WING ON GROUP

POWER ™

PFP2N60 / PFF2N60
600V N-Channel MOSFET

FEATURES

❑ Originative New Design
❑ 100% EAS Test
❑ Rugged Gate Oxide Technology
❑ Extremely Low Intrinsic Capacitances
❑ Remarkable Switching Characteristics
❑ Unequalled Gate Charge : 9.5 nC (Typ.)
❑ Extended Safe Operating Area
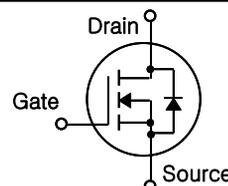❑ Lower $R_{DS(ON)}$: 4.0 Ω (Typ.) @V_{GS}=10V

APPLICATION

❑ High current, High speed switching
❑ Suitable for power supplies, adaptors and PFC
❑ SMPS (Switched Mode Power Supplies)

BV_{DSS} = 600 V

$R_{DS(on)}$ = 5.0 Ω

I_D = 2.0 A

Drain

Gate

Source

TO-220

1. Gate 2. Drain 3. Source

TO-220F

1. Gate 2. Drain 3. Source

Absolute Maximum Ratings T_C=25℃ unless otherwise specified

Symbol	Parameter		PFP2N60	PFF2N60	Units
V_{DSS}	Drain-Source Voltage		600		V
I_D	Drain Current – Continuous (T_C = 25℃)		2.0	2.0*	A
	Drain Current – Continuous (T_C = 100℃)		1.3	1.3*	A
I_{DM}	Drain Current – Pulsed	(Note 1)	6	6*	A
V_{GS}	Gate-Source Voltage		±30		V
E_{AS}	Single Pulsed Avalanche Energy	(Note 2)	120		mJ
I_{AR}	Avalanche Current	(Note 1)	2.0		A
E_{AR}	Repetitive Avalanche Energy	(Note 1)	5.4		mJ
dv/dt	Peak Diode Recovery dv/dt	(Note 3)	5.5		V/ns
P_D	Power Dissipation (T_C = 25℃)		54	23	W
	– Derate above 25℃		0.43	0.18	W/℃
T_J, T_{STG}	Operating and Storage Temperature Range		-55 to +150		℃
T_L	Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds		300		℃

* Drain current limited by maximum junction temperature

Thermal Resistance Characteristics

Symbol	Parameter	PFP2N60	PFF2N60	Units
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case	2.32	5.5	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink	0.5	--	℃/W
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	62.5	62.5	

Electrical Characteristics T_C=25 °C unless otherwise specified

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
On Characteristics						
V_{GS}	Gate Threshold Voltage	$V_{DS} = V_{GS}$, $I_D = 250\ \mu A$	2.0	--	4.0	V
$R_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10$ V, $I_D = 1.0$ A	--	4.0	5.0	Ω
Off Characteristics						
BV_{DSS}	Drain-Source Breakdown Voltage	$V_{GS} = 0$ V, $I_D = 250\ \mu A$	600	--	--	V
$\Delta BV_{DSS}/\Delta T_J$	Breakdown Voltage Temperature Coefficient	$I_D = 250\ \mu A$, Referenced to 25℃	--	0.6	--	V/℃
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 600$ V, $V_{GS} = 0$ V	--	--	1	μA
		$V_{DS} = 480$ V, $T_C = 125$℃	--	--	10	μA
I_{GSSF}	Gate-Body Leakage Current, Forward	$V_{GS} = 30$ V, $V_{DS} = 0$ V	--	--	100	nA
I_{GSSR}	Gate-Body Leakage Current, Reverse	$V_{GS} = -30$ V, $V_{DS} = 0$ V	--	--	-100	nA
Dynamic Characteristics						
C_{iss}	Input Capacitance	$V_{DS} = 25$ V, $V_{GS} = 0$ V, f = 1.0 MHz	--	320	420	pF
C_{oss}	Output Capacitance		--	35	46	pF
C_{rss}	Reverse Transfer Capacitance		--	4.5	6.0	pF
Switching Characteristics						
$t_{d(on)}$	Turn-On Time	$V_{DS} = 300$ V, $I_D = 2.0$ A, $R_G = 25\ \Omega$	--	8	30	ns
t_r	Turn-On Rise Time		--	23	60	ns
$t_{d(off)}$	Turn-Off Delay Time		--	25	60	ns
t_f	Turn-Off Fall Time	(Note 4,5)	--	28	70	ns
Q_g	Total Gate Charge	$V_{DS} = 480$ V, $I_D = 2.0$ A, $V_{GS} = 10$ V	--	9.5	13	nC
Q_{gs}	Gate-Source Charge		--	1.6	--	nC
Q_{gd}	Gate-Drain Charge	(Note 4,5)	--	4.0	--	nC
Source-Drain Diode Maximum Ratings and Characteristics						
I_S	Continuous Source-Drain Diode Forward Current		--	--	2.0	A
I_{SM}	Pulsed Source-Drain Diode Forward Current		--	--	6	A
V_{SD}	Source-Drain Diode Forward Voltage	$I_S = 2.0$ A, $V_{GS} = 0$ V	--	--	1.5	V
trr	Reverse Recovery Time	$I_S = 2.0$ A, $V_{GS} = 0$ V	--	230	--	ns
Qrr	Reverse Recovery Charge	$di_F/dt = 100$ A/μs (Note 4)	--	1.0	--	μC

