

## HFP4N60

### 600V N-Channel MOSFET

#### FEATURES

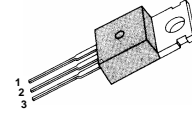
- ❑ Originative New Design
- ❑ Superior Avalanche Rugged Technology
- ❑ Robust Gate Oxide Technology
- ❑ Very Low Intrinsic Capacitances
- ❑ Excellent Switching Characteristics
- ❑ Unrivalled Gate Charge : 15 nC (Typ.)
- ❑ Extended Safe Operating Area
- ❑ Lower  $R_{DS(ON)}$  : 2.0  $\Omega$  (Typ.) @  $V_{GS}=10V$

$$BV_{DSS} = 600 \text{ V}$$

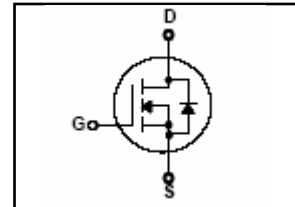
$$R_{DS(on) \text{ typ}} = 2.0 \ \Omega$$

$$I_D = 4.0 \text{ A}$$

#### TO-220



1. Gate 2. Drain 3. Source



#### Absolute Maximum Ratings $T_C=25^\circ\text{C}$ unless otherwise specified

Symbol	Parameter	Value	Units
$V_{DSS}$	Drain-Source Voltage	600	V
$I_D$	Drain Current – Continuous ( $T_C = 25^\circ\text{C}$ )	4.0	A
	Drain Current – Continuous ( $T_C = 100^\circ\text{C}$ )	2.5	A
$I_{DM}$	Drain Current – Pulsed (Note 1)	16	A
$V_{GS}$	Gate-Source Voltage	$\pm 30$	V
$E_{AS}$	Single Pulsed Avalanche Energy (Note 2)	240	mJ
$I_{AR}$	Avalanche Current (Note 1)	4.0	A
$E_{AR}$	Repetitive Avalanche Energy (Note 1)	10	mJ
dv/dt	Peak Diode Recovery dv/dt (Note 3)	5.5	V/ns
$P_D$	Power Dissipation ( $T_C = 25^\circ\text{C}$ )	100	W
	– Derate above $25^\circ\text{C}$	0.8	W/ $^\circ\text{C}$
$T_J, T_{STG}$	Operating and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
$T_L$	Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds	300	$^\circ\text{C}$

#### Thermal Resistance Characteristics

Symbol	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	--	1.25	$^\circ\text{C}/\text{W}$
$R_{\theta CS}$	Case-to-Sink	0.5	--	
$R_{\theta JA}$	Junction-to-Ambient	--	62.5	

