

9347963 UNITRODE CORP

92D 10702 D T-39-11

POWER MOSFET TRANSISTORS100 Volt, 0.3 Ohm
N-ChannelUFN520
UFN521
UFN522
UFN523**FEATURES**

- Compact Plastic Package
- Fast Switching
- Low Drive Current
- Ease of Paralleling
- No Second Breakdown
- Excellent Temperature Stability

DESCRIPTION

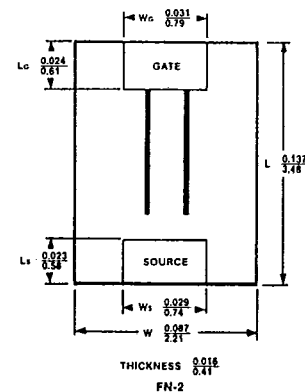
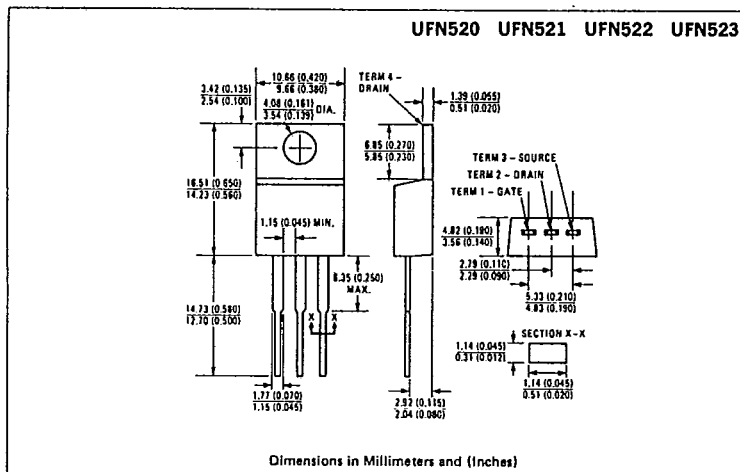
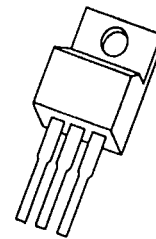
The Unitrode power MOSFET design utilizes the most advanced technology available. This efficient design achieves a very low $R_{DS(on)}$ and a high transconductance.

The Unitrode power MOSFET features all of the advantages of MOS technology such as voltage control, freedom from second breakdown, very fast switching speeds, and thermal stability.

These power MOSFETs are ideally suited for many high-speed, high-power switching applications such as switching power supplies, motor controls, and wide-band and audio amplifiers.

PRODUCT SUMMARY

Part Number	V_{DS}	$R_{DS(on)}$	I_D
UFN520	100V	0.30 Ω	8.0A
UFN521	60V	0.30 Ω	8.0A
UFN522	100V	0.40 Ω	7.0A
UFN523	60V	0.40 Ω	7.0A

**MECHANICAL SPECIFICATIONS****TO-220AB**

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ABSOLUTE MAXIMUM RATINGS

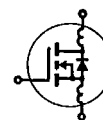
Parameter	UFN520	UFN521	UFN522	UFN523	Units
V_{DS} Drain - Source Voltage ①	100	60	100	60	V
V_{DGR} Drain - Gate Voltage ($R_{GS} = 1\text{ M}\Omega$) ①	100	60	100	60	V
$I_D @ T_C = 25^\circ\text{C}$ Continuous Drain Current	8.0	8.0	7.0	7.0	A
$I_D @ T_C = 100^\circ\text{C}$ Continuous Drain Current	5.0	5.0	4.0	4.0	A
I_{DM} Pulsed Drain Current ③	32	32	28	28	A
V_{GS} Gate - Source Voltage	± 20				V
$P_D @ T_C = 25^\circ\text{C}$ Max. Power Dissipation	40 (See Fig. 14)				W
Linear Derating Factor	0.32 (See Fig. 14)				W/K
I_{LM} Inductive Current, Clamped	(See Fig. 15 and 16) $L = 100\mu\text{H}$				A
	32	32	28	28	
T_J Operating Junction and T_{stg} Storage Temperature Range	-55 to 150				$^\circ\text{C}$
Lead Temperature	300 (0.063 in. (1.6mm) from case for 10s)				$^\circ\text{C}$

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ELECTRICAL CHARACTERISTICS @ $T_C = 25^\circ\text{C}$ (Unless otherwise specified)