Notes ;
1. Repetitive Rating : Pulse width limited by maximum junction temperature
2. I_{AS}=2.0A, V_{DD}=50V, R_G=25Ω, Starting T_J =25°C
3. I_{SD}≤2.0A, di/dt≤300A/μs, V_{DD}≤BV_{DSS} , Starting T_J =25 °C
4. Pulse Test : Pulse Width ≤ 300μs, Duty Cycle ≤ 2%
5. Essentially Independent of Operating Temperature

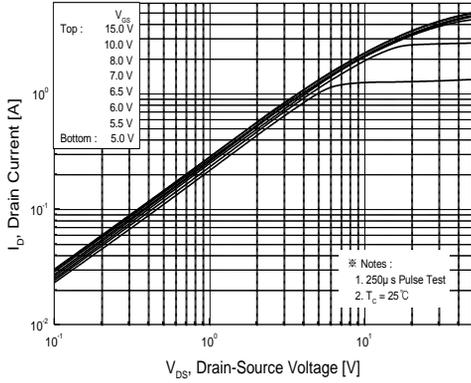# Typical Characteristics

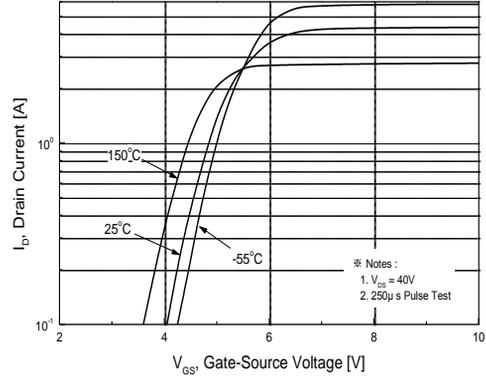**Figure 1. On Region Characteristics**
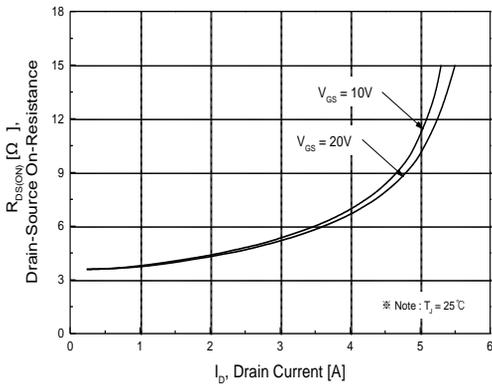

Figure 2. Transfer Characteristics

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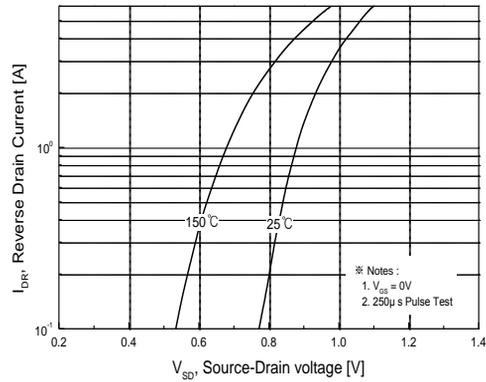

