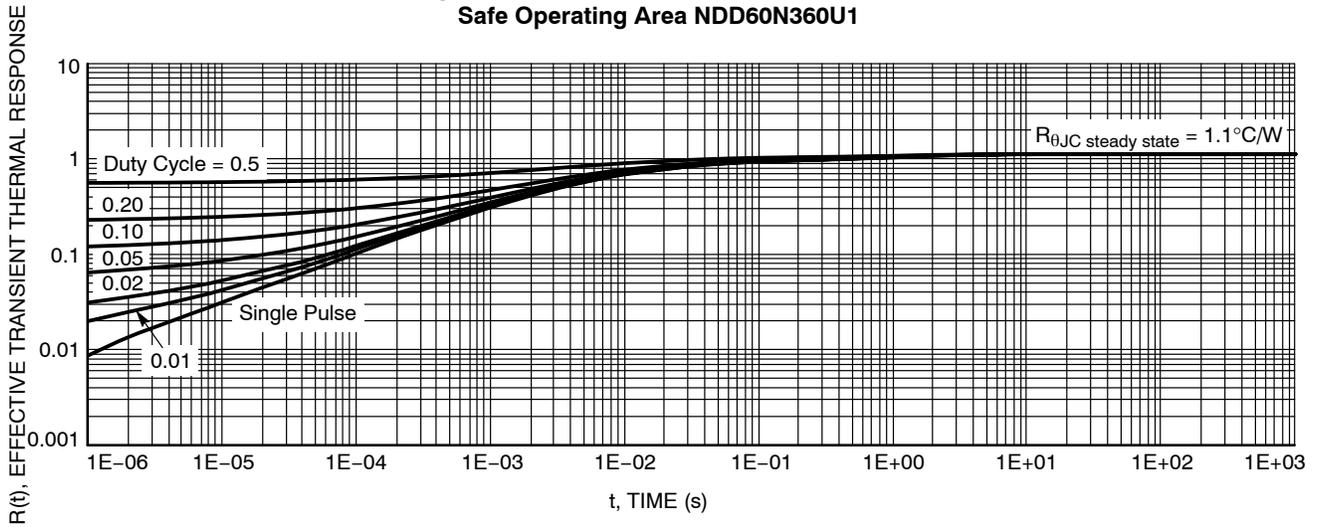


Figure 14. Thermal Impedance (Junction-to-Case) for NDD60N360U1

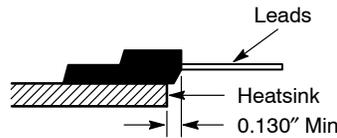


Figure 15. Mounting Position for Isolation Test

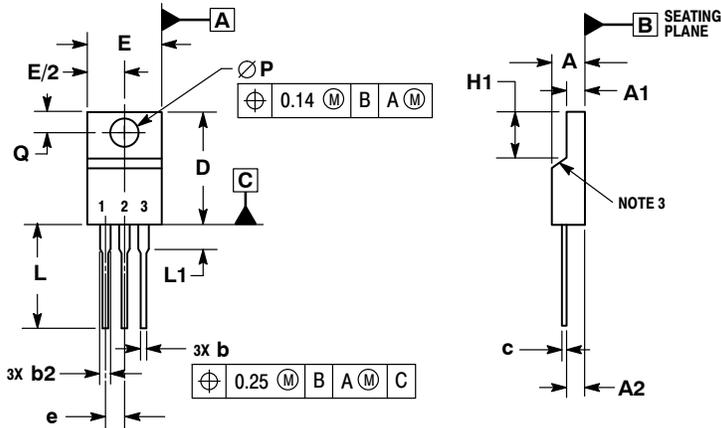
Measurement made between leads and heatsink with all leads shorted together.

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

NDF60N360U1, NDD60N360U1

PACKAGE DIMENSIONS

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

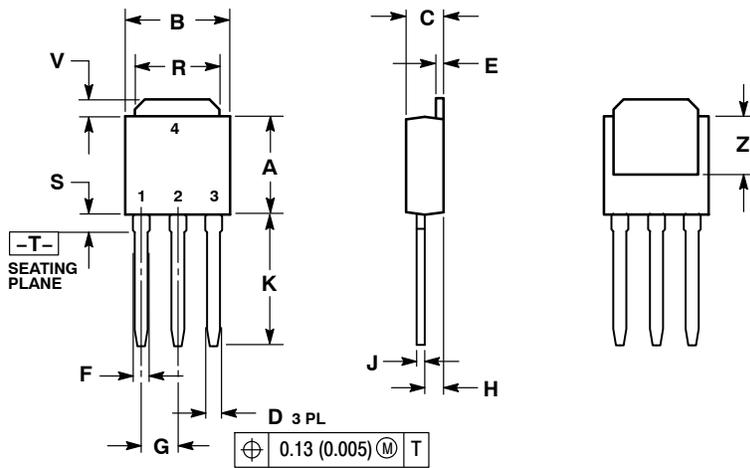


NOTES:

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.

