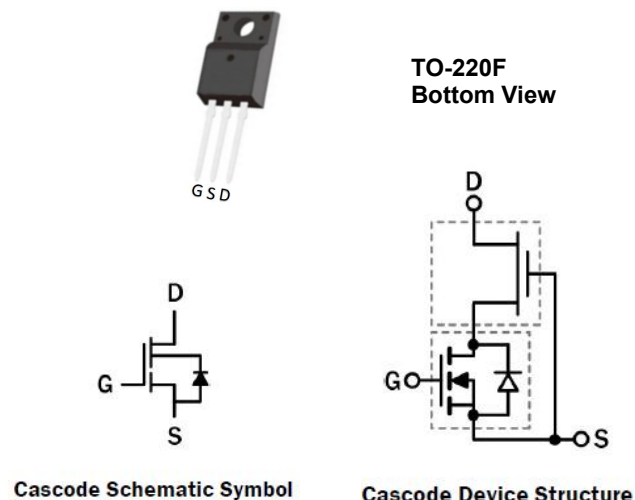


Features

- 650V, 11A, $R_{DS(on)}$ (typ.) = 125mΩ@VGS = 12V.
- Very low Q_{RR}
- Reduced Crossover Loss
- Easy to drive with commonly-used gate drivers
- Excellent $Q_G \times R_{DS(on)}$ figure of merit (FOM)
- RoHS compliant and Halogen-free

Application

- High efficiency power supplies
- Telecom and datacom
- Automotive
- Servo motors



Absolute Maximum Ratings (T_c = 25° C unless otherwise noted)

Symbol	Parameter		Limit	Unit
V _{DS}	Drain-Source Voltage		650	V
V _{(TR)DSS}	Transient Drain to Source Voltage ^a		800	V
V _{GSS}	Gate-Source Voltage		± 20	V
I _D	Drain Current-Continuous	T _C = 25°C ^b	11	A
	Drain Current-Continuous	T _C = 100°C ^b	7	A
I _{DM}	Drain Current-Pulsed	Pulse Width = 100μs	49	A
P _D	Maximum power Dissipation @T _C = 25°C		28	W
T _C	Operating Temperature Case		-55 to +150	°C
T _J	Operating Temperature Junction		-55 to +150	°C
T _S	Storage Temperature		-55 to +150	°C
T _{SOLD}	Soldering Peak Temperature ^c		260	°C

Thermal Characteristics

Symbol	Parameter	Typical	Unit
R _{θJC}	Thermal Resistance Junction-Case	4.4	°C/W
R _{θJA}	Thermal Resistance Junction-Ambient ^d	50	°C/W

Electrical Characteristics ($T_J = 25^\circ \text{C}$ unless otherwise noted)

■ Off Characteristics

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$V_{(BL)DSS}$	Reverse Breakdown Voltage	$V_{GS} = 0V$	650	-	-	V
I_{DSS}	Reverse Leakage Current	$V_{GS} = 0V, V_{DS} = 650V$ $T_J = 25^\circ \text{C}$	-	-	20	μA
		$V_{GS} = 0V, V_{DS} = 650V$ $T_J = 150^\circ \text{C}$	-	50	-	μA
I_{GSS}	Gate-to-source Leakage Current	$V_{DS} = 0V, V_{GS} = \pm 20V$	-	-	± 150	nA

■ On Characteristics

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 500\mu A$	3	4	5	V
$R_{DS(on)eff}$	On Resistance	$V_{GS} = 12V, I_D = 4A$ $T_J = 25^\circ \text{C}$	-	125	160	m Ω
		$V_{GS} = 12V, I_D = 4A$ $T_J = 150^\circ \text{C}$	-	250	-	

■ Dynamic Characteristics

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
C_{ISS}	Input Capacitance	$V_{GS} = 0V,$ $V_{DS} = 400V$ $f = 1MHz$	-	524	-	pF
C_{OSS}	Output Capacitance		-	29	-	
C_{RSS}	Transfer Capacitance		-	0.8	-	
$C_{o(er)}$	Output Capacitance, energy related	$V_{GS} = 0V,$ $V_{DS} = 0 \sim 400V$	-	46	-	pF
$C_{o(tr)}$	Output Capacitance, time related		-	115	-	
Q_{OSS}	Output Charge		-	46	-	nC