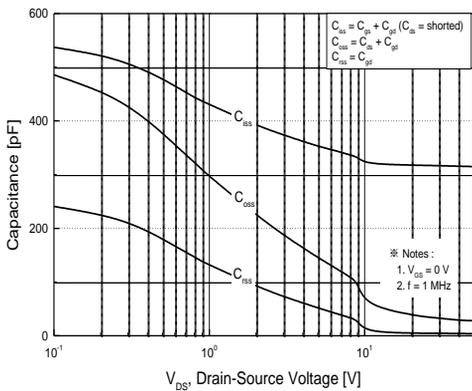**Figure 4. Body Diode Forward Voltage Variation with Source Current and Temperature**
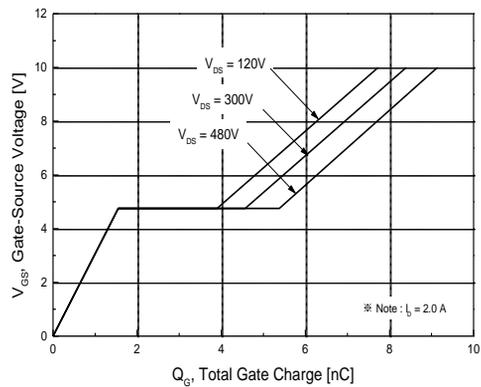

Figure 5. Capacitance Characteristics

Figure 6. Gate Charge Characteristics
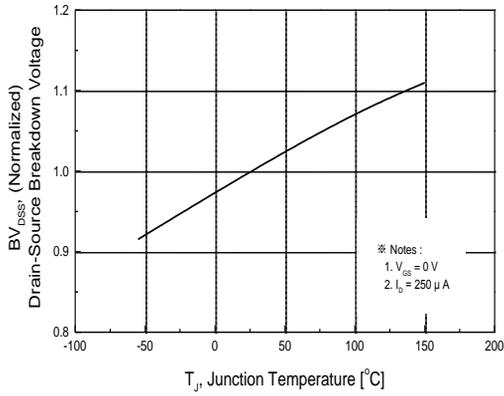
Typical Characteristics (continued)

**Figure 7. Breakdown Voltage Variation
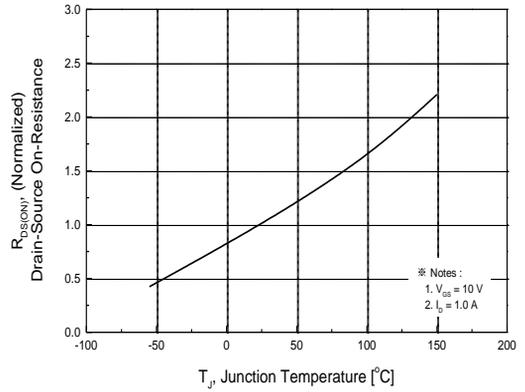vs Temperature**

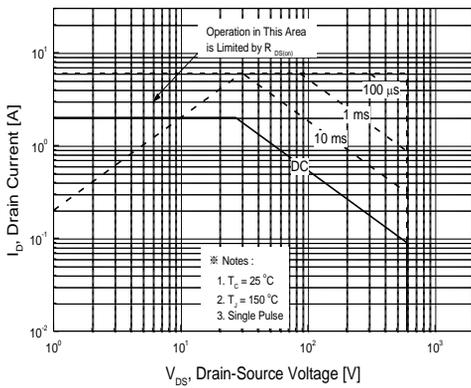**Figure 8. On-Resistance Variation
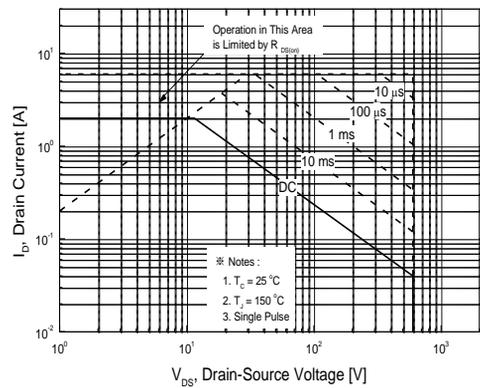vs Temperature**

