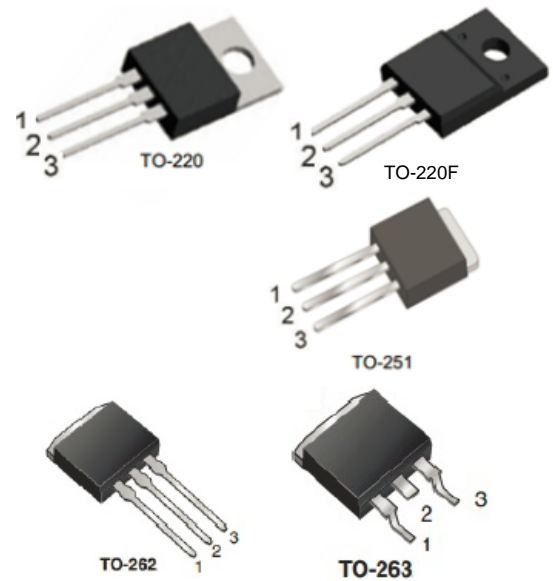
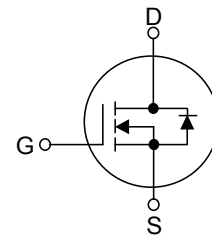


**650V N-Channel Power MOSFET**
**Features**

- $V_{DS}$ : 650V,  $I_D$ : 4A,  $R_{DS(ON)} < 2.6\Omega$  @  $V_{GS} = 10V$
- Fast switching capability
- Lead free in compliance with EU RoHS directive.
- Green molding compound


**Ordering Information**

Part No.	Package	Packing
HKTR4N65-TU	TO-251	75pcs / Tube
HKTF4N65-TU	TO-220	50pcs / Tube
HKTF4N65F-TU	TO-220F	50pcs / Tube
HKTY4N65-TU	TO-262	50pcs / Tube
HKTE4N65-TU	TO-263	50pcs / Tube
HKTE4N65-TR	TO-263	800pcs / 13" Reel

**Block Diagram**

**ABSOLUTE MAXIMUM RATINGS** ( $T_C = 25^\circ\text{C}$ , unless otherwise specified)

PARAMETER		SYMBOL	RATINGS	UNIT
Drain-Source Voltage		$V_{DSS}$	650	V
Gate-Source Voltage		$V_{GSS}$	$\pm 30$	V
Continuous Drain Current		$I_D$	4.0	A
Pulsed Drain Current (Note 2)		$I_{DM}$	16	A
Avalanche Energy	Single Pulsed (Note 3)	$E_{AS}$	260	mJ
Power Dissipation	TO-220/TO-262/TO-263	$P_D$	106	W
	TO-220F		35	W
	TO-251		50	W
Junction Temperature		$T_J$	+150	$^\circ\text{C}$
Operating Temperature		$T_{OPR}$	-55 ~ +150	$^\circ\text{C}$
Storage Temperature		$T_{STG}$	-55 ~ +150	$^\circ\text{C}$

Notes: 1. Absolute maximum ratings are those values beyond which the device could be permanently damaged.

Absolute maximum ratings are stress ratings only and functional device operation is not implied.

2. Repetitive Rating : Pulse width limited by maximum junction temperature

3.  $L = 30\text{mH}$ ,  $I_{AS} = 3.6\text{A}$ ,  $V_{DD} = 50\text{V}$ ,  $R_G = 25\ \Omega$ , Starting  $T_J = 25^\circ\text{C}$

**650V N-Channel Power MOSFET**

PARAMETER		SYMBOL	RATING	UNIT
Junction to Ambient	TO-220/TO-220F TO-262/TO-263	$\theta_{JA}$	62.5	°C/W
	TO-251		110	
Junction to Case	TO-220/TO-220F TO-262/TO-263	$\theta_{JC}$	2.35	°C/W
	TO-220F		5.5	
	TO-251		2.9	