■ On Characteristics

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-On Delay Time	$V_{GS} = 0 \sim 12V,$ $V_{DS} = 400V,$ $I_D = 7A,$ $R_g = 47\Omega$	-	60	-	ns
t_r	Turn-On Rise Time		-	18	-	
$t_{d(off)}$	Turn-Off Delay Time		-	80	-	
t_f	Turn-Off Fall Time		-	12	-	
Q_G	Total Gate Charge	$V_{GS} = 0 \sim 12V,$ $V_{DS} = 400V,$ $I_D = 7A$	-	16	-	nC
Q_{GS}	Gate-Source Charge		-	4.8	-	
Q_{GD}	Gate-Drain Charge		-	4.4	-	



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■ Drain-Source Diode Characteristics

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{SD}	Reverse Voltage	$V_{GS} = 0V, I_S = 3.5 A$	-	1.2	-	V
		$V_{GS} = 0V, I_S = 7 A$	-	1.6	-	V
t_{RR}	Reverse Recovery Time	$I_S = 7 A, V_{DS} = 400V,$ $di/dt = 1000 A/\mu s$	-	21	-	ns
Q_{RR}	Reverse Recovery Charge		-	46	-	nC

Notes:

- In off-state, spike duty cycle $D < 0.01$, spike duration $< 1\mu s$.
- For increased stability at high current operation.
- Reflow MSL3.
- Device on one layer epoxy PCB for drain connection (vertical and without air stream cooling, with $6cm^2$ copper area and $70\mu m$ thickness).

Typical Characteristics ($T_c = 25^\circ\text{C}$ unless otherwise noted)

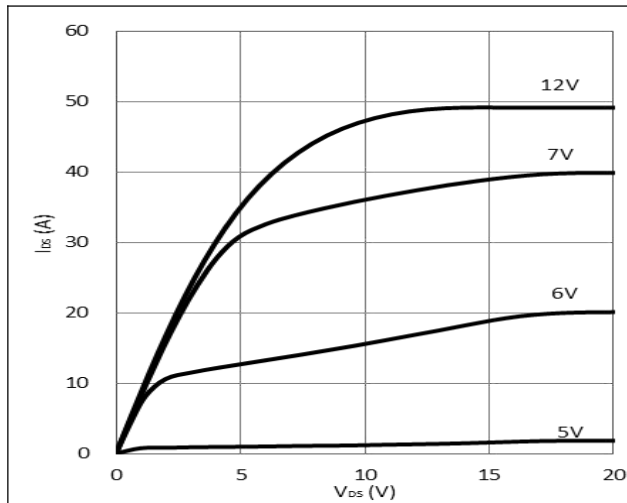


Figure 1. Typical Output Characteristics $T_j = 25^\circ\text{C}$
Parameter: V_{GS}

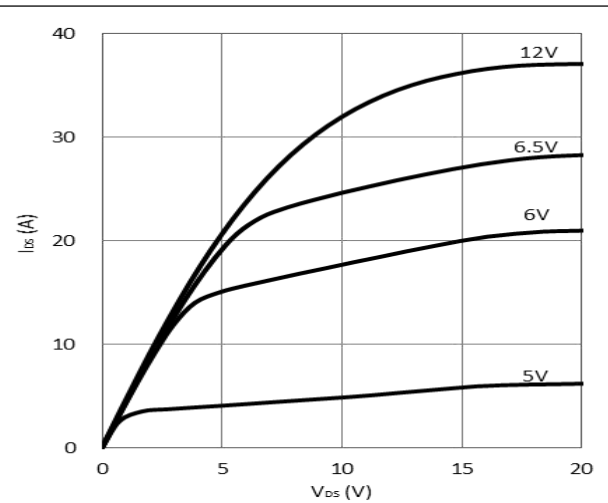


Figure 2. Typical Output Characteristics $T_j = 150^\circ\text{C}$
Parameter: V_{GS}