Parameter	Type	Min.	Typ.	Max.	Units	Test Conditions
BV_{DSS} Drain - Source Breakdown Voltage	UFN520	100	—	—	V	$V_{GS} = 0\text{V}$ $I_D = 250\mu\text{A}$
	UFN522	—	—	—	V	
	UFN521 UFN523	60	—	—	V	
$V_{GS(th)}$ Gate Threshold Voltage	ALL	2.0	—	4.0	V	$V_{DS} = V_{GS}$, $I_D = 250\mu\text{A}$
I_{GSS} Gate-Source Leakage Forward	ALL	—	—	500	nA	$V_{GS} = 20\text{V}$
I_{GSS} Gate-Source Leakage Reverse	ALL	—	—	-500	nA	$V_{GS} = -20\text{V}$
I_{DSS} Zero Gate Voltage Drain Current	ALL	—	—	250	μA	$V_{DS} = \text{Max. Rating}$, $V_{GS} = 0\text{V}$
		—	—	1000	μA	$V_{DS} = \text{Max. Rating} \times 0.8$, $V_{GS} = 0\text{V}$, $T_C = 125^\circ\text{C}$
$I_{D(on)}$ On-State Drain Current ②	UFN520	8.0	—	—	A	$V_{DS} > I_{D(on)} \times R_{DS(on)} \text{ max.}$, $V_{GS} = 10\text{V}$
	UFN521	—	—	—	A	
	UFN522 UFN523	7.0	—	—	A	
$R_{DS(on)}$ Static Drain-Source On-State Resistance ②	UFN520	—	0.25	0.30	Ω	$V_{GS} = 10\text{V}$, $I_D = 4.0\text{A}$
	UFN521	—	—	—	Ω	
	UFN522 UFN523	—	0.30	0.40	Ω	
g_{fs} Forward Transconductance ②	ALL	1.5	2.9	—	S (Ω)	$V_{DS} > I_{D(on)} \times R_{DS(on)} \text{ max.}$, $I_D = 4.0\text{A}$
C_{iss} Input Capacitance	ALL	—	450	600	pF	$V_{GS} = 0\text{V}$, $V_{DS} = 25\text{V}$, $f = 1.0\text{ MHz}$ See Fig. 10
C_{oss} Output Capacitance	ALL	—	200	400	pF	
C_{rss} Reverse Transfer Capacitance	ALL	—	50	100	pF	
$t_{d(on)}$ Turn-On Delay Time	ALL	—	20	40	ns	$V_{DD} = 0.5 BV_{DSS}$, $I_D = 4.0\text{A}$, $Z_0 = 50\Omega$ See Fig. 17 (MOSFET switching times are essentially independent of operating temperature.)
t_r Rise Time	ALL	—	35	70	ns	
$t_{d(off)}$ Turn-Off Delay Time	ALL	—	50	100	ns	
t_f Fall Time	ALL	—	35	70	ns	
Q_g Total Gate Charge (Gate-Source Plus Gate-Drain)	ALL	—	10	15	nC	$V_{GS} = 15\text{V}$, $I_D = 10\text{A}$, $V_{DS} = 0.8 \text{ Max. Rating}$. See Fig. 18 for test circuit. (Gate charge is essentially independent of operating temperature.)
Q_{gs} Gate-Source Charge	ALL	—	6.0	—	nC	
Q_{gd} Gate-Drain ("Miller") Charge	ALL	—	4.0	—	nC	
L_D Internal Drain Inductance	ALL	—	3.5	—	nH	Measured from the contact screw on tab to center of die.
		—	4.5	—	nH	Measured from the drain lead, 6mm (0.25 in.) from package to center of die.
L_S Internal Source Inductance	ALL	—	7.5	—	nH	Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad.

Modified MOSFET symbol showing the internal device inductances.



THERMAL RESISTANCE

R_{thJC} Junction-to-Case	ALL	—	—	3.12	K/W	
R_{thCS} Case-to-Sink	ALL	—	1.0	—	K/W	Mounting surface flat, smooth, and greased.
R_{thJA} Junction-to-Ambient	ALL	—	—	80	K/W	Free Air Operation