**ELECTRICAL CHARACTERISTICS** ( $T_C=25^\circ\text{C}$ , unless otherwise specified)

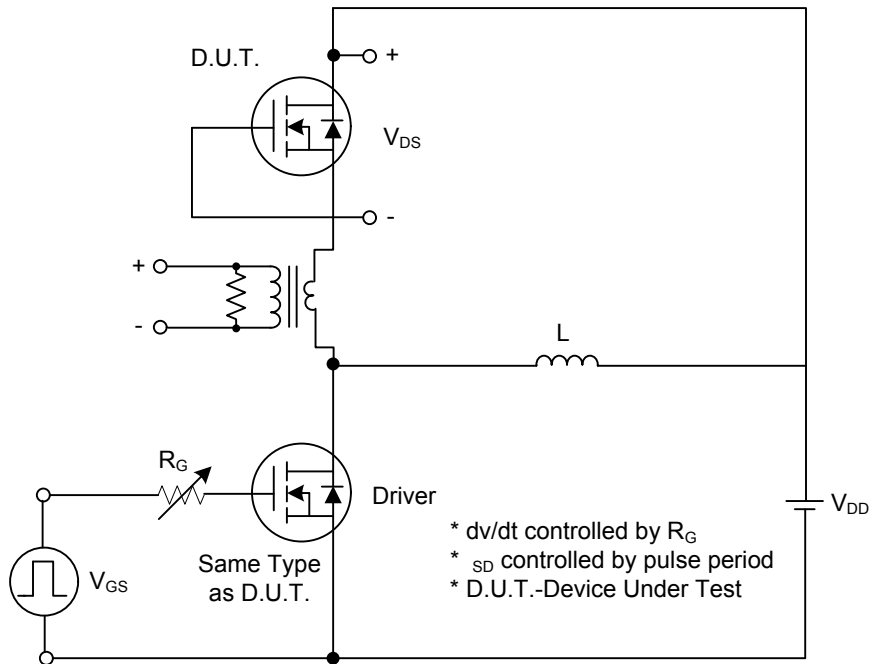
PARAMETER		SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>OFF CHARACTERISTICS</b>							
Drain-Source Breakdown Voltage		$BV_{DSS}$	$V_{GS} = 0V, I_D = 250\mu A$	650			V
Drain-Source Leakage Current		$I_{DSS}$	$V_{DS} = 650V, V_{GS} = 0V$			1	$\mu A$
Gate-Source Leakage Current	Forward	$I_{GSS}$	$V_{GS} = 30V, V_{DS} = 0V$			100	nA
	Reverse		$V_{GS} = -30V, V_{DS} = 0V$			-100	nA
<b>ON CHARACTERISTICS</b>							
Gate Threshold Voltage		$V_{GS(TH)}$	$V_{DS} = V_{GS}, I_D = 250\mu A$	2.0		4.0	V
Static Drain-Source On-State Resistance		$R_{DS(ON)}$	$V_{GS} = 10V, I_D = 2A$		2.2	2.6	$\Omega$
<b>DYNAMIC CHARACTERISTICS</b>							
Input Capacitance		$C_{ISS}$	$V_{DS} = 25V, V_{GS} = 0V,$ $f = 1MHz$		670		pF
Output Capacitance		$C_{OSS}$			70		pF
Reverse Transfer Capacitance		$C_{RSS}$			23		pF
<b>SWITCHING CHARACTERISTICS</b>							
Turn-On Delay Time		$t_{D(ON)}$	$V_{DD} = 325V, I_D = 4.0A,$ $R_G = 25\Omega$ (Note 1, 2)		45		ns
Turn-On Rise Time		$t_R$			100		ns
Turn-Off Delay Time		$t_{D(OFF)}$			200		ns
Turn-Off Fall Time		$t_F$			130		ns
Total Gate Charge		$Q_G$	$V_{DS} = 520V, I_D = 4.0A,$ $V_{GS} = 10V$ (Note 1, 2)		100		nC
Gate-Source Charge		$Q_{GS}$			17		nC
Gate-Drain Charge		$Q_{GD}$			20		nC
<b>SOURCE- DRAIN DIODE RATINGS AND CHARACTERISTICS</b>							
Drain-Source Diode Forward Voltage		$V_{SD}$	$V_{GS} = 0V, I_S = 4A$			1.4	V
Maximum Continuous Drain-Source Diode Forward Current		$I_S$				4	A
Maximum Pulsed Drain-Source Diode Forward Current		$I_{SM}$				16	A
Reverse Recovery Time		$t_{rr}$	$V_{GS} = 0V, I_S = 4A,$		260		ns
Reverse Recovery Charge		$Q_{RR}$	$dI_F/dt = 100 A/\mu s$ (Note 1)		2.5		$\mu C$