**Figure 9. Maximum Safe Operating Area
for PFP2N60**

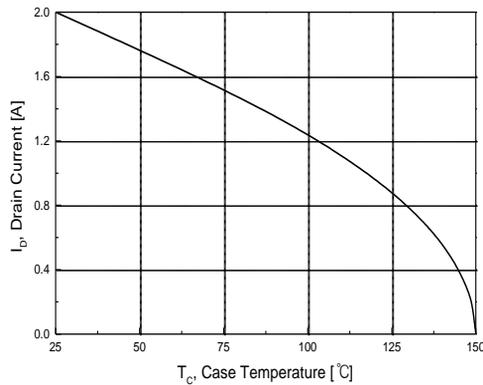**Figure 10. Maximum Safe Operating Area
for PFF2N60**

Figure 11. Maximum Drain Current vs Case Temperature

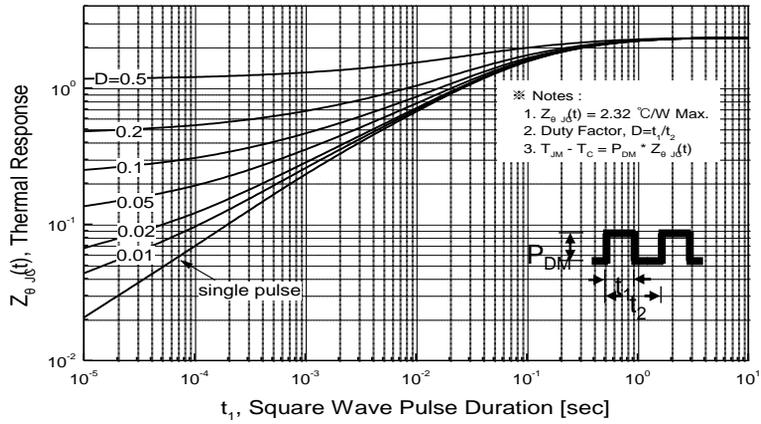## Typical Characteristics   (continued)

Figure 12. Transient Thermal Response Curve for PFP2N60
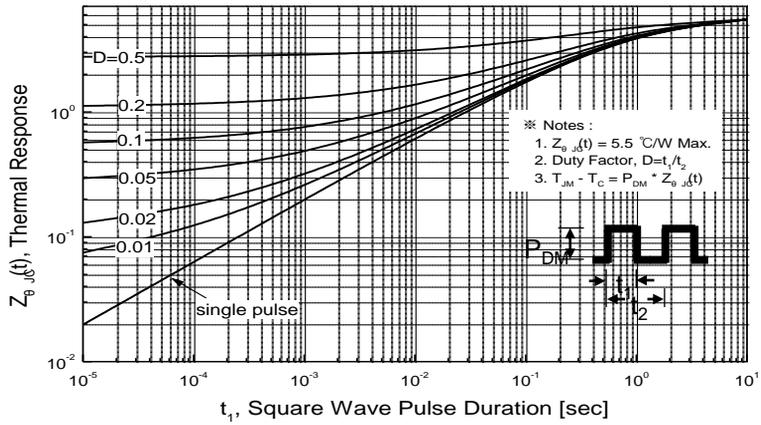

Figure 13. Transient Thermal Response Curve for PFF2N60

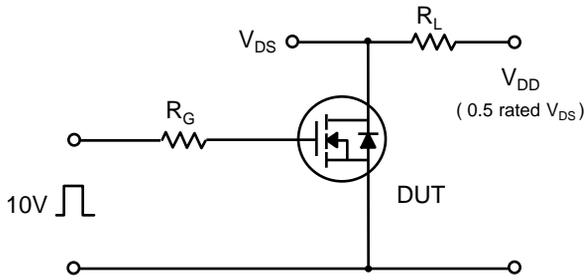# Characteristics Test Circuit & Waveform
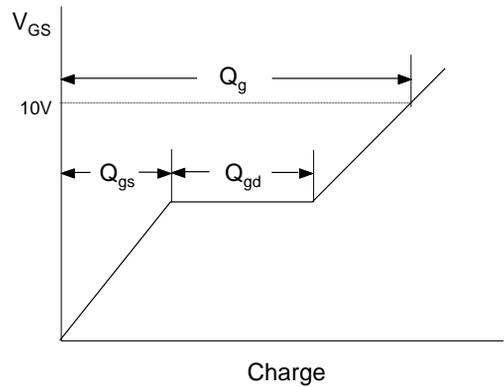