**Electrical Characteristics**  $T_C=25\text{ }^\circ\text{C}$  unless otherwise specified

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
<b>On Characteristics</b>						
$V_{GS}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 250\ \mu\text{A}$	2.5	--	4.5	V
$R_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10\ \text{V}, I_D = 2.0\ \text{A}$	--	2.0	2.5	$\Omega$
<b>Off Characteristics</b>						
$BV_{DSS}$	Drain-Source Breakdown Voltage	$V_{GS} = 0\ \text{V}, I_D = 250\ \mu\text{A}$	600	--	--	V
$\Delta BV_{DSS} / \Delta T_J$	Breakdown Voltage Temperature Coefficient	$I_D = 250\ \mu\text{A}$ , Referenced to $25\text{ }^\circ\text{C}$	--	0.65	--	$\text{V}/^\circ\text{C}$
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = 600\ \text{V}, V_{GS} = 0\ \text{V}$	--	--	1	$\mu\text{A}$
		$V_{DS} = 480\ \text{V}, T_C = 125\text{ }^\circ\text{C}$	--	--	10	$\mu\text{A}$
$I_{GSSF}$	Gate-Body Leakage Current, Forward	$V_{GS} = 30\ \text{V}, V_{DS} = 0\ \text{V}$	--	--	100	nA
$I_{GSSR}$	Gate-Body Leakage Current, Reverse	$V_{GS} = -30\ \text{V}, V_{DS} = 0\ \text{V}$	--	--	-100	nA
<b>Dynamic Characteristics</b>						
$C_{iss}$	Input Capacitance	$V_{DS} = 25\ \text{V}, V_{GS} = 0\ \text{V}, f = 1.0\ \text{MHz}$	--	500	650	pF
$C_{oss}$	Output Capacitance		--	45	60	pF
$C_{rss}$	Reverse Transfer Capacitance		--	10	13	pF
<b>Switching Characteristics</b>						
$t_{d(on)}$	Turn-On Time	$V_{DS} = 300\ \text{V}, I_D = 4.0\ \text{A}, R_G = 25\ \Omega$  (Note 4,5)	--	15	30	ns
$t_r$	Turn-On Rise Time		--	40	80	ns
$t_{d(off)}$	Turn-Off Delay Time		--	50	100	ns
$t_f$	Turn-Off Fall Time		--	40	80	ns
$Q_g$	Total Gate Charge	$V_{DS} = 480\ \text{V}, I_D = 4.0\ \text{A}, V_{GS} = 10\ \text{V}$  (Note 4,5)	--	15	20	nC
$Q_{gs}$	Gate-Source Charge		--	3.5	--	nC
$Q_{gd}$	Gate-Drain Charge		--	6.0	--	nC
<b>Source-Drain Diode Maximum Ratings and Characteristics</b>						
$I_S$	Continuous Source-Drain Diode Forward Current		--	--	4.0	A
$I_{SM}$	Pulsed Source-Drain Diode Forward Current		--	--	16	
$V_{SD}$	Source-Drain Diode Forward Voltage	$I_S = 4.0\ \text{A}, V_{GS} = 0\ \text{V}$	--	--	1.4	V
$t_{rr}$	Reverse Recovery Time	$I_S = 4.0\ \text{A}, V_{GS} = 0\ \text{V}$	--	300	--	ns
$Q_{rr}$	Reverse Recovery Charge	$di_F/dt = 100\ \text{A}/\mu\text{s}$ (Note 4)	--	2.2	--	$\mu\text{C}$

**Notes ;**

1. Repetitive Rating : Pulse width limited by maximum junction temperature
2.  $L=27.5\text{mH}, I_{AS}=4.0\text{A}, V_{DD}=50\text{V}, R_G=25\Omega$ , Starting  $T_J=25\text{ }^\circ\text{C}$
3.  $I_{SD} \leq 4.0\text{A}, di/dt \leq 300\text{A}/\mu\text{s}, V_{DD} \leq BV_{DSS}$ , Starting  $T_J=25\text{ }^\circ\text{C}$
4. Pulse Test : Pulse Width  $\leq 300\mu\text{s}$ , Duty Cycle  $\leq 2\%$
5. Essentially Independent of Operating Temperature