 Notes: 1. Pulse Test: Pulse width  $\leq 300\mu s$ , Duty cycle  $\leq 2\%$ 

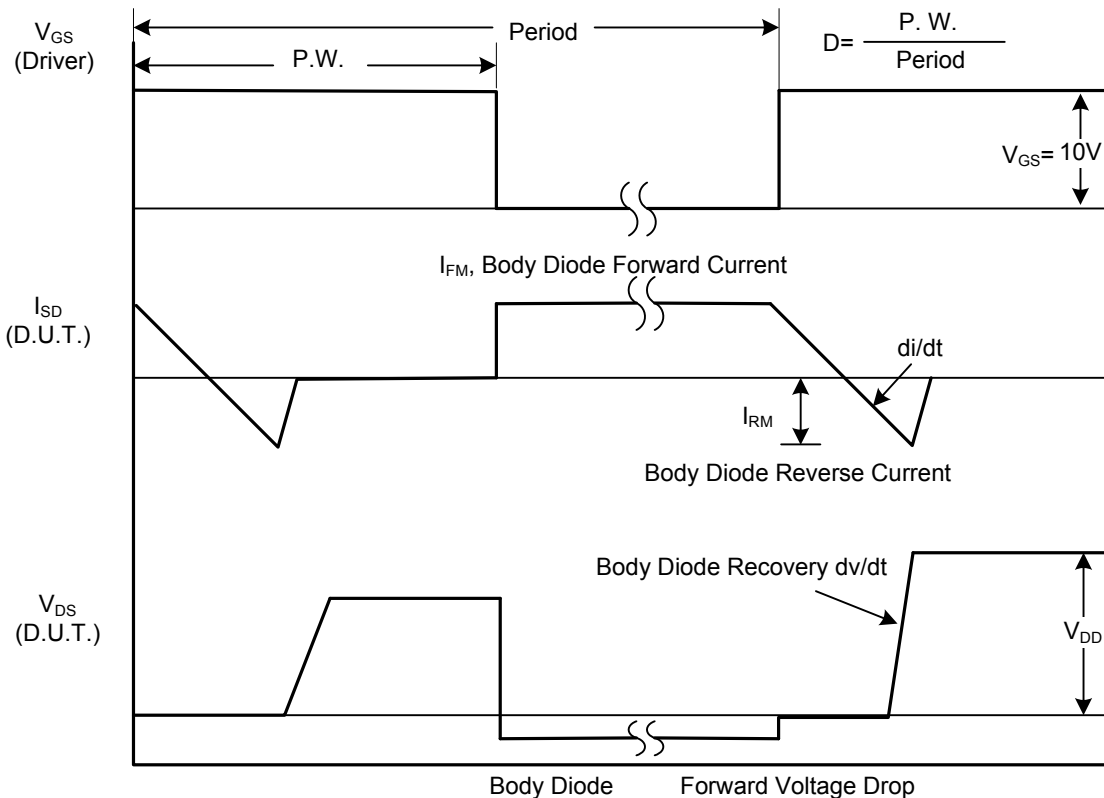
2. Essentially independent of operating temperature

**650V N-Channel Power MOSFET**

**TEST CIRCUITS AND WAVEFORMS**



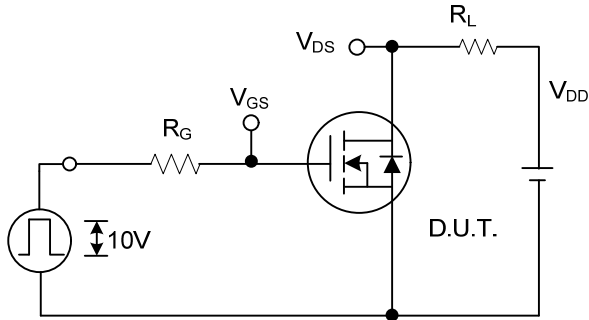
**Peak Diode Recovery dv/dt Test Circuit**



