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ON Semiconductor®

NDP6060L / NDB6060L
N-Channel Logic Level Enhancement Mode Field Effect Transistor

General Description

These logic level N-Channel enhancement mode power field effect transistors are produced using ON Semiconductor's proprietary, high cell density, DMOS technology. This very high density process has been especially tailored to minimize on-state resistance, provide superior switching performance, and withstand high energy pulses in the avalanche and commutation modes. These devices are particularly suited for low voltage applications such as automotive, DC/DC converters, PWM motor controls, and other battery powered circuits where fast switching, low in-line power loss, and resistance to transients are needed.

Features

- 48A, 60V. $R_{DS(ON)}$ = 0.025Ω @ V_{GS} = 5V.
- Low drive requirements allowing operation directly from logic drivers. $V_{GS(TH)}$ < 2.0V.
- Critical DC electrical parameters specified at elevated temperature.
- Rugged internal source-drain diode can eliminate the need for an external Zener diode transient suppressor.
- 175°C maximum junction temperature rating.
- High density cell design for extremely low $R_{DS(ON)}$.
- TO-220 and TO-263 (D^{2}PAK) package for both through hole and surface mount applications.

TO-220
NDP Series

TO-263AB
NDB Series
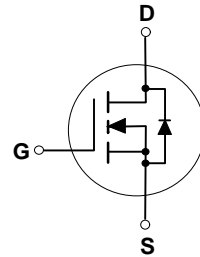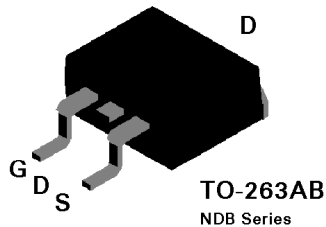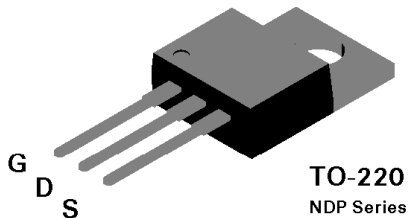
Absolute Maximum Ratings
T_C = 25°C unless otherwise noted

Symbol	Parameter	NDP6060L	NDB6060L	Units
V_{DSS}	Drain-Source Voltage	60		V
V_{DGR}	Drain-Gate Voltage ($R_{GS} \leq$ 1 MΩ)	60		V
V_{GSS}	Gate-Source Voltage - Continuous	± 16		V
	- Nonrepetitive (t_P < 50 μs)	± 25		
I_D	Drain Current - Continuous	48		A
	- Pulsed	144		
P_D	Total Power Dissipation @ T_C = 25°C	100		W
	Derate above 25°C	0.67		W/°C
T_J,T_{STG}	Operating and Storage Temperature	-65 to 175		°C
T_L	Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds	275		°C

Electrical Characteristics (T_C = 25°C unless otherwise noted)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
DRAIN-SOURCE AVALANCHE RATINGS (Note 1)							
W_{DSS}	Single Pulse Drain-Source Avalanche Energy	V_{DD} = 25 V, I_D = 48 A				200	mJ
I_{AR}	Maximum Drain-Source Avalanche Current					48	A
OFF CHARACTERISTICS							
BV_{DSS}	Drain-Source Breakdown Voltage	V_{GS} = 0 V, I_D = 250 µA		60			V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 60 V, V_{GS} = 0 V				250	µA
			T_J = 125°C			1	mA
I_{GSSF}	Gate - Body Leakage, Forward	V_{GS} = 16 V, V_{DS} = 0 V				100	nA
I_{GSSR}	Gate - Body Leakage, Reverse	V_{GS} = -16 V, V_{DS} = 0 V				-100	nA
ON CHARACTERISTICS (Note 1)							
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS}, I_D = 250 µA		1		2	V
			T_J = 125°C	0.65		1.5	
$R_{DS(ON)}$	Static Drain-Source On-Resistance	V_{GS} = 5 V, I_D = 24 A				0.025	Ω
			T_J = 125°C			0.04	
		V_{GS} = 10 V, I_D = 24 A				0.02	
$I_{D(on)}$	On-State Drain Current	V_{GS} = 5 V, V_{DS} = 10 V		48			A
g_{FS}	Forward Transconductance	V_{DS} = 10 V, I_D = 24 A		10			S
DYNAMIC CHARACTERISTICS							
C_{iss}	Input Capacitance	V_{DS} = 25 V, V_{GS} = 0 V, f = 1.0 MHz			1630	2000	pF
C_{oss}	Output Capacitance				460	800	pF
C_{rss}	Reverse Transfer Capacitance				150	400	pF
SWITCHING CHARACTERISTICS (Note 1)							
$t_{D(on)}$	Turn - On Delay Time	V_{DD} = 30 V, I_D = 48 A, V_{GS} = 5 V, R_{GEN} = 15 Ω, R_{GS} = 15 Ω			15	30	nS
t_r	Turn - On Rise Time				320	500	nS
$t_{D(off)}$	Turn - Off Delay Time				49	100	nS
t_f	Turn - Off Fall Time				161	300	nS
Q_g	Total Gate Charge	V_{DS} = 48 V, I_D = 48 A, V_{GS} = 5 V			36	60	nC
Q_{gs}	Gate-Source Charge				8.2		nC
Q_{gd}	Gate-Drain Charge				21		nC

Electrical Characteristics (T$_C$ = 25°C unless otherwise noted)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
DRAIN-SOURCE DIODE CHARACTERISTICS							
I$_S$	Maximum Continuos Drain-Source Diode Forward Current					48	A
I$_{SM}$	Maximum Pulsed Drain-Source Diode Forward Current					144	A
V$_{SD}$	Drain-Source Diode Forward Voltage	V$_{GS}$ = 0 V, I$_S$ = 24 A (Note 1)				1.3	V
			T$_J$ = 125°C			1.2	
t$_{rr}$	Reverse Recovery Time	V$_{GS}$ = 0 V, I$_F$ = 48 A, dI$_F$/dt = 100 A/µs		35	75	140	ns
I$_{rr}$	Reverse Recovery Current			2	3.6	8	A
THERMAL CHARACTERISTICS							
R$_{\theta JC}$	Thermal Resistance, Junction-to-Case					1.5	°C/W
R$_{\theta JA}$	Thermal Resistance, Junction-to-Ambient					62.5	°C/W

Note:
1. Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.