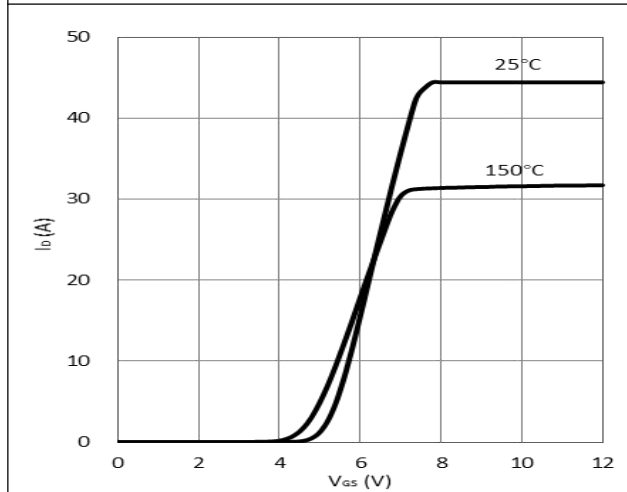


Figure 3. Typical Transfer Characteristics $V_{DS} = 10\text{V}$
Parameter: T_j

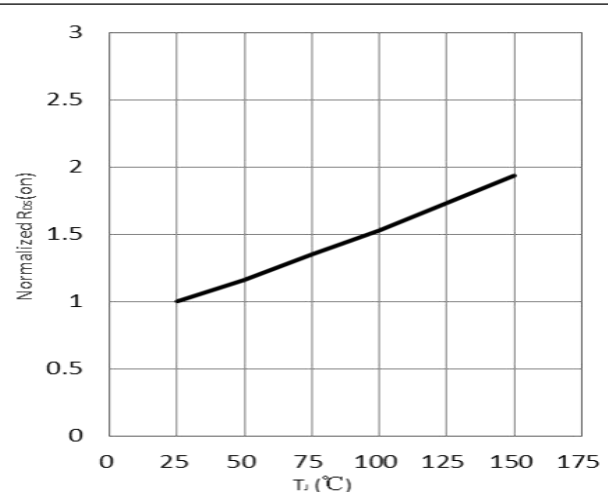


Figure 4. Normalized On-resistance
 $I_D = 4\text{ A}$, $V_{GS} = 12\text{ V}$

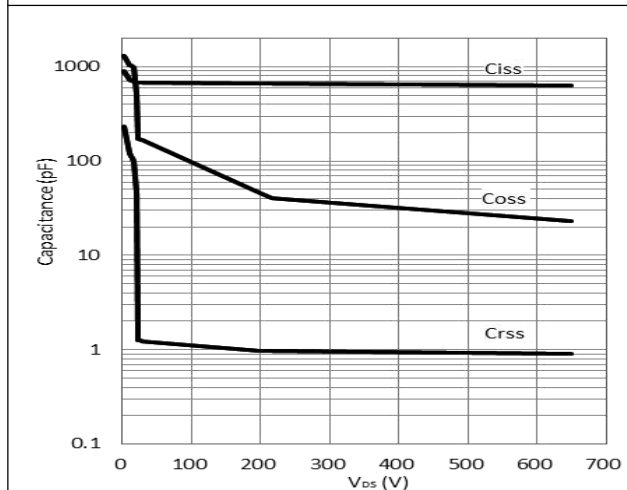


Figure 5. Typical Capacitance
 $V_{GS} = 0\text{ V}$, $f = 1\text{ MHz}$

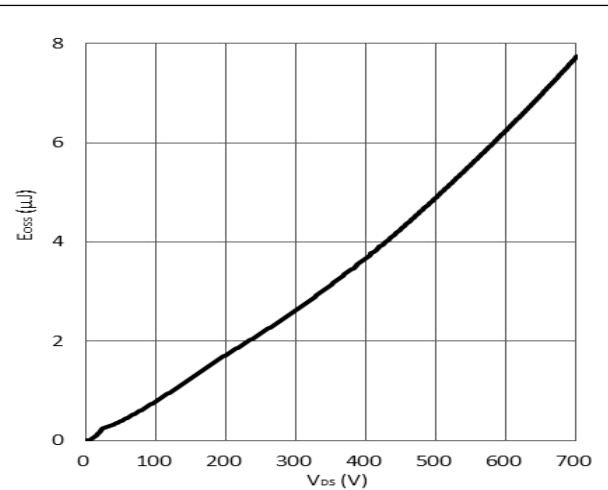


Figure 6. Typical C_{OSS} Stored Energy

Typical Characteristics ($T_c = 25^\circ\text{C}$ unless otherwise noted)