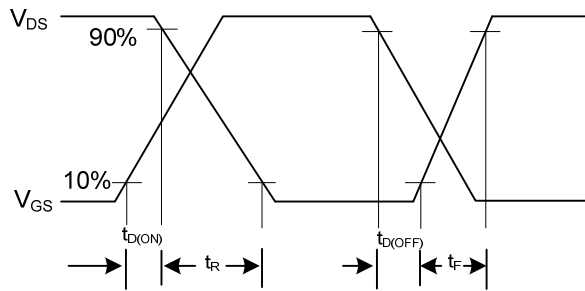
**Peak Diode Recovery dv/dt Waveforms**

**650V N-Channel Power MOSFET**

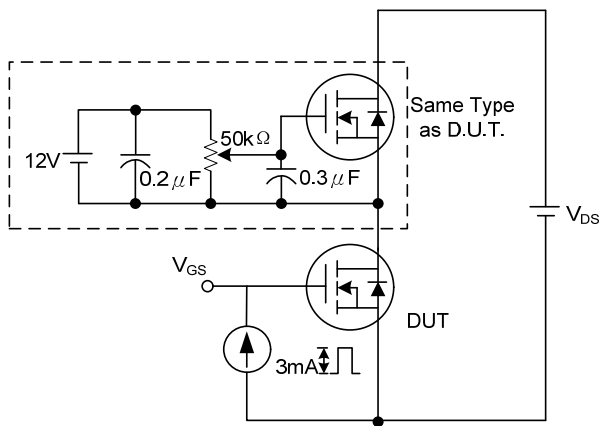
**TEST CIRCUITS AND WAVEFORMS(Cont.)**



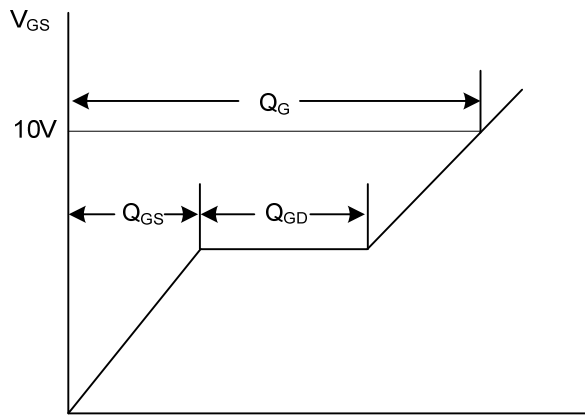
**Switching Test Circuit**



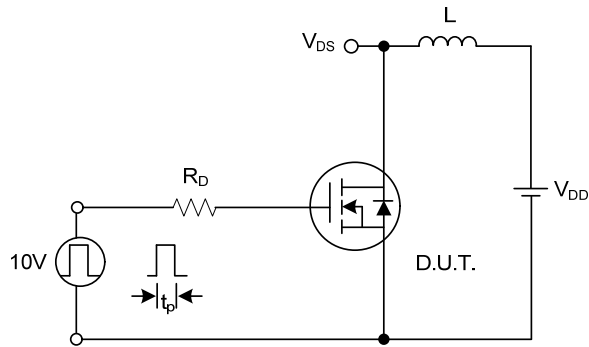
**Switching Waveforms**



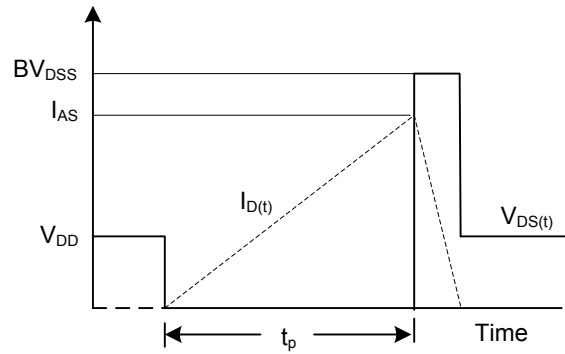