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SOURCE-DRAIN DIODE RATINGS AND CHARACTERISTICS

I_S	Continuous Source Current (Body Diode)	UFN520 UFN521	—	—	8.0	A	Modified MOSFET symbol showing the integral reverse P-N junction rectifier. 
		UFN522 UFN523	—	—	7.0	A	
I_{SM}	Pulse Source Current (Body Diode) ③	UFN520 UFN521	—	—	32	A	
		UFN522 UFN523	—	—	28	A	
V_{SD}	Diode Forward Voltage ②	UFN520 UFN521	—	—	2.5	V	$T_C = 25^\circ\text{C}, I_S = 8.0\text{A}, V_{GS} = 0\text{V}$
		UFN522 UFN523	—	—	2.3	V	$T_C = 25^\circ\text{C}, I_S = 7.0\text{A}, V_{GS} = 0\text{V}$
t_{rr}	Reverse Recovery Time	ALL	—	280	—	ns	$T_J = 150^\circ\text{C}, I_F = 8.0\text{A}, dI_F/dt = 100\text{A}/\mu\text{s}$
Q_{RR}	Reverse Recovered Charge	ALL	—	1.6	—	μC	$T_J = 150^\circ\text{C}, I_F = 8.0\text{A}, dI_F/dt = 100\text{A}/\mu\text{s}$
t_{on}	Forward Turn-on Time	ALL	Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by $L_S + L_D$.				

① $T_J = 25^\circ\text{C}$ to 150°C . ② Pulse Test: Pulse width $\leq 300\mu\text{s}$, Duty Cycle $\leq 2\%$.

③ Repetitive Rating: Pulse width limited by max. junction temperature. See Transient Thermal Impedance Curve (Fig. 5).

Fig. 1 — Typical Output Characteristics

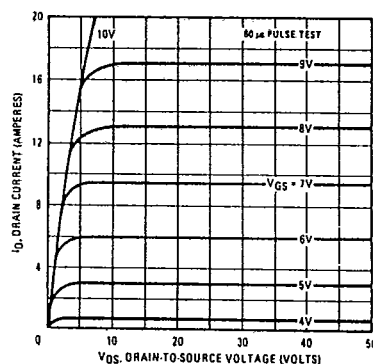


Fig. 2 — Typical Transfer Characteristics

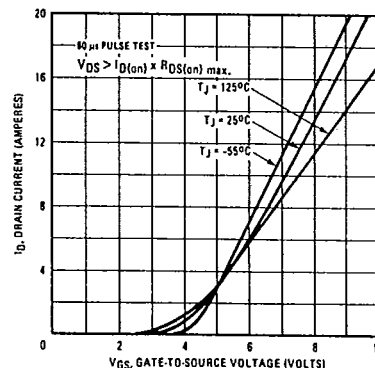


Fig. 3 — Typical Saturation Characteristics

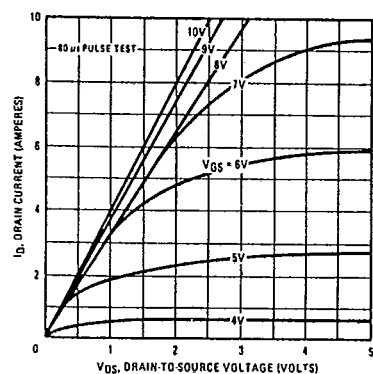
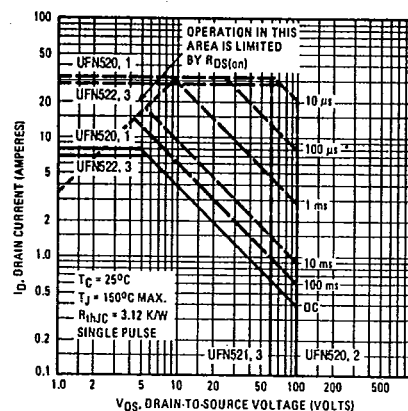


Fig. 4 — Maximum Safe Operating Area



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Fig. 5 — Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