Fig 14. Resistive Switching Test Circuit & Waveforms
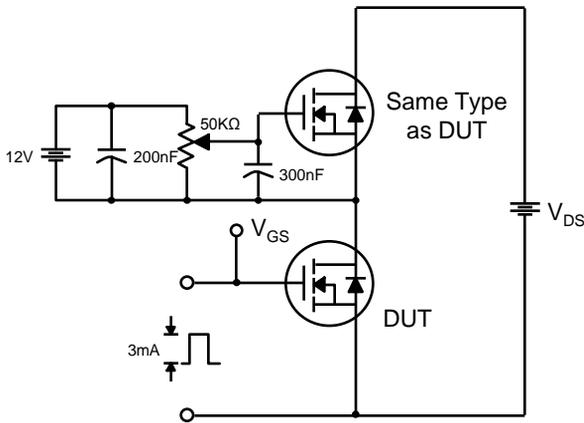
Fig 15. Gate Charge Test Circuit & Waveform

$$E_{AS} = \frac{1}{2} \, L_L \, I_{AS}^2 \, \frac{BV_{DSS}}{BV_{DSS} - V_{DD}}$$
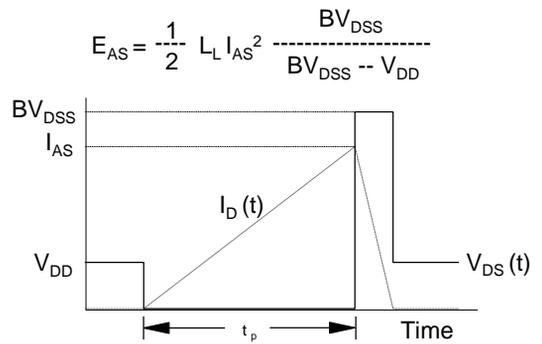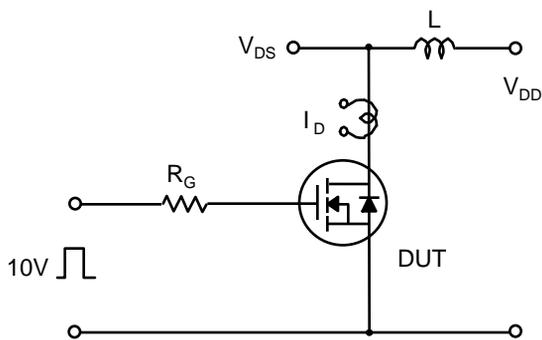
Fig 16. Unclamped Inductive Switching Test Circuit & Waveforms

Characteristics Test Circuit & Waveform (continued)

DUT

V_{DS}

I_S

L

Driver

R_G

Same Type as DUT

V_{GS}

V_{DD}

• dv/dt controlled by R_G
• I_S controlled by pulse period

V_{GS}
(Driver)

$$D = \frac{\text{Gate Pulse Width}}{\text{Gate Pulse Period}}$$

10V

I_S
(DUT)

I_{FM} , Body Diode Forward Current

di/dt

I_{RM}

Body Diode Reverse Current

V_{DS}
(DUT)