**Gate Charge Test Circuit**



**Gate Charge Waveform**



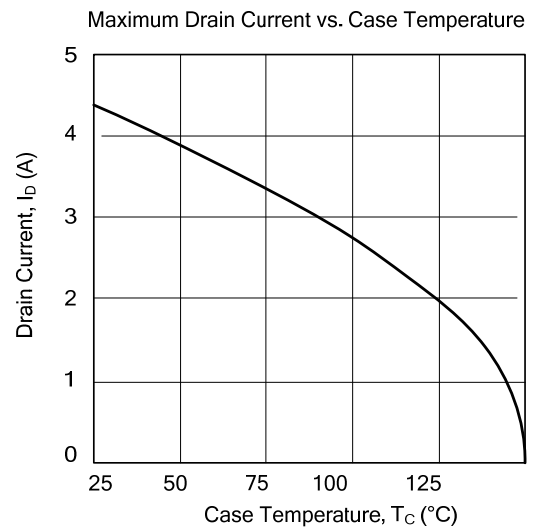
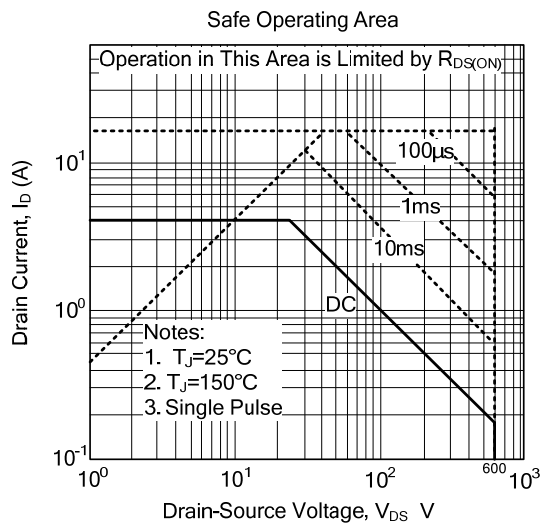
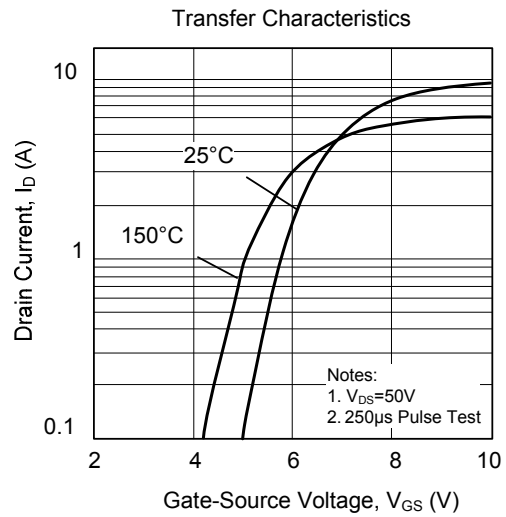
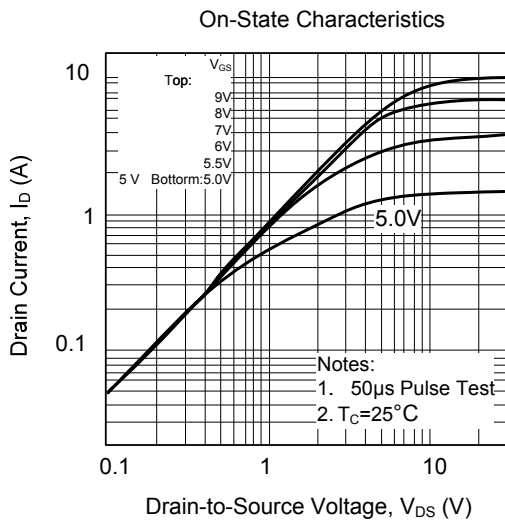
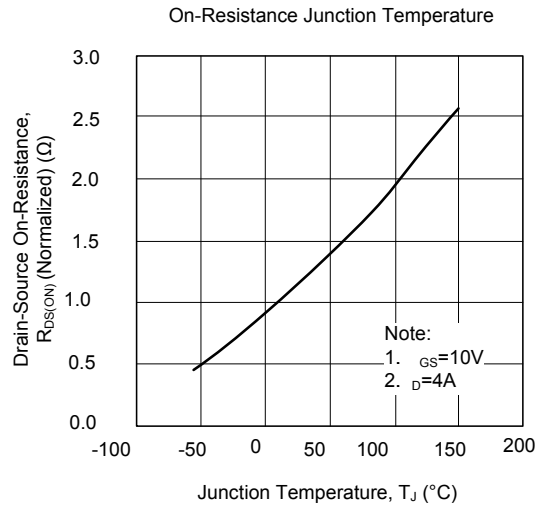
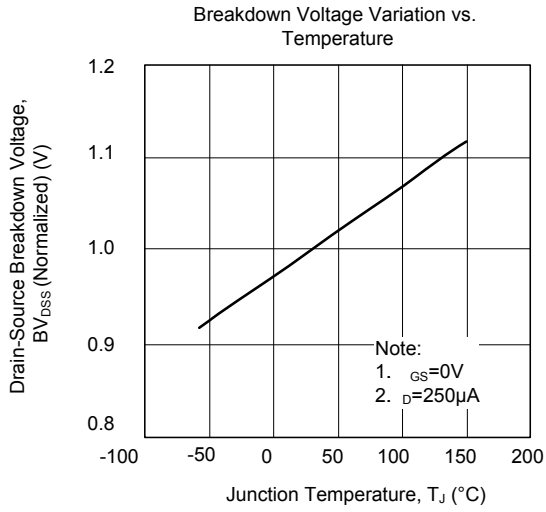
**Unclamped Inductive Switching Test Circuit**