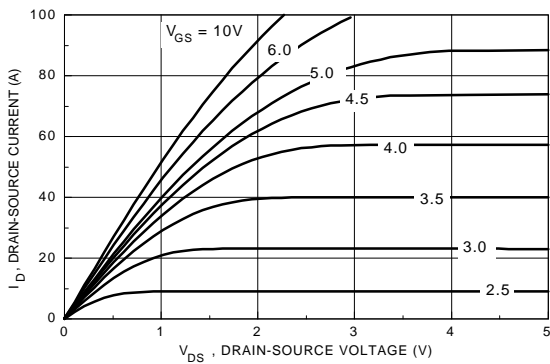**Typical Electrical Characteristics**

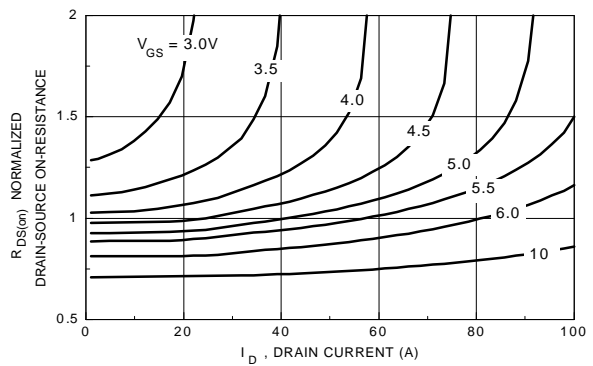Figure 1. On-Region Characteristics.

Figure 2. On-Resistance Variation with Gate
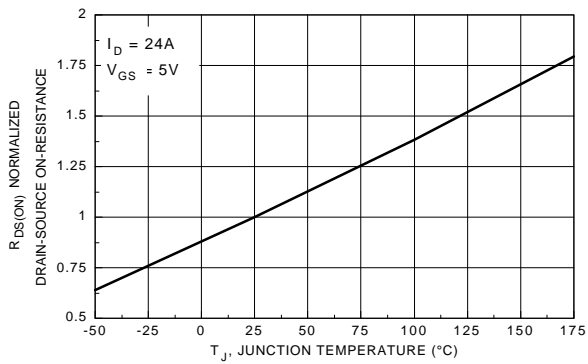Voltage and Drain Current.

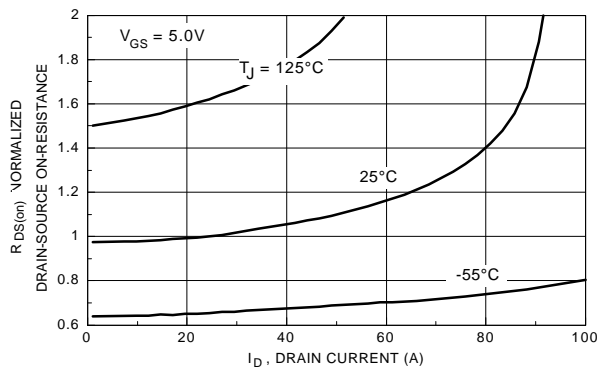Figure 3. On-Resistance Variation
with Temperature.

Figure 4. On-Resistance Variation with Drain
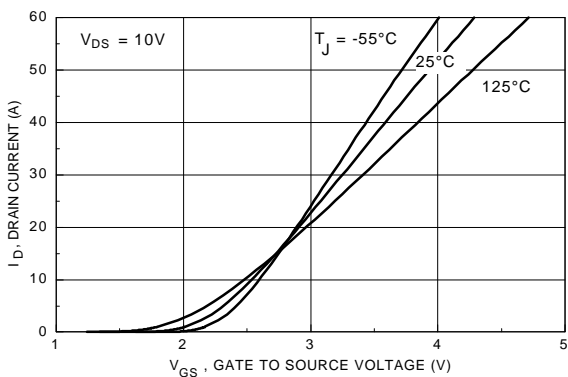Current and Temperature.

Figure 5. Transfer Characteristics.

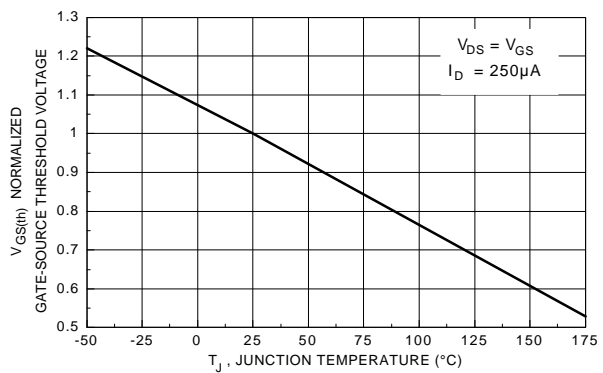Figure 6. Gate Threshold Variation with
Temperature.