Body Diode Recovery dv/dt

V_f

V_{DD}

Body Diode
Forward Voltage Drop
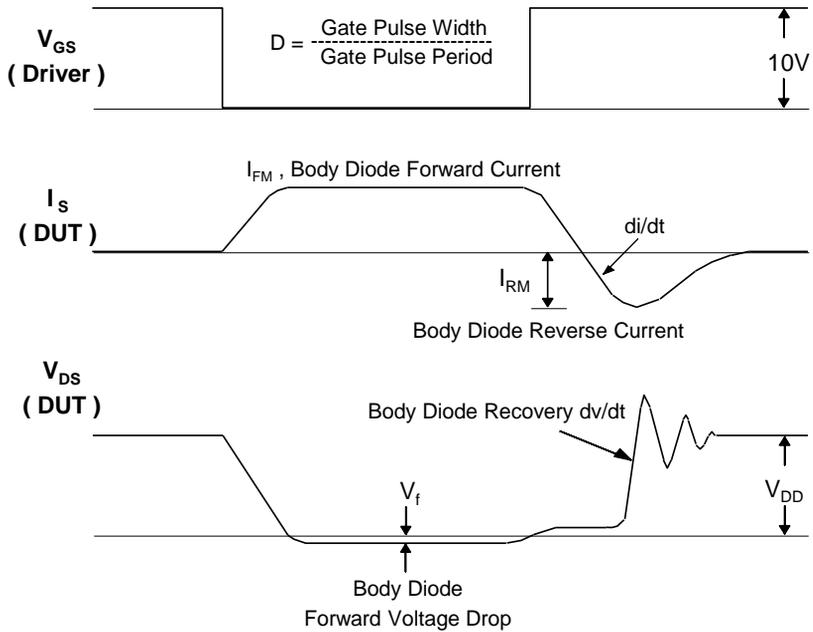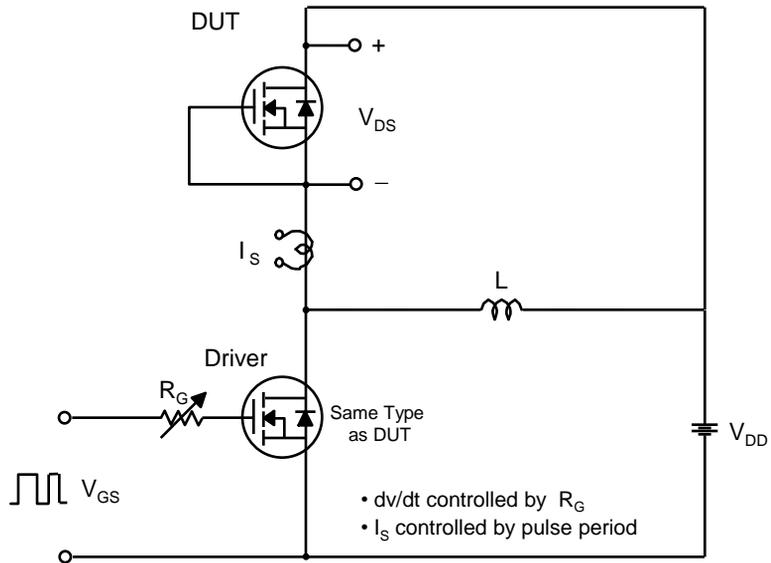
Fig 17. Peak Diode Recovery dv/dt Test Circuit & Waveforms

Package Dimension

TO-220

9.90 ±0.20

(8.70)

ø3.60 ±0.10

(1.70)

1.30 ±0.10

2.80 ±0.10

9.20 ±0.20

(1.46)

(3.70)

(3.00)

15.90 ±0.20

18.95MAX.

13.08 ±0.20

(1.00)

(45°)

10.08 ±0.30

1.27 ±0.10

1.52 ±0.10

0.80 ±0.10

2.54TYP
[2.54 ±0.20]

2.54TYP
[2.54 ±0.20]

4.50 ±0.20

1.30 $^{+0.10}_{-0.05}$

0.50 $^{+0.10}_{-0.05}$

2.40 ±0.20

10.00 ±0.20

Package Dimension

TO-220F

3.30 ±0.10

10.16 ±0.20

(7.00)

ø3.18 ±0.10

2.54 ±0.20

(0.70)

6.68 ±0.20

15.87 ±0.20

15.80 ±0.20

(1.00x45°)

MAX1.47

0.80 ±0.10

9.75 ±0.30

(30°)

0.35 ±0.10   #1

0.50 $^{+0.10}_{-0.05}$ 2.76 ±0.20

2.54TYP
[2.54 ±0.20]

2.54TYP
[2.54 ±0.20]