**Unclamped Inductive Switching Waveforms**

**650V N-Channel Power MOSFET**

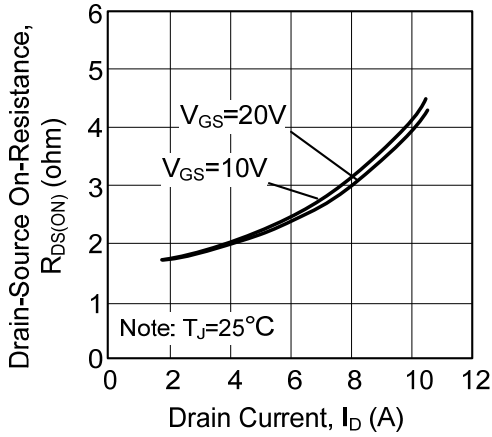
**TYPICAL CHARACTERISTICS**



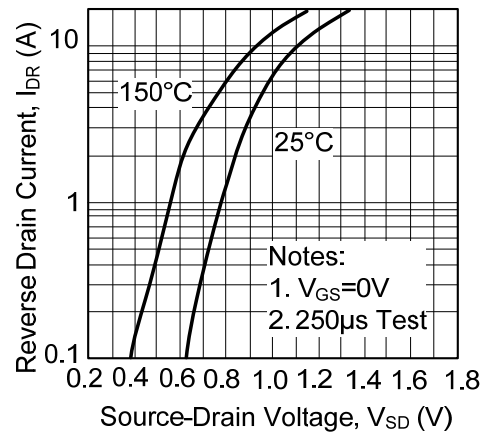
**650V N-Channel Power MOSFET**

**TYPICAL CHARACTERISTICS(Cont.)**

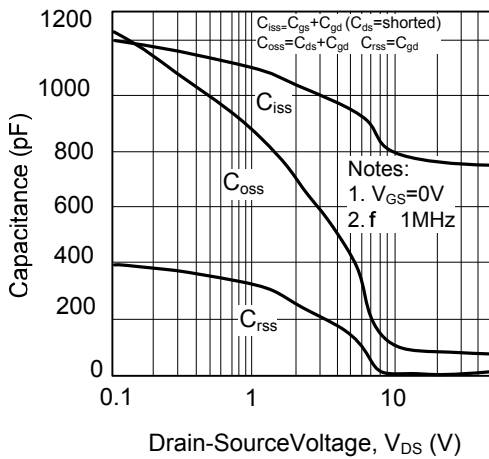
On-Resistance Variation vs. Drain Current and Gate Voltage



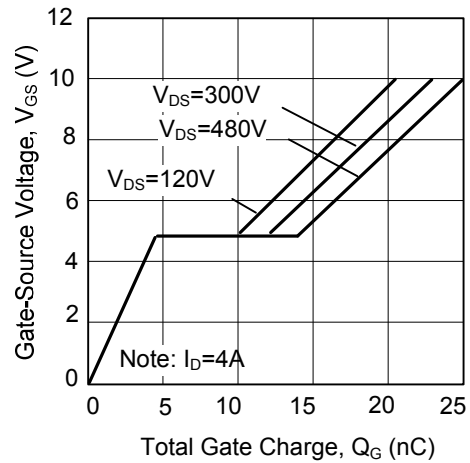
On State Current vs. Allowable Case Temperature



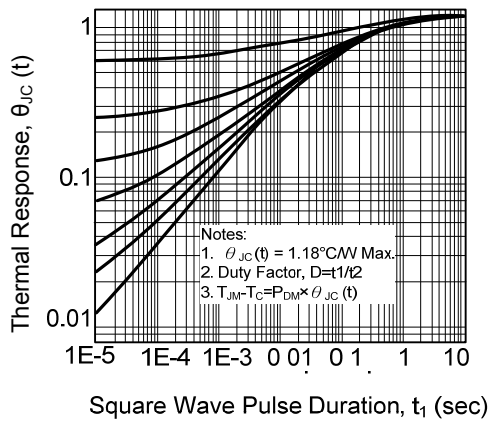
Capacitance Characteristics (Non-Repetitive)