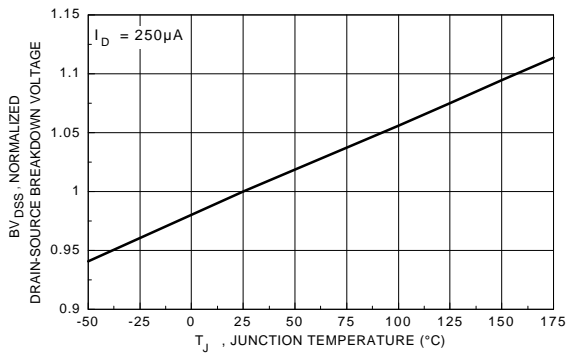# Typical Electrical Characteristics (continued)

Figure 7. Breakdown Voltage Variation with Temperature.
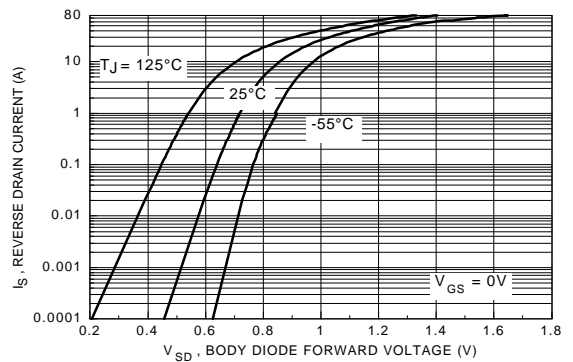
Figure 8. Body Diode Forward Voltage Variation with Current and Temperature.
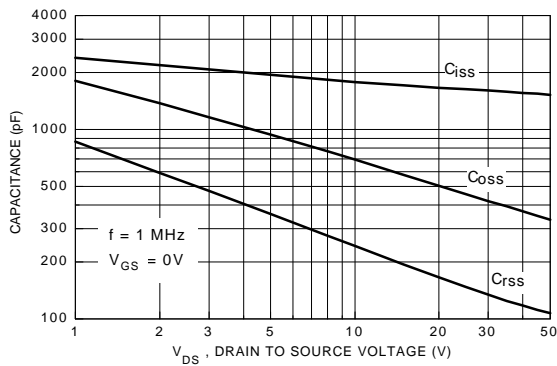

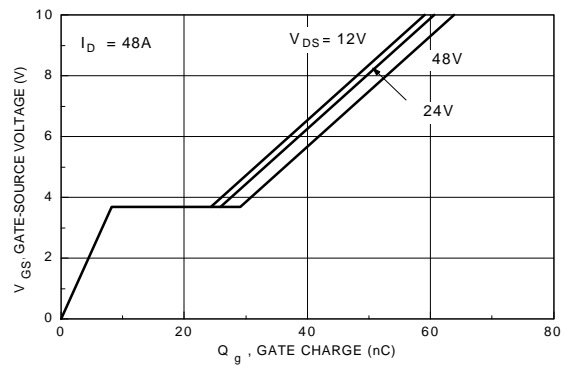Figure 9. Capacitance Characteristics.

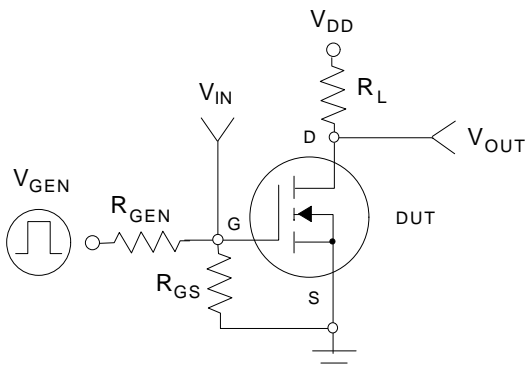Figure 10. Gate Charge Characteristics.
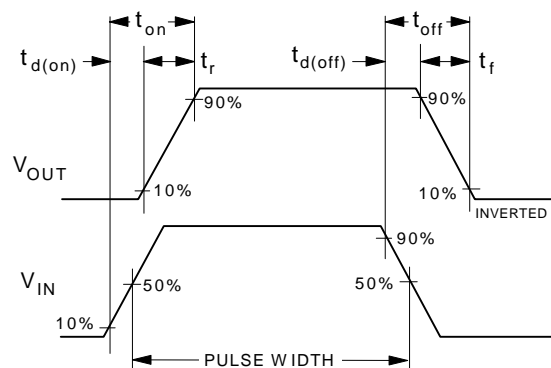

Figure 11. Switching Test Circuit.

Figure 12. Switching Waveforms.

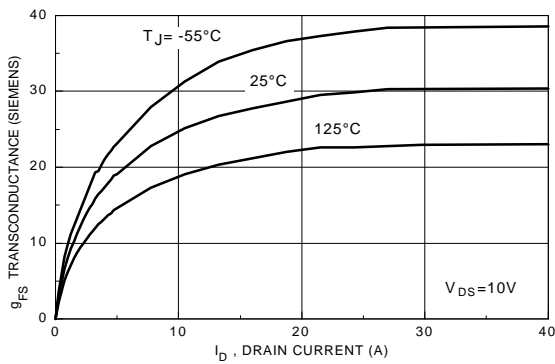## Typical Electrical Characteristics (continued)

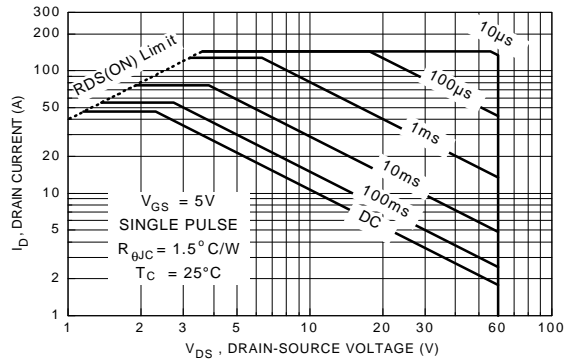**Figure 13. Transconductance Variation with Drain Current. and Temperature**