Typical Characteristics

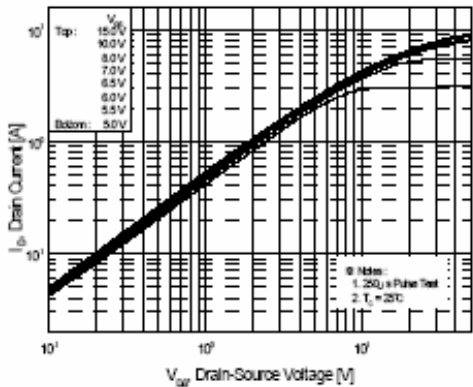


Figure 1. On Region Characteristics

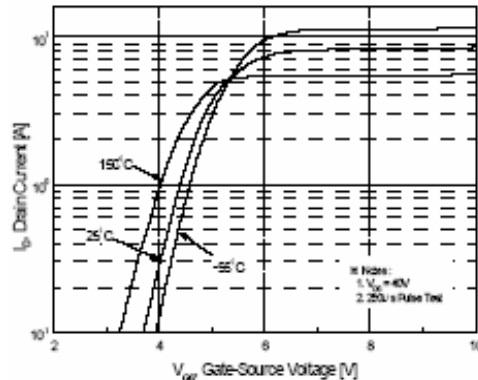


Figure 2. Transfer Characteristics

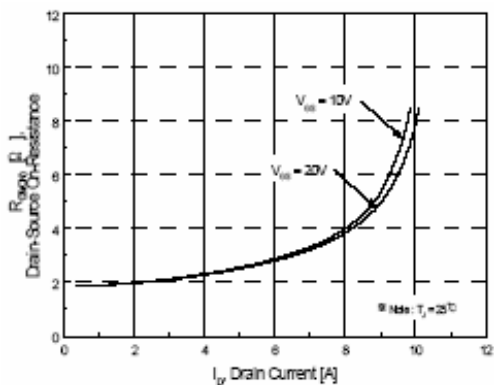


Figure 3. On Resistance Variation vs. Drain Current and Gate Voltage

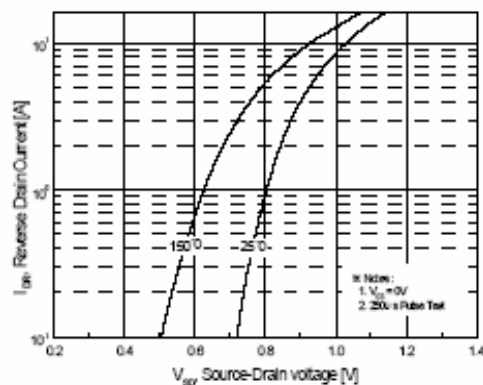


Figure 4. Body Diode Forward Voltage Variation with Source Current and Temperature

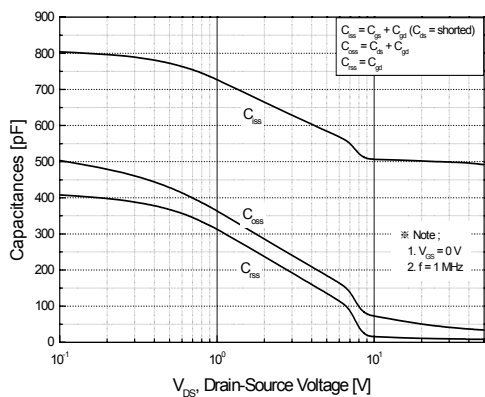


Figure 5. Capacitance Characteristics

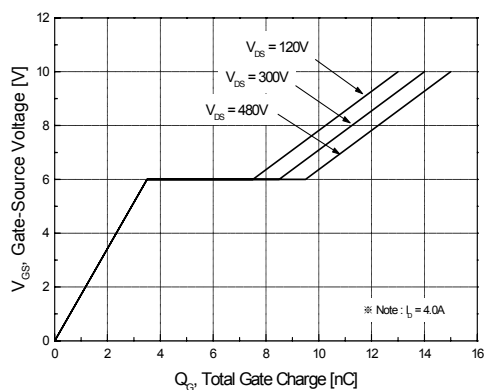


Figure 6. Gate Charge Characteristics

Typical Characteristics (continued)