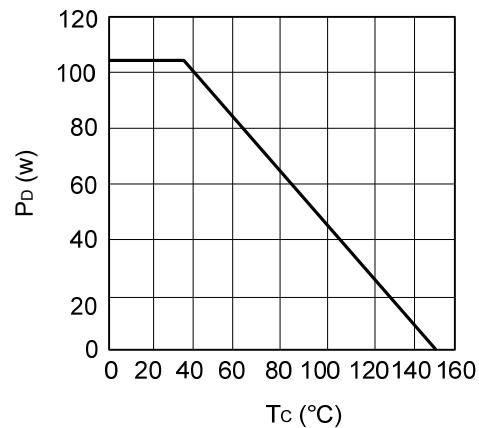
Gate Charge Characteristics



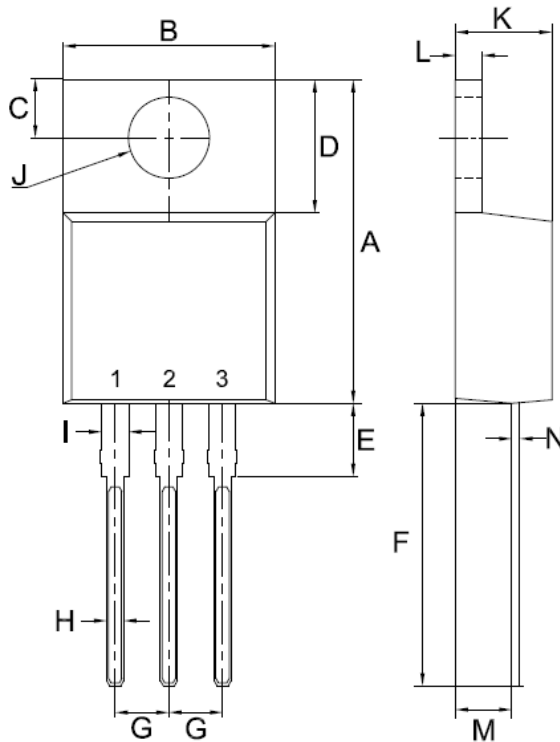
Transient Thermal Response Curve



Power Dissipation

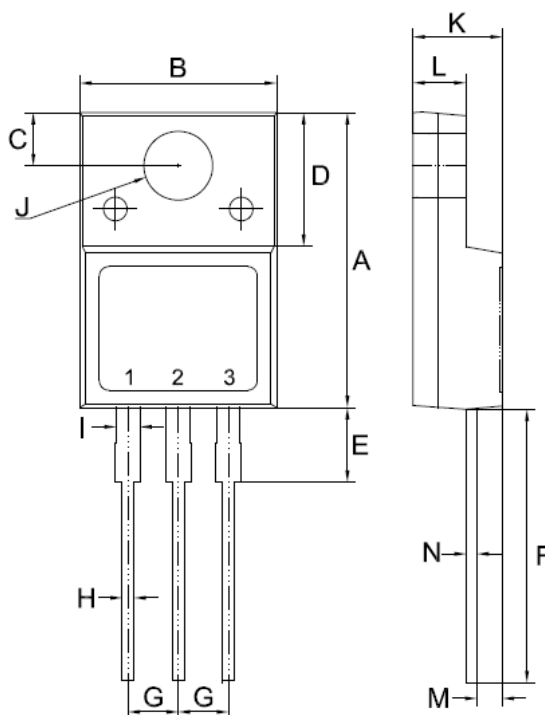


**TO-220 Mechanical Drawing**



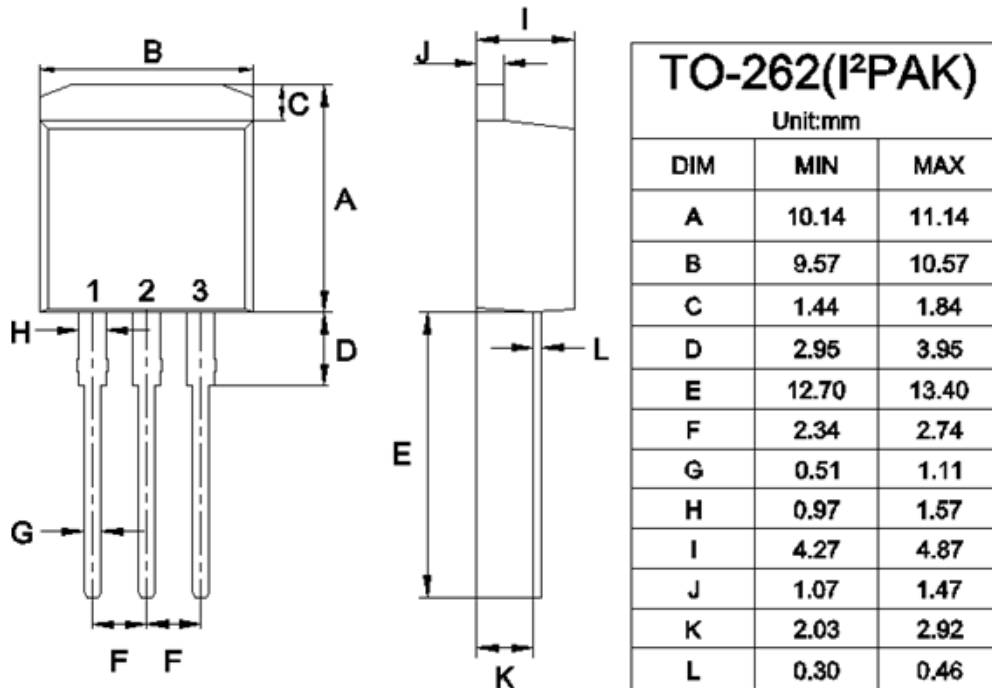
TO-220		
Unit:mm		
DIM	MIN	MAX
A	14.80	15.80
B	9.57	10.57
C	2.54	2.94
D	5.80	6.80
E	2.95	3.95
F	12.70	13.40
G	2.34	2.74
H	0.51	1.11
I	0.97	1.57
J	3.54 $\phi$	4.14 $\phi$
K	4.27	4.87
L	1.07	1.47
M	2.03	2.92
N	0.30	0.64