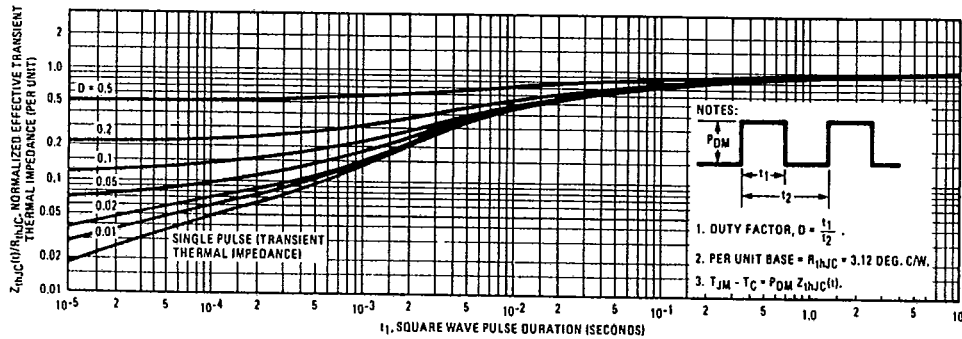


Fig. 6 — Typical Transconductance Vs. Drain Current

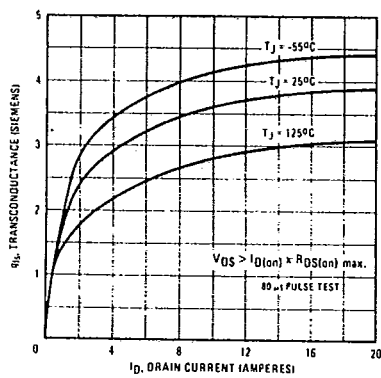


Fig. 7 — Typical Source-Drain Diode Forward Voltage

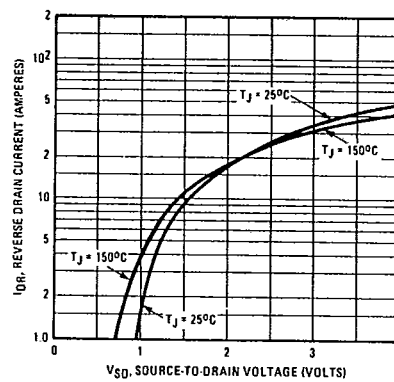


Fig. 8 — Breakdown Voltage Vs. Temperature

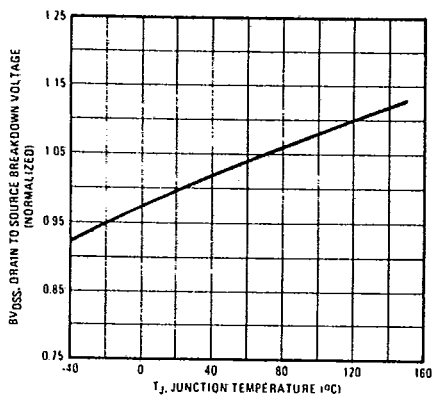
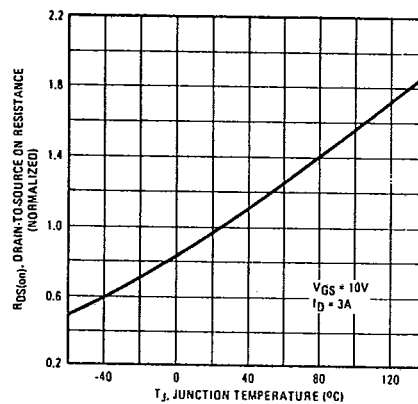


Fig. 9 — Normalized On-Resistance Vs. Temperature



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Fig. 10 - Typical Capacitance Vs. Drain-to-Source Voltage