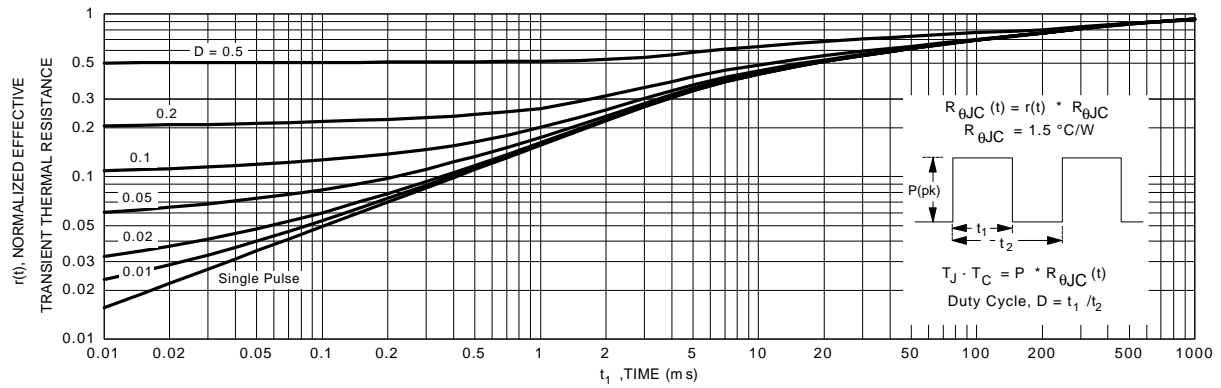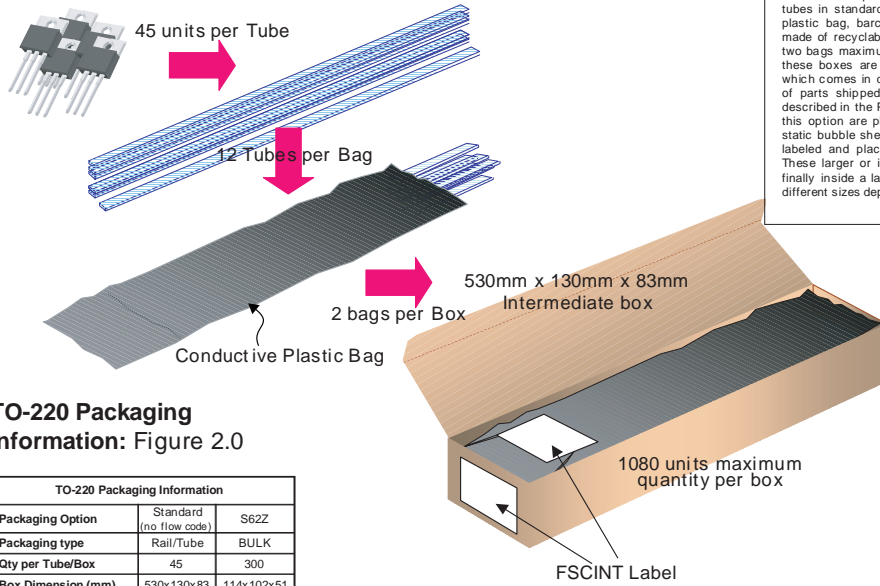

Figure 14. Maximum Safe Operating. Area

Figure 15. Transient Thermal Response Curve.

TO-220 Tape and Reel Data and Package Dimensions

TO-220 Tube Packing
Configuration: Figure 1.0

45 units per Tube

12 Tubes per Bag

Conductive Plastic Bag

2 bags per Box

530mm x 130mm x 83mm
Intermediate box

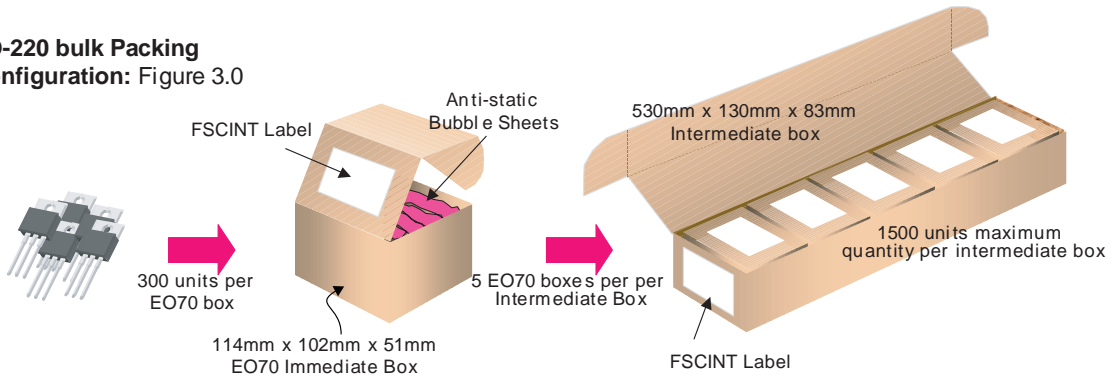1080 units maximum
quantity per box

FSCINT Label

Packaging Description:

TO-220 parts are shipped normally in tube. The tube is made of PVC plastic treated with anti-static agent. These tubes in standard option are placed inside a dissipative plastic bag, barcode labeled, and placed inside a box made of recyclable corrugated paper. One box contains two bags maximum (see fig. 1.0). And one or several of these boxes are placed inside a labeled shipping box which comes in different sizes depending on the number of parts shipped. The other option comes in bulk as described in the Packaging Information table. The units in this option are placed inside a small box laid with anti-static bubble sheet. These smaller boxes are individually labeled and placed inside a larger box (see fig. 3.0). These larger or intermediate boxes then will be placed finally inside a labeled shipping box which still comes in different sizes depending on the number of units shipped.