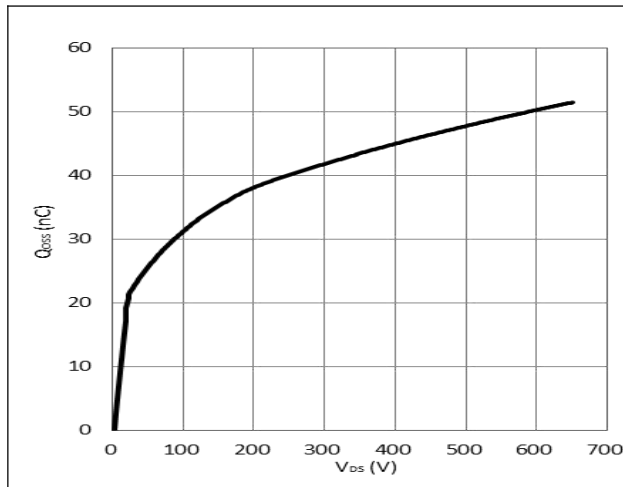


Figure 7. Typical Q_{oss}

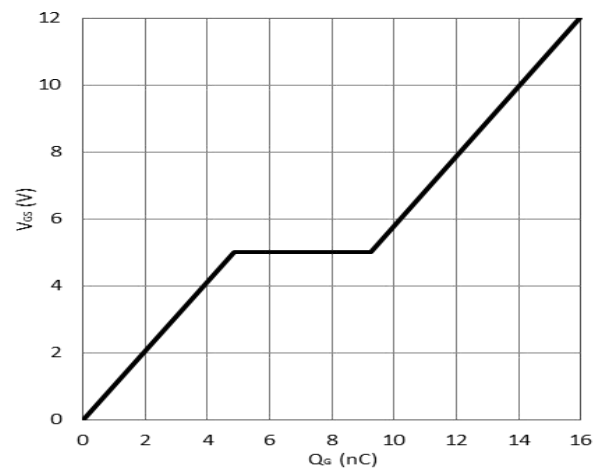


Figure 8. Typical Gate Charge

$I_{DS} = 7\text{A}$, $V_{DS} = 400\text{V}$

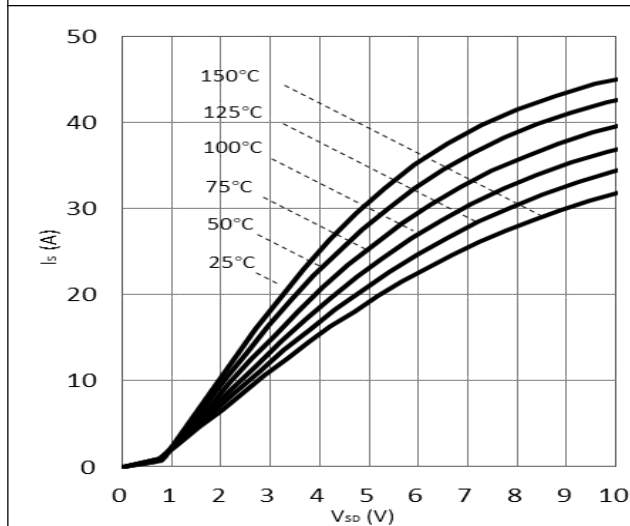


Figure 9. Forward Characteristics of Rev. Diode $I_s = f(V_{sd})$, Parameter T_J

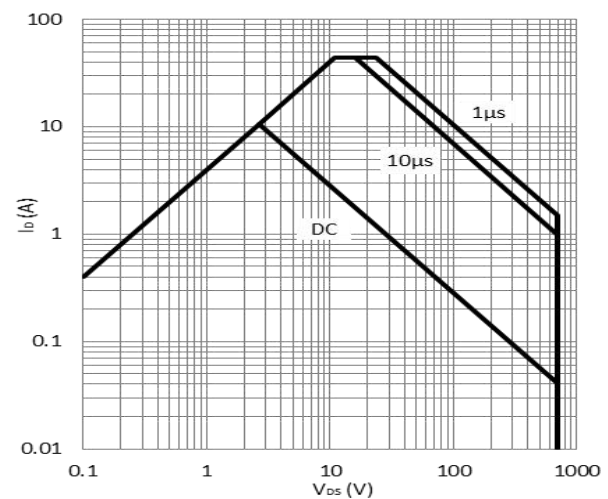


Figure 10. Safe Operating Area $T_c = 25^\circ\text{C}$
(calculated based on thermal limit)