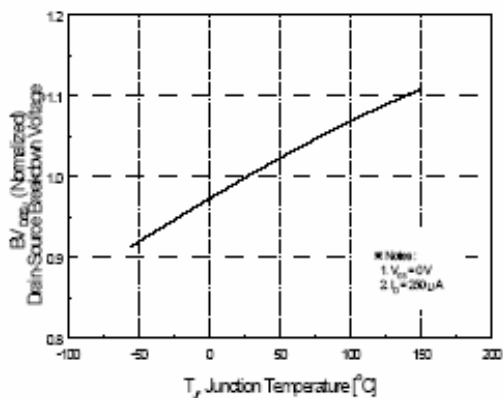


Figure 7. Breakdown Voltage Variation vs Temperature

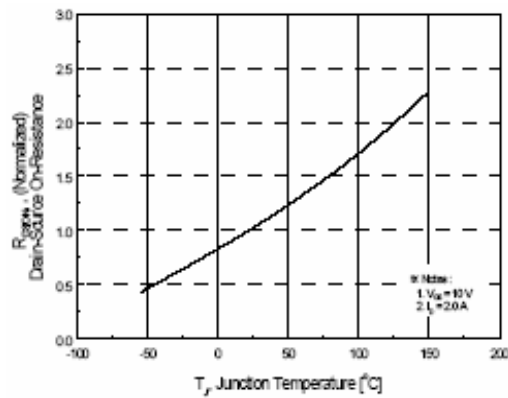


Figure 8. On-Resistance Variation vs Temperature

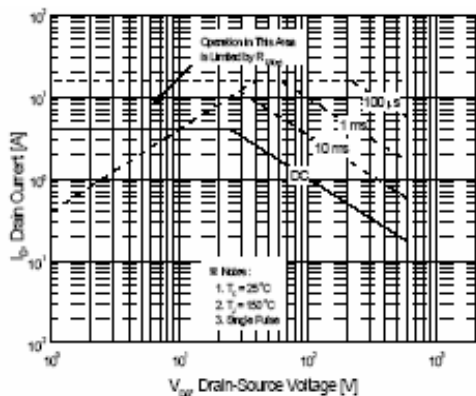


Figure 9. Maximum Safe Operating Area

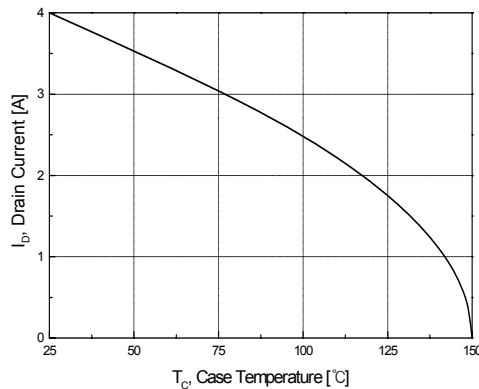