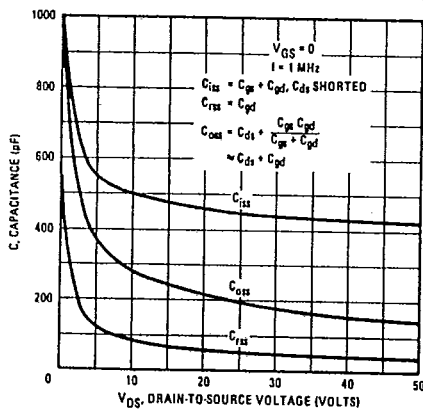


Fig. 11 - Typical Gate Charge Vs. Gate-to-Source Voltage

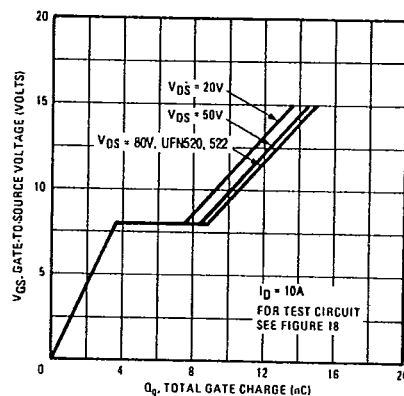


Fig. 12 - Typical On-Resistance Vs. Drain Current

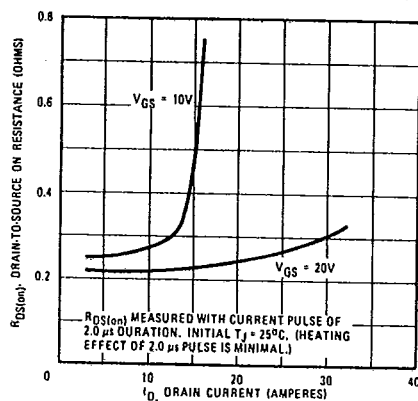


Fig. 13 - Maximum Drain Current Vs. Case Temperature

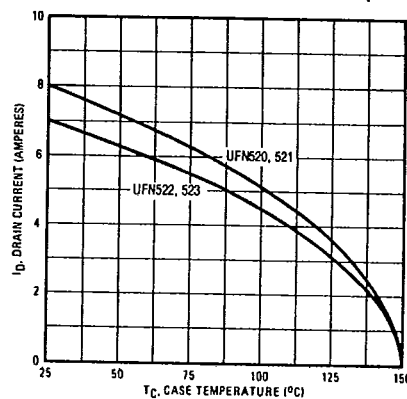
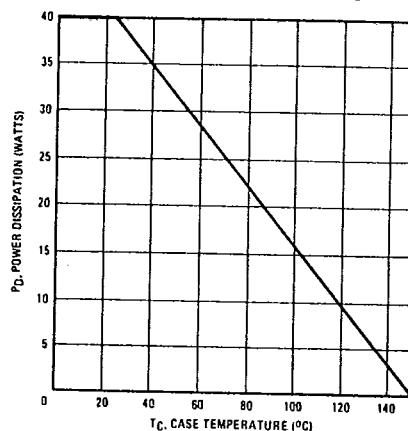


Fig. 14 - Power Vs. Temperature Derating Curve



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Fig. 15 — Clamped Inductive Test Circuit

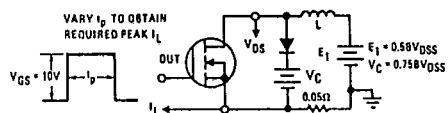


Fig. 16 — Clamped Inductive Waveforms



Fig. 17 — Switching Time Test Circuit

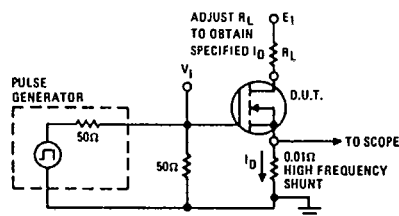
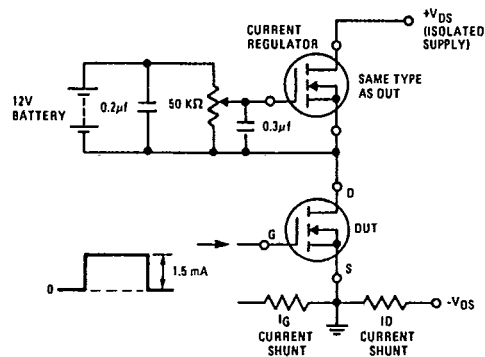


Fig. 18 — Gate Charge Test Circuit



TO-220 PACKAGE MOUNTING AND THERMAL CONSIDERATIONS

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The leads of the TO-220 rectifiers and Schottky diodes may be formed, but they are not intended to be flexible or ductile enough for unrestrained lead wrapping.

The figures show the typical device and hardware recommended. Several typical configurations of lead forming are illustrated.

The advantages of mounting the flange to the printed circuit board is that improved thermal heat transfer allows operating at higher levels of power dissipation. The individual specification sheets give the safe operating area as a function of a case temperature.

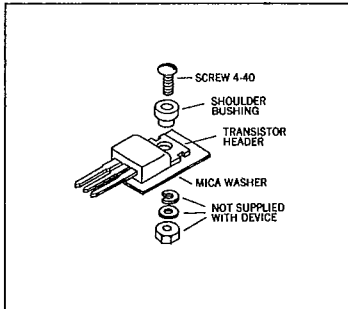


Figure A. Device and Hardware for Insulated Mounting.

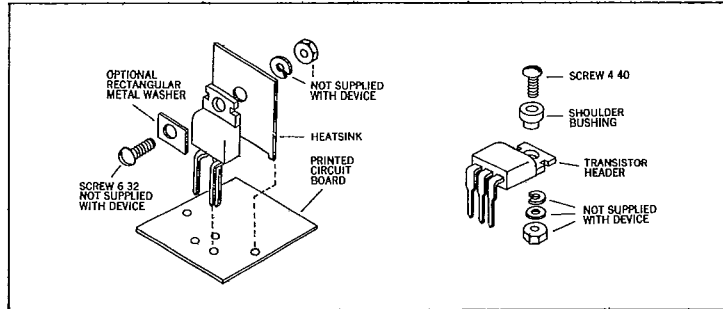


Figure B. Two Alternative Configurations for Axial Strain Relief and Electrical Isolation.