TO-220 Packaging
Information: Figure 2.0

TO-220 Packaging Information		
Packaging Option	Standard (no flow code)	S62Z
Packaging type	Rail/Tube	BULK
Qty per Tube/Box	45	300
Box Dimension (mm)	530x130x83	114x102x51
Max qty per Box	1,080	1,500
Weight per unit (gm)	1.4378	1.4378
Note/Comments		

TO-220 bulk Packing
Configuration: Figure 3.0

FSCINT Label

Anti-static
Bubble Sheets

530mm x 130mm x 83mm
Intermediate box

300 units per
EO70 box

114mm x 102mm x 51mm
EO70 Immediate Box

5 EO70 boxes per per
Intermediate Box

1500 units maximum
quantity per intermediate box

FSCINT Label

TO-220 Tube
Configuration: Figure 4.0
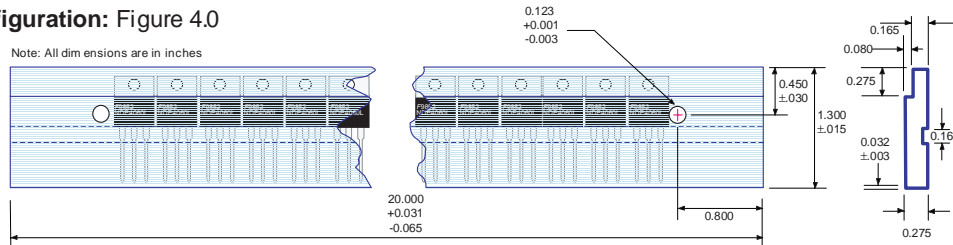
Note: All dimensions are in inches

0.123
+0.001
-0.003

0.450
±.030

1.300
±.015

20.000
+0.031
-0.065

0.800

0.165

0.080

0.275

0.032
±.003

0.160

0.275

TO-220 (FS PKG Code 37)

1:1

Scale 1:1 on letter size paper

Dimensions shown below are in:
inches [millimeters]

Part Weight per unit (gram): 1.4378

$\phi \frac{0.1610}{0.1390} \left[\phi \frac{4.09}{3.53} \right]$

$\frac{0.1350}{0.1000} \left[\frac{3.43}{2.54} \right]$

$\frac{0.4200}{0.3800} \left[\frac{10.67}{9.65} \right]$

$\frac{0.6500}{0.5600} \left[\frac{16.51}{14.22} \right]$

PIN#1 ID

TYP. $\frac{0.0700}{0.0450} \left[\frac{1.78}{1.14} \right]$

TYP. $\frac{0.0400}{0.0150} \left[\frac{1.02}{0.38} \right]$

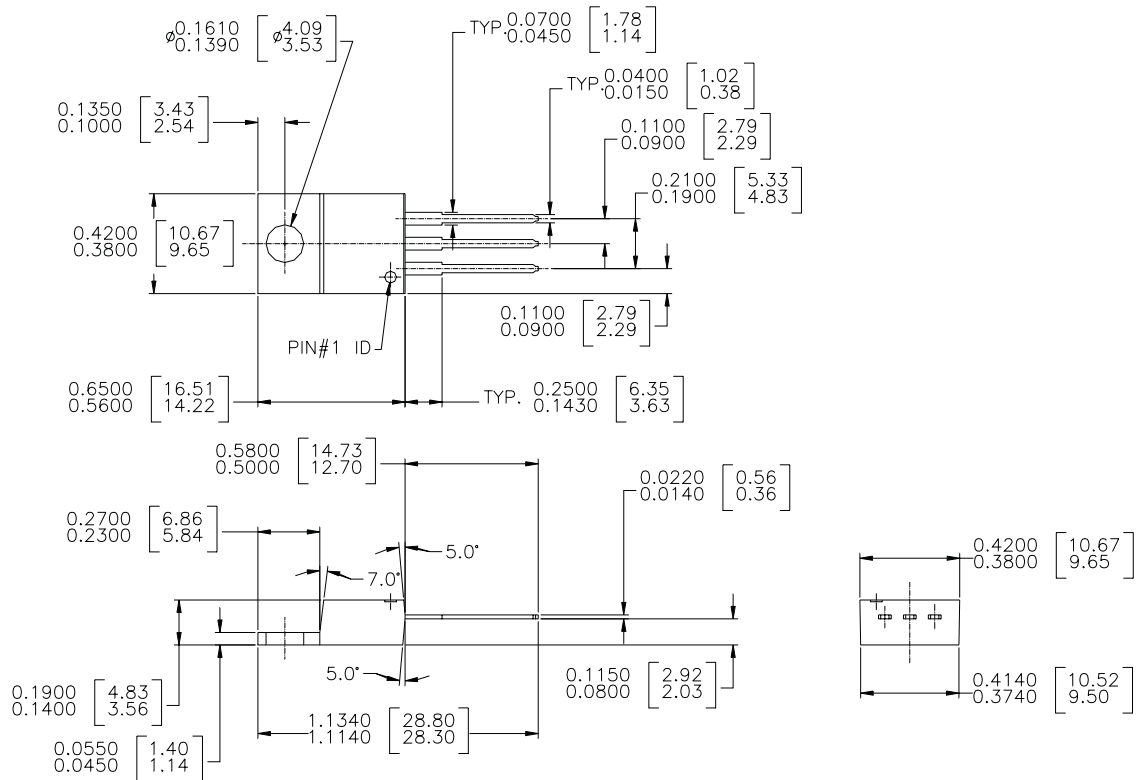$\frac{0.1100}{0.0900} \left[\frac{2.79}{2.29} \right]$