Figure 10. Maximum Drain Current vs Case Temperature

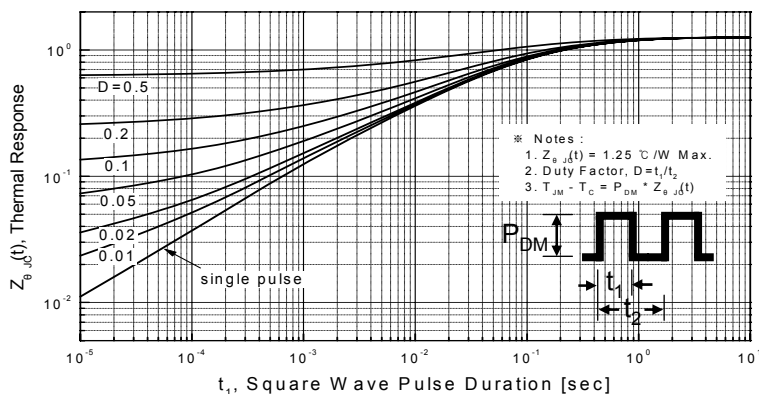


Figure 11. Transient Thermal Response Curve

Fig 12. Gate Charge Test Circuit & Waveform

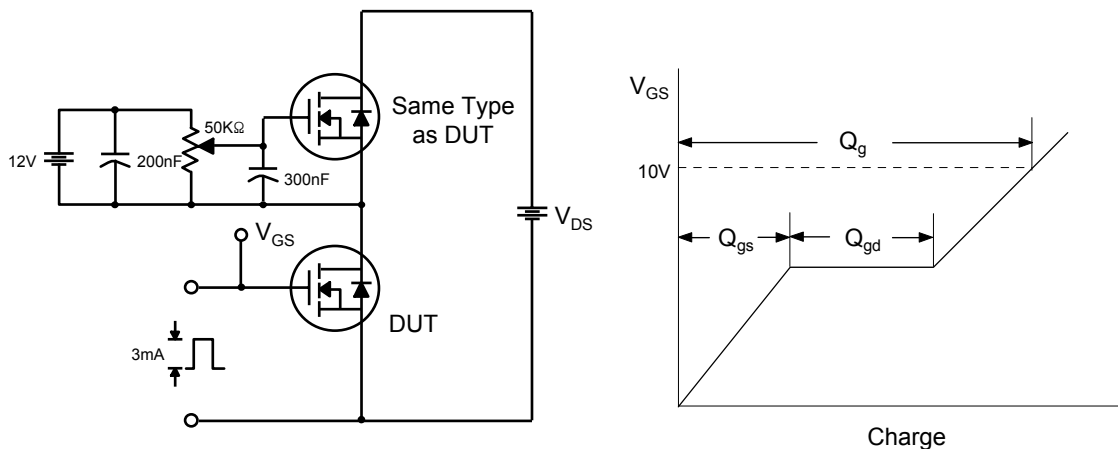


Fig 13. Resistive Switching Test Circuit & Waveforms

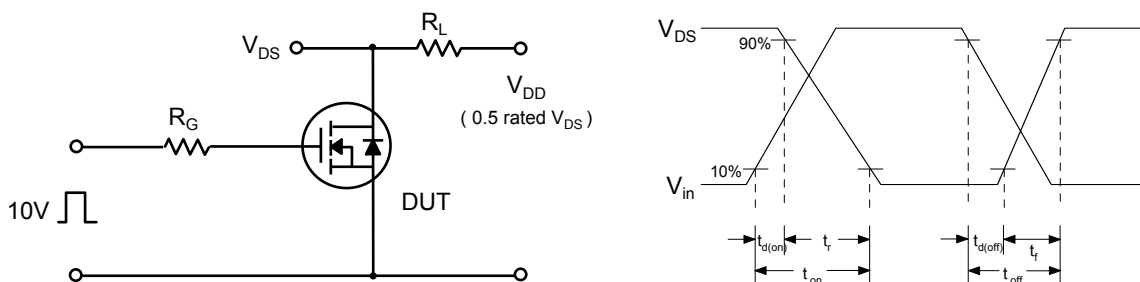