**TO-220F Mechanical Drawing**

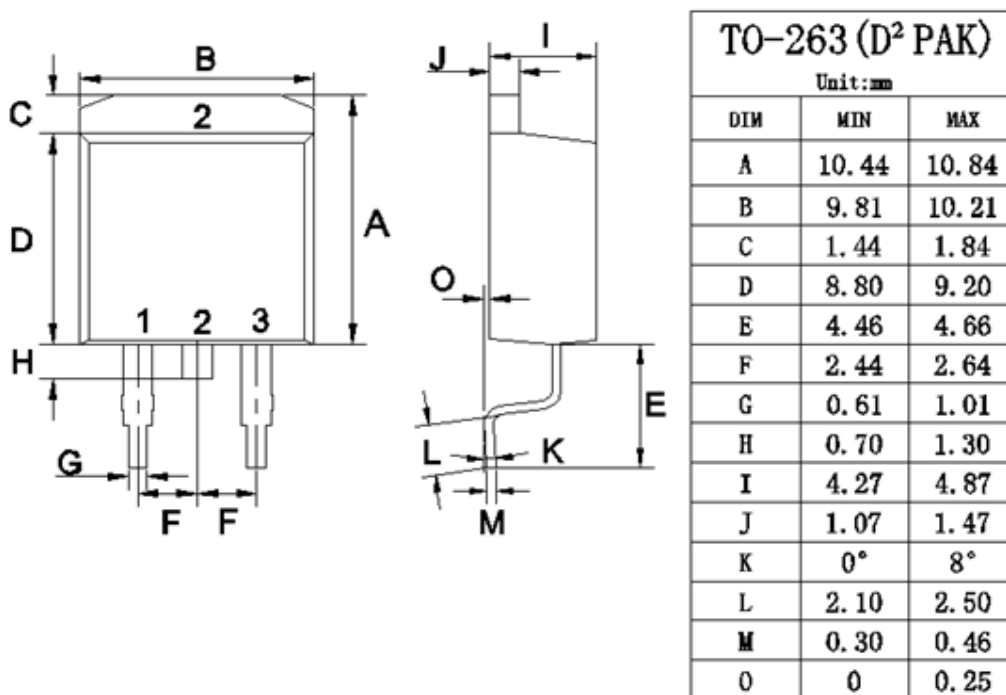


TO-220F		
Unit:mm		
DIM	MIN	MAX
A	14.50	15.50
B	9.50	10.50
C	2.50	2.90
D	6.30	7.30
E	3.30	4.30
F	13.00	14.00
G	2.35	2.75
H	0.30	0.90
I	0.90	1.50
J	3.20	3.80
K	4.24	4.84
L	2.52	2.92
M	1.09	1.49
N	0.47	0.64

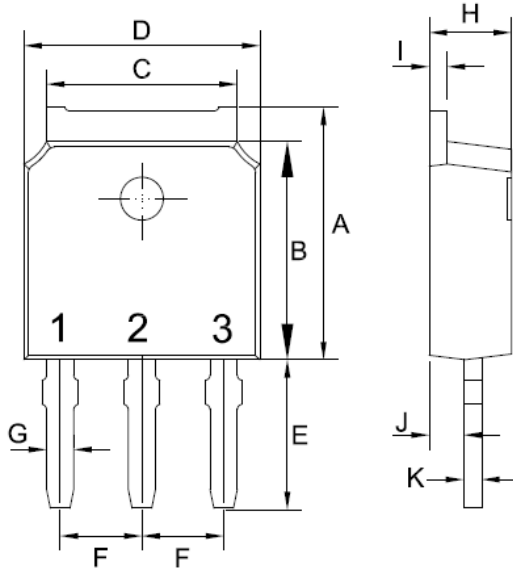
**TO-262 Mechanical Drawing**



**TO-263 Mechanical Drawing**



**TO-251 Mechanical Drawing**



TO-251 (IPAK)		
Unit:mm		
DIM	MIN	MAX
A	6.85	7.25
B	5.90	6.30
C	5.13	5.53
D	6.40	6.80
E	3.95	4.35
F	2.19	2.39
G	0.45	0.85
H	2.20	2.40
I	0.41	0.61
J	0.71	1.31
K	0.41	0.61