$\frac{0.2100}{0.1900} \left[\frac{5.33}{4.83} \right]$

$\frac{0.1100}{0.0900} \left[\frac{2.79}{2.29} \right]$

TYP. $\frac{0.2500}{0.1430} \left[\frac{6.35}{3.63} \right]$

$\frac{0.5800}{0.5000} \left[\frac{14.73}{12.70} \right]$

$\frac{0.2700}{0.2300} \left[\frac{6.86}{5.84} \right]$

$\frac{0.0220}{0.0140} \left[\frac{0.56}{0.36} \right]$

5.0°

7.0°

5.0°

$\frac{0.1900}{0.1400} \left[\frac{4.83}{3.56} \right]$

$\frac{0.0550}{0.0450} \left[\frac{1.40}{1.14} \right]$

$\frac{1.1340}{1.1140} \left[\frac{28.80}{28.30} \right]$

$\frac{0.1150}{0.0800} \left[\frac{2.92}{2.03} \right]$

$\frac{0.4200}{0.3800} \left[\frac{10.67}{9.65} \right]$

$\frac{0.4140}{0.3740} \left[\frac{10.52}{9.50} \right]$
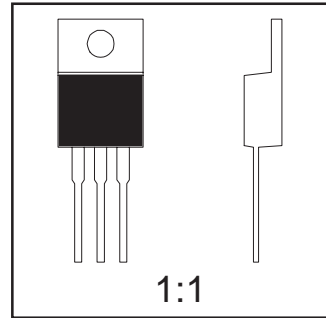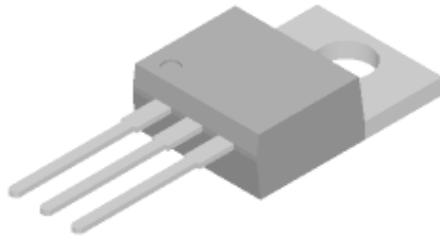
NOTE : UNLESS OTHERWISE SPECIFIED

　　1. STANDARD LEAD FINISH :
　　200 MICROINCHES / 5.08 MICRON MINIMUM
　　LEAD / TIN 15/85 ON OLIN 194 COPPER OR EQUIVALENT

　　2. DIMENSION BASED ON JEDEC STANDARD TO-220
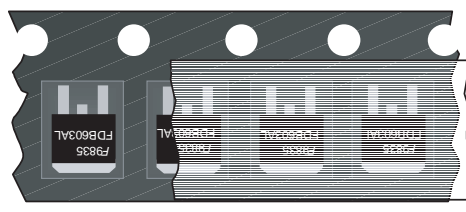　　VARIATION AB, ISSUE J, DATED 3/24/87

TO 220 3 LEAD

TO-263AB/D²PAK Tape and Reel Data and Package Dimensions

TO-263AB/D²PAK Packaging
Configuration: Figure 1.0

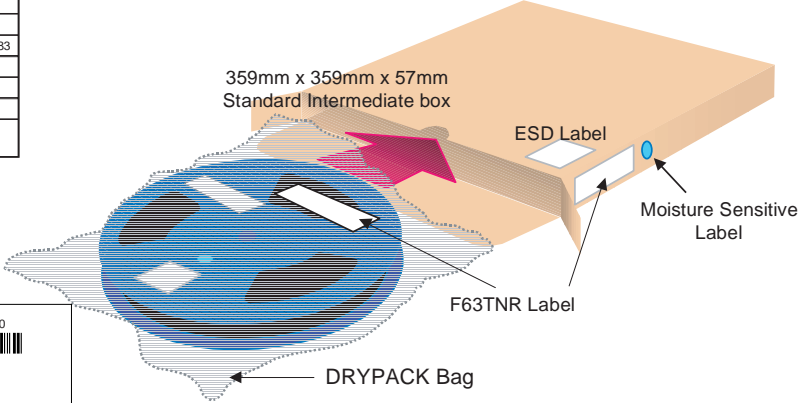ESD Label

Antistatic Cover Tape
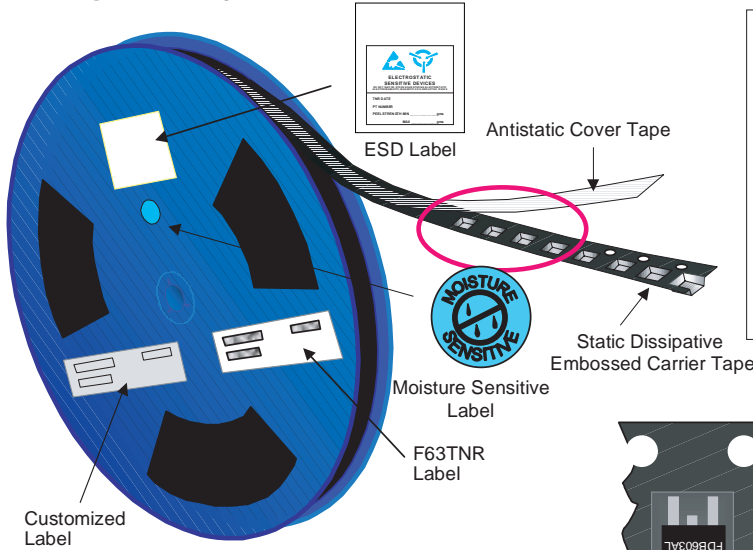
Packaging Description:

TO-263/D²PAK parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 800 units per 13" or 330cm diameter reel. The reels are dark blue in color and is made of polystyrene plastic (anti-static coated). This and some other options are further described in the Packaging Information table.