Fig 14. Unclamped Inductive Switching Test Circuit & Waveforms

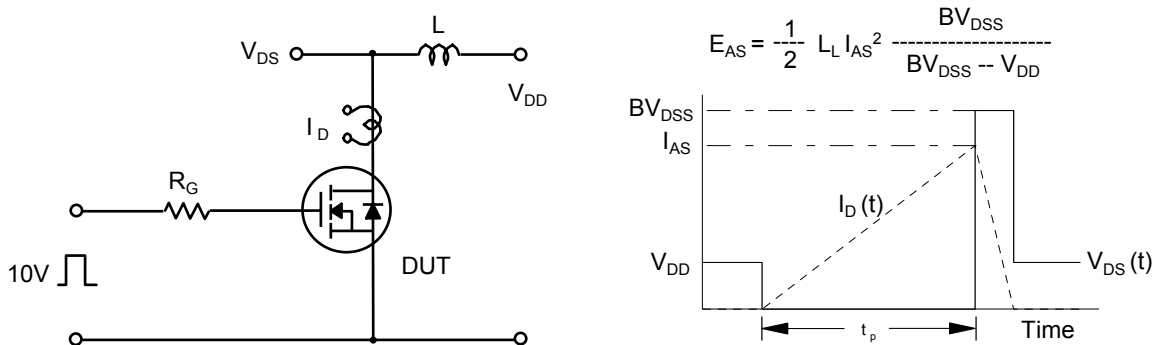
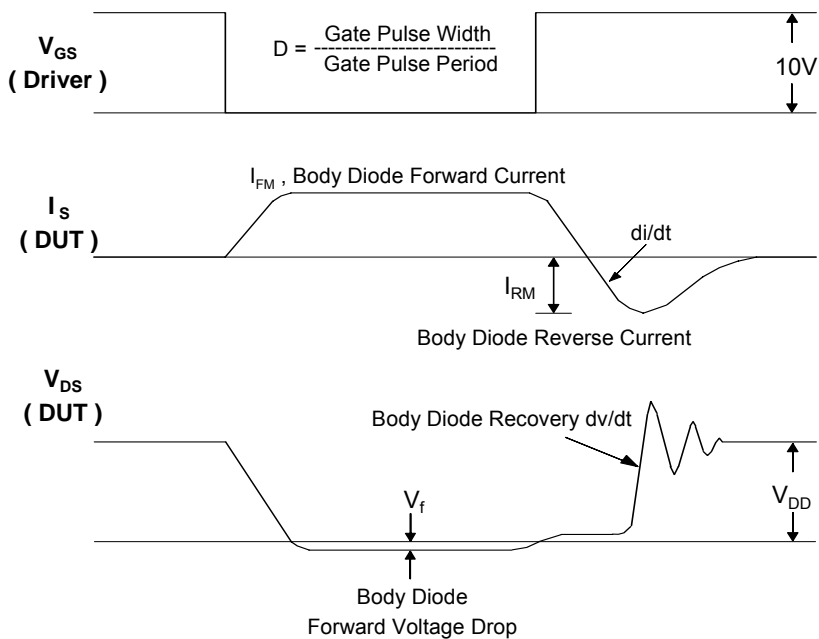
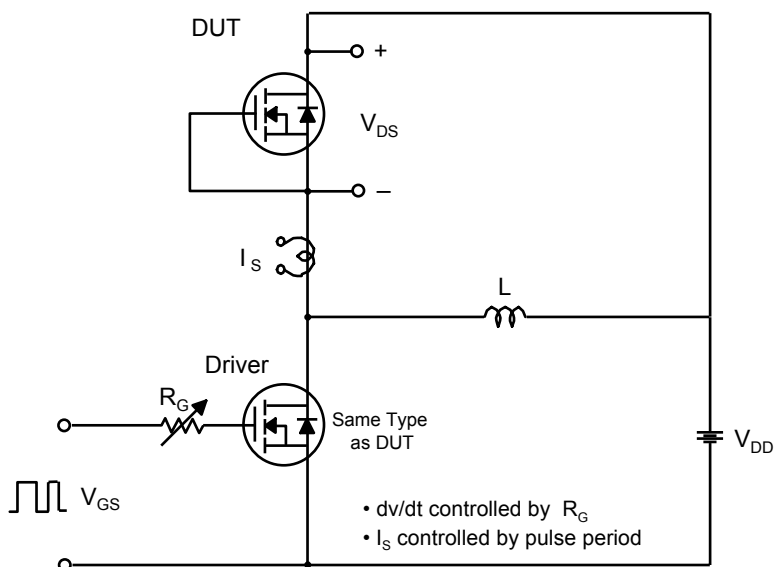
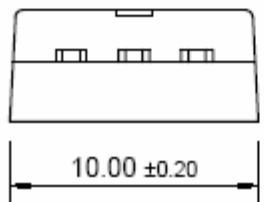
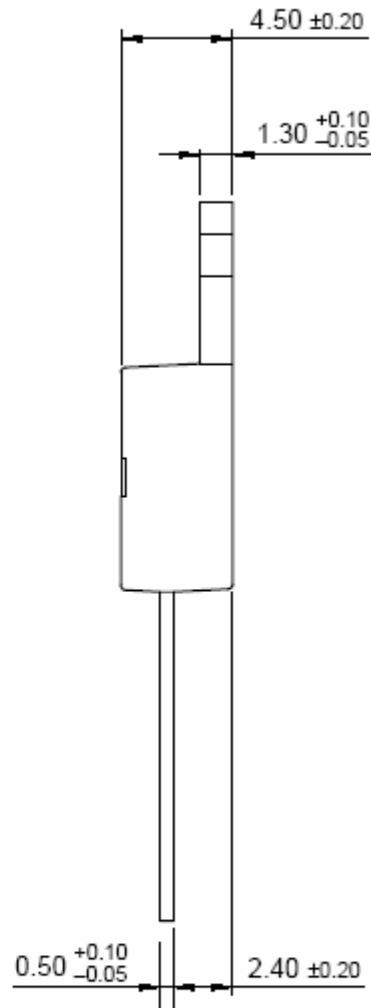
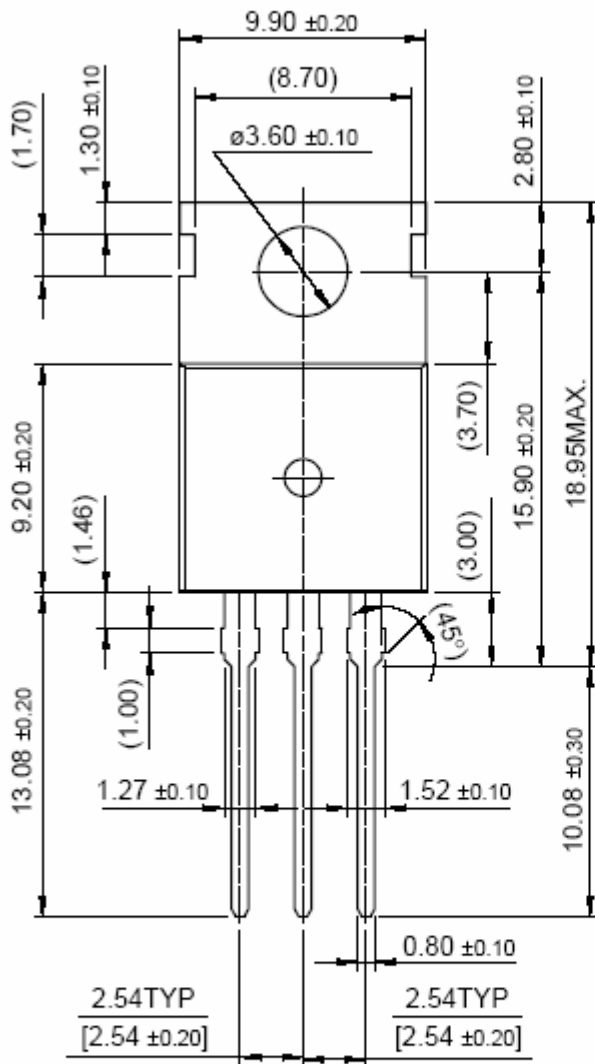