BENDING THE LEADS

Whenever the leads of the T-220 are to be formed, whether by a special fixture or by the use of long-nosed pliers, several important considerations must be followed. Internal damage to the device or lead damage may result if any or all of these precautions are not considered.

1. Minimum bend distance between the plastic body and the bend is $\frac{1}{8}$ inch.
2. The minimum radius of the bend is $\frac{1}{16}$ inch.
3. Avoid repeating bending at the same flexure point.
4. Whenever possible, use one of the lead forming configurations which relieve strain induced by mechanical or thermal loads.
5. Leads should not be bent greater than 90 degrees.
6. Avoid axial pulling or bending that would induce axial strain. The maximum axial component is 4 pounds.

7. Forming fixtures or pliers should not touch the plastic case because axial strain of $\approx .005$ " could cause irreversible internal damage.

8. The leads must be fully restrained during the lead forming operation to prevent relative movement between the body and the leads.

SOLDERING INTO THE CIRCUIT

The leads on the TO-220 are solderable; however, there are a few precautions that must be observed.

1. Soldering temperature must not exceed 270°C .
2. Maximum soldering temperature must not be applied for more than 5 seconds.
3. Maximum soldering temperature should not be applied closer than $\frac{1}{8}$ inch from the plastic body of the device.

TO-220 PACKAGE MOUNTING AND THERMAL CONSIDERATIONS

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MOUNTING THE FLANGE

Flange mounting is recommended for maximum power handling applications. A 6-32 machine screw is recommended. Eyeletting (hollow rivet) is acceptable if care is taken not to distort the flange. For insulated mount, a 4-40 screw and a shoulder bushing is recommended (see figure). Suggested material for bushings are: Diallphthalate, fiber-glass-filled nylon, or fiber-glass-filled polycarbonate. Note unfilled nylon should be avoided. The flange should not be directly soldered because the use of lead-tin could produce temperatures in excess of the maximum storage temperature. See the individual specification for the device.

Check list and summary for flange mounting:

1. Use recommended hardware.

2. Always fasten the flange prior to lead soldering.
3. Do not allow the forming tool to come in contact with the plastic body.
4. Maximum mounting torque is 8 inch-pounds.
5. Avoid modifying the flange by machining and do not use oversized screws.
6. Provide axial and transverse strain relief of the leads.
7. Use recommended insulation bushings. Avoid materials that exhibit hot-creep problems.

Thermal Considerations TO-220 Power Diodes

Thermal Resistance, Case to Ambient;

Free Air, No Heatsink 60°C/W typical

Thermal Capacitance

of Package 4.8 watt-seconds/°C

Thermal Time Constant 305 seconds

Device Type	I_F (A)	Thermal Resistance Junction Case °C/W
UES1401-4	8	2.5
UES1501-4	16	1.5
USD635-50	6	3.0
USD835-50	12	2.4
USD935-50	16	2.0

Note: When using a 2 mil MICA washer for electrical isolation, add 0.4°C/W to heatsink thermal resistance.

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Thermal joint compound should be used at the interface of the TO-220 flange and the heatsink to which it is attached.

Consider a TO-220 power rectifier with a thermal resistance junction to case of 1.5°C/W. The junction temperature produced depends upon the mounting conditions and power dissipated in the circuit. The table

shows junction temperature resulting from 15W of dissipation when mounted on an infinite heatsink at 100°C with different methods of interfacing.

Interface Condition Between Case and Heatsink	Thermal Resistance Case-Heatsink °C/W	Junction Temperature °C
Assumed direct, ideal metallic contact (no interference)	0.0	122
1 mil air gap*	1.2	140
Thermal compound; Tab screw torqued at 8 inch-pound	0.09	124
2 mil mica washer with thermal compound applied to both surfaces; tab screw torqued at 8 inch pound	0.58	131

* A film of air one mil in length has the thermal resistance of $\approx 1.2^\circ\text{C/W}$.

When using a small heat sink in free air one must consider the additional thermal resistance of the heat sink to ambient and operate at an appropriate power level. For example with an

18°C/W rated sink and thermal compound as above the device will have a junction temperature of 123°C when operating at 5W in an ambient of 25°C free air.