These full reels are individually barcode labeled, dry packed, and placed inside a standard intermediate box (illustrated in figure 1.0) made of recyclable corrugated brown paper. One box contains one reel maximum. And these boxes are placed inside a barcode labeled shipping box which comes in different sizes depending on the number of parts shipped.
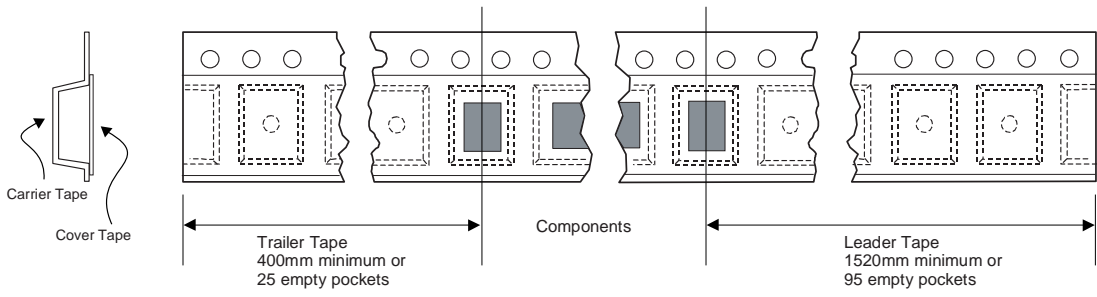
Static Dissipative
Embossed Carrier Tape

Moisture Sensitive Label

F63TNR Label

Customized Label

TO-263AB/D²PAK Packaging Information		
Packaging Option	Standard (no flow code)	L86Z
Packaging type	TNR	Rail/Tube
Qty per Reel/Tube/Bag	800	45
Reel Size	13" Dia	-
Box Dimension (mm)	359x359x57	530x130x83
Max qty per Box	800	1,080
Weight per unit (gm)	1.4378	1.4378
Weight per Reel	1.6050	-
Note/Comments		

TO-263AB/D²PAK Unit Orientation

359mm x 359mm x 57mm
Standard Intermediate box

ESD Label

Moisture Sensitive Label

F63TNR Label

F63TNR Label sample

LOT: CBVK741B019   QTY: 800
FSID: FDB6320L   SPEC:
D/C1: D9842   QTY1:   SPEC REV:
D/C2:   QTY2:   CPN:
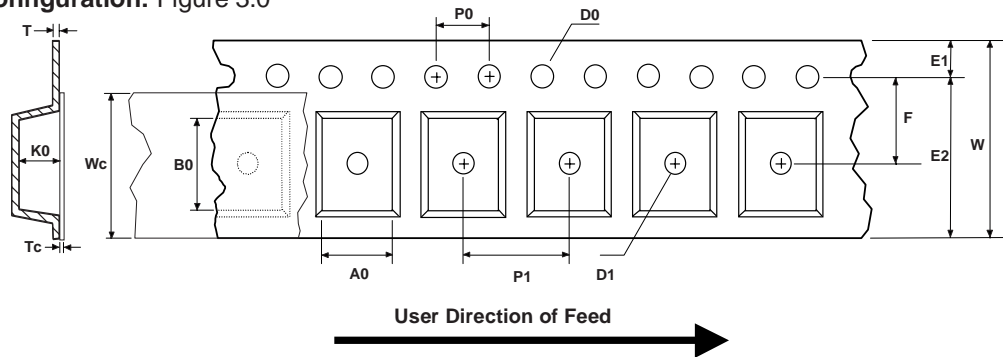   N/F: F   (F63TNR)3

DRYPACK Bag

TO-263AB/D²PAK Tape Leader and Trailer
Configuration: Figure 2.0

Carrier Tape

Cover Tape

Trailer Tape
400mm minimum or
25 empty pockets

Components

Leader Tape
1520mm minimum or
95 empty pockets

TO-263AB/D²PAK Tape and Reel Data and Package Dimensions, continued

TO-263AB/D²PAK Embossed Carrier Tape
Configuration: Figure 3.0

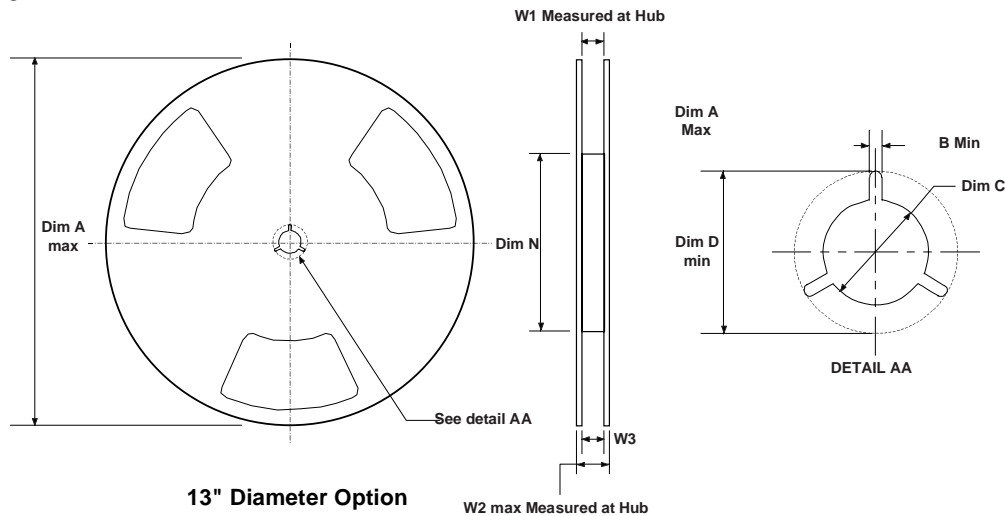**User Direction of Feed**

Pkg type	A0	B0	W	D0	D1	E1	E2	F	P1	P0	K0	T	Wc	Tc
TO263AB/ D²PAK (24mm)	10.60 +/-0.10	15.80 +/-0.10	24.0 +/-0.3	1.55 +/-0.05	1.60 +/-0.10	1.75 +/-0.10	22.25 min	11.50 +/-0.10	16.0 +/-0.1	4.0 +/-0.1	4.90 +/-0.10	0.450 +/-0.150	21.0 +/-0.3	0.06 +/-0.02

Dimensions are in millimeter

Notes: A0, B0, and K0 dimensions are determined with respect to the EIA/Jedec RS-481 rotational and lateral movement requirements (see sketches A, B, and C).