9.40 ±0.20

4.70 ±0.20
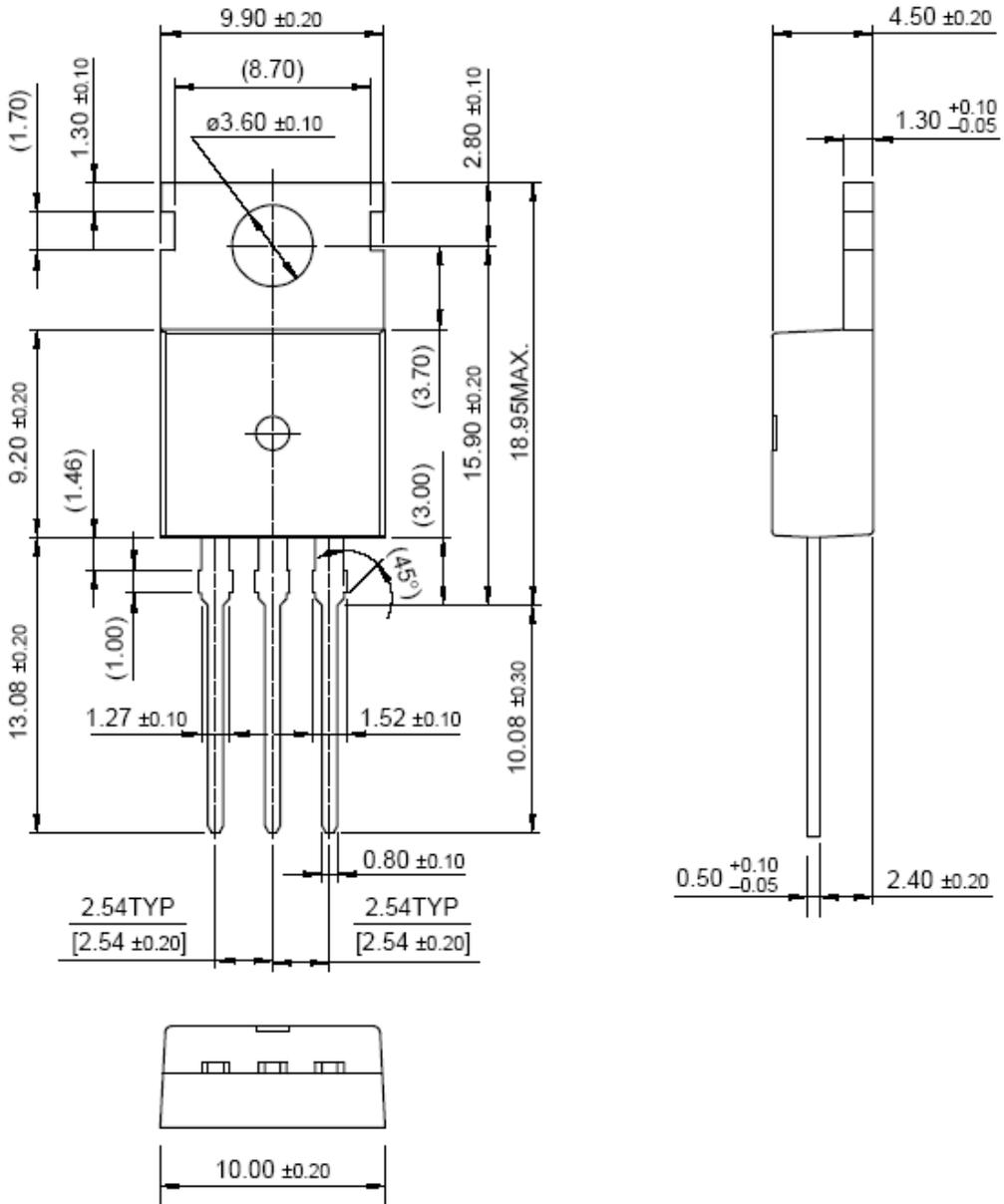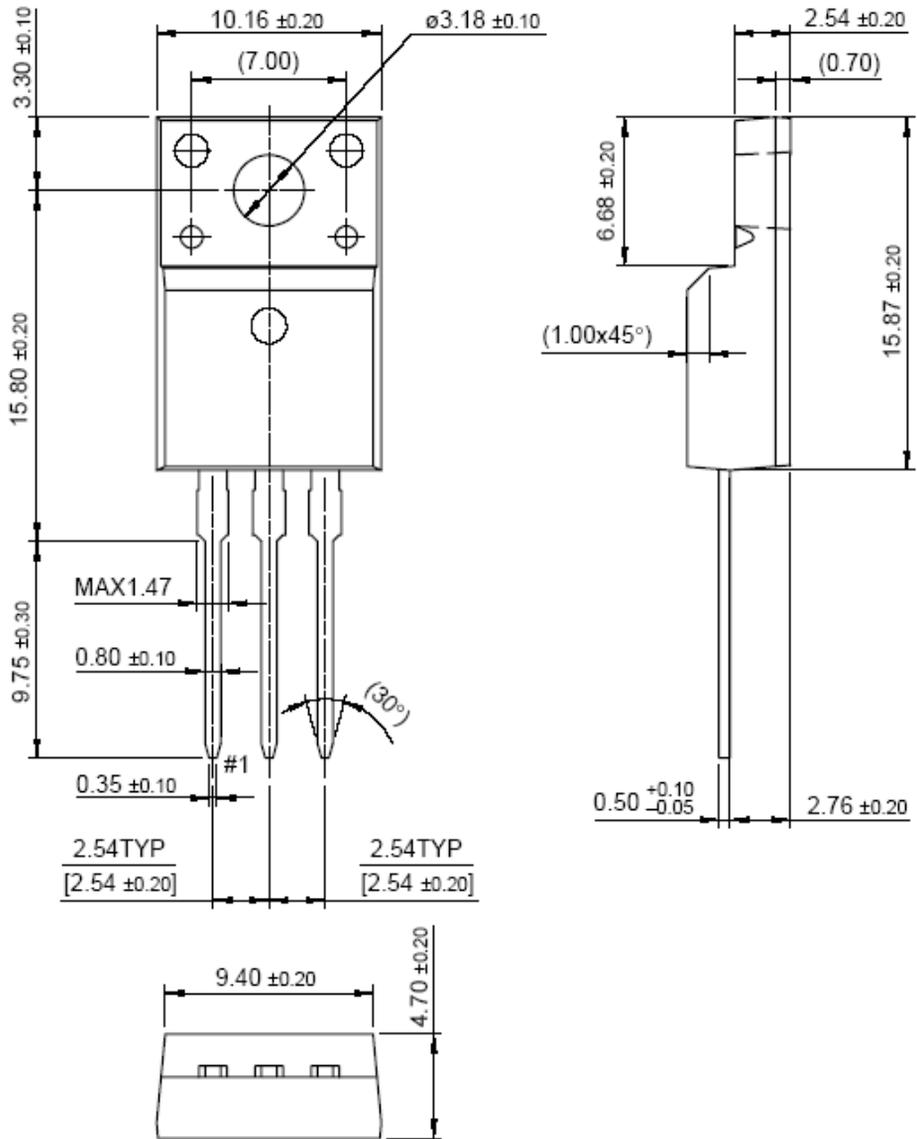
Reliability Qualification

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: MIL-STD-750C 1038,   JIS C 7021 B-3

T_A=150℃ 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.
Conditions: MIL-STD-750C 1038,   JIS C 7021 B-3

T_A=150℃ V_{DS}= V_{GSS} max

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

C. Temperature Humidity Bias (THB)

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, JIS C 7021 B-11

T_A=85℃   RH=85% V_{DS}=80% max rated V_{DS}

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

Reliability Qualification (Continued)

D. High Temperature Storage (HTS)

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

Conditions: MIL-STD-750C 1031.4, JIS C 7021 B-10

$T_A=T_{stg}$(max) 150 ℃

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

E. 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: MIL-STD-750C 1071.2, JIS C 7021 A-6

T_A=121℃±2℃ RH=100% P=1 atmosphere (15psig)

Sample Size	#of Fail	Cum. Fail%	48hrs
22	0	0.0%	0

F. Temperature Cycle Air-to Air (T/C)

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℃~150℃, 10 minutes dwell time at each temperature

Sample Size	#of Fail	Cum. Fail%	100cycles	200cycles
22	0	0.0%	0	0