Fig 15. Peak Diode Recovery dv/dt Test Circuit & Waveforms



Package Dimension

TO-220



## Reliability Qualification

### A. High Temperature Reverse Bias ( HTRB )

The purpose of this test is to determine the sensitivity of the product to mobile ion contamination and related failure mechanisms.

Conditions: JESD22-A108, JIS C 7021 B-8

$T_A=150^{\circ}\text{C}$   $V_{DS}=80\%$  max rated  $V_{DS}$

Sample Size	#of Fail	Cum. Fail%	168hrs	300hrs
45	0	0.0%	0	0

### B. High Temperature Gate Bias ( HTGB )

The purpose of this test is to determine the sensitivity of the product to mobile ion contamination between gate and source and related failure mechanisms.

$T_A=150^{\circ}\text{C}$   $V_{DS}=V_{GSS}$  max

Sample Size	#of Fail	Cum. Fail%	168hrs	300hrs
45	0	0.0%	0	0

### C. Pressure Cooker Test ( PCT )

#### Autoclave ( ACLV )

The purpose of this test is to evaluate the moisture resistance of non-hermetic components under pressure/temperature conditions.

Conditions: JESD22-A102, JIS C 7021 A-6

$T_A=121^{\circ}\text{C}$  RH=100% P=1 atmosphere (15psig)

Sample Size	#of Fail	Cum. Fail%	48hrs
45	0	0.0%	0



**Reliability Qualification (Continued)****D. Temperature Humidity Bias ( THBT )**

The purpose of this test is to evaluate the moisture resistance of non-hermetic components.

The addition of voltage bias accelerates the corrosive effect after moisture penetration has taken place. with time, this is a catastrophically destructive test.

Conditions: JESD22-A101

$T_A=85^{\circ}\text{C}$  RH=85%  $V_{DS}=80\%$  max rated  $V_{DS}$

Sample Size	#of Fail	Cum. Fail%	168hrs	300hrs
45	0	0.0%	0	0

**E. High Temperature Storage Life ( HTSL )**

The purpose of this test is to expose time/temperature failure mechanisms and to evaluate long-term strong stability.

Conditions: JESD22-A103, JIS C 7021 B-10

$T_A=T_{stg}(\text{max})$

Sample Size	#of Fail	Cum. Fail%	168hrs	300hrs
45	0	0.0%	0	0

**F. Temperature Cycle Air-to Air ( TMCL )**

The purpose of this test is to evaluate the ability of the device to withstand both exposure to extreme temperature and the transition between temperature extreme, and to exposure excessive thermal mismatch between materials.

Conditions: JESD22-A104, JIS C 7021 A-4

Air to air,  $-65^{\circ}\text{C}\sim 150^{\circ}\text{C}$ , 15 minutes dwell time at each temperature

Sample Size	#of Fail	Cum. Fail%	100cycles	200cycles
45	0	0.0%	0	0