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	---

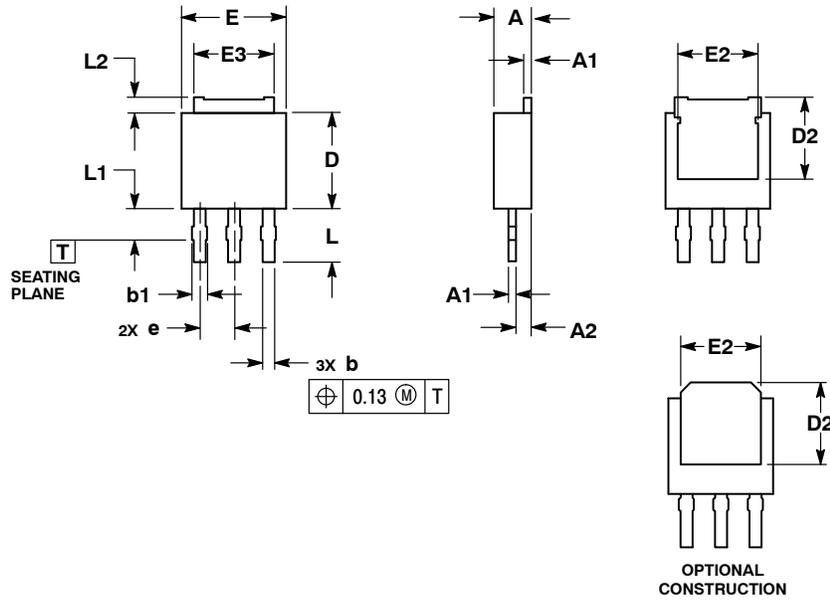
STYLE 2:

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

NDF60N360U1, NDD60N360U1

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.

DIM	MILLIMETERS	
	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

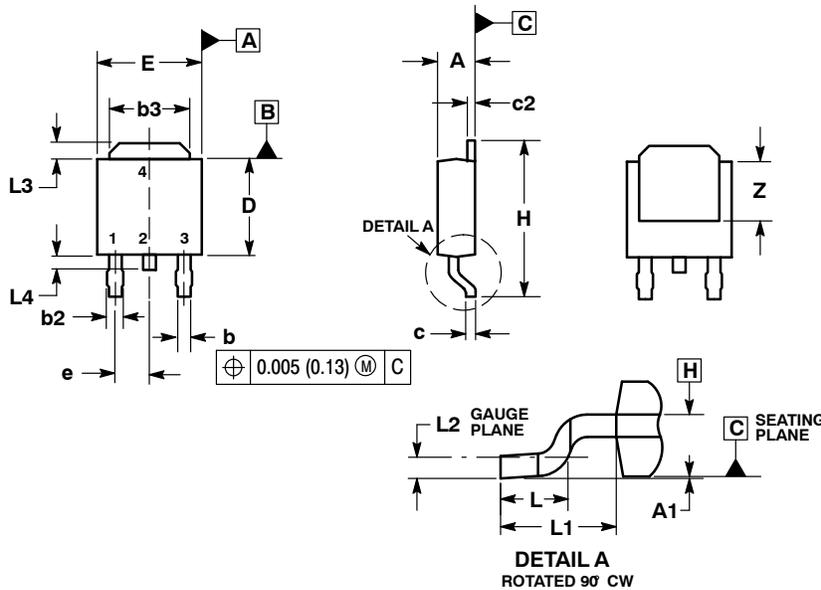
STYLE 2:

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

NDF60N360U1, NDD60N360U1

PACKAGE DIMENSIONS

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



NOTES:

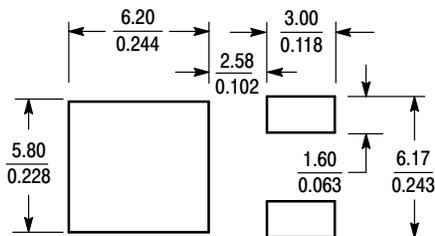
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS b3, L3 AND Z.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.006 INCHES PER SIDE.
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.

DIM	INCHES		MILLIMETERS	
	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:

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.

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