10 deg maximum component rotation

Sketch A (Side or Front Sectional View)
Component Rotation

Sketch B (Top View)
Component Rotation

Sketch C (Top View)
Component lateral movement
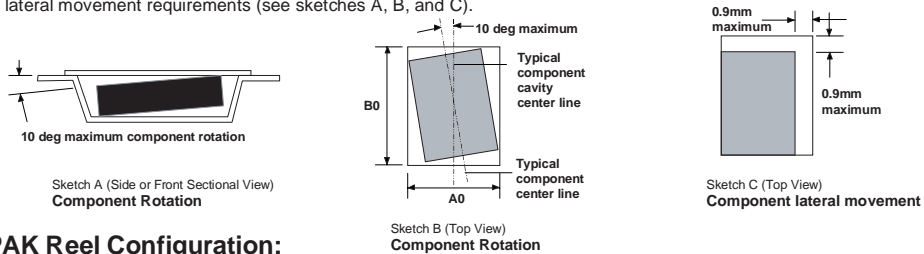
TO-263AB/D²PAK Reel Configuration: Figure 4.0

13" Diameter Option

| Tape Size	Reel Option	Dim A	Dim B	Dim C	Dim D	Dim N	Dim W1	Dim W2	Dim W3 (LSL-USL)
24mm	13" Dia	13.00 330	0.059 1.5	512 +0.020/-0.008 13 +0.5/-0.2	0.795 20.2	4.00 100	0.961 +0.078/-0.000 24.4 +2/0	1.197 30.4	0.941 – 0.1.079 23.9 – 27.4

Dimensions are in inches and millimeters

TO-263AB/D²PAK (FS PKG Code 45)
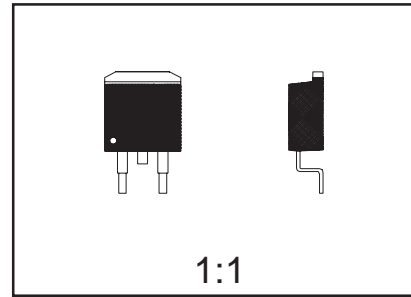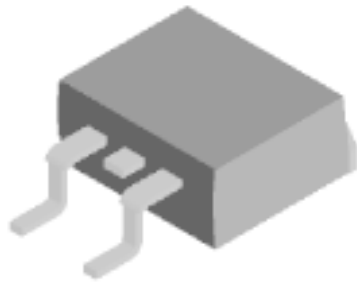
1:1

Scale 1:1 on letter size paper

Dimensions shown below are in:
inches [millimeters]

Part Weight per unit (gram): 1.4378

LAND PATTERN RECOMMENDATION
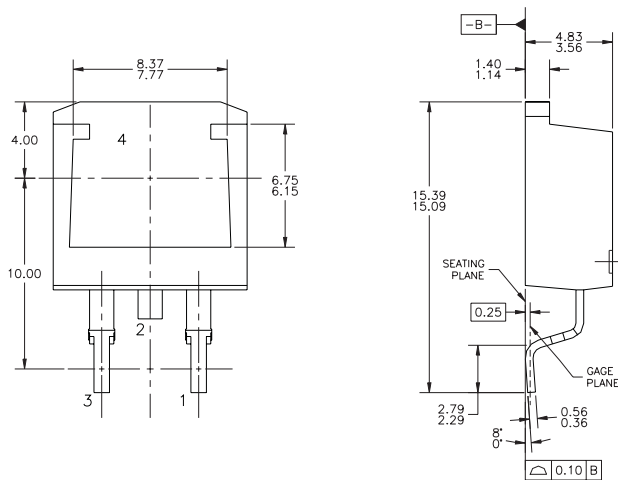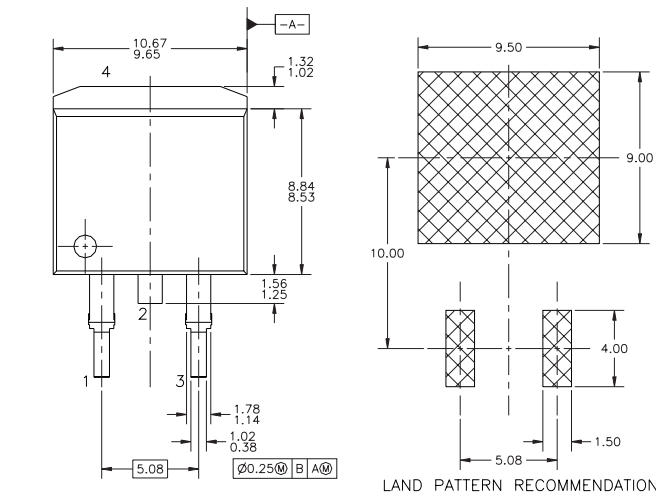
NOTES: UNLESS OTHERWISE SPECIFIED
  A)   ALL DIMENSIONS ARE IN MILLIMETERS.
  B)   STANDARD LEAD FINISH:
       200 MICROINCHES / 5.08 MICROMETERS MIN.
       LEAD/TIN 15/85 ON OLIN 194 COPPER OR
       EQUIVALENT.
  C)   MAXIMUM VERTICAL BURR ON HEATSINK NOT
       TO EXCEED 0.003 INCH / 0.05mm.
  D)   NO PACKAGE CHIPS, CRACKS OR SURFACE
       IDENTIFICATION ALLOWED AFTER FORMING.
  E)   REFERENCE JEDEC, TO-263, ISSUE C,
       VARIATION AB, DATED 2/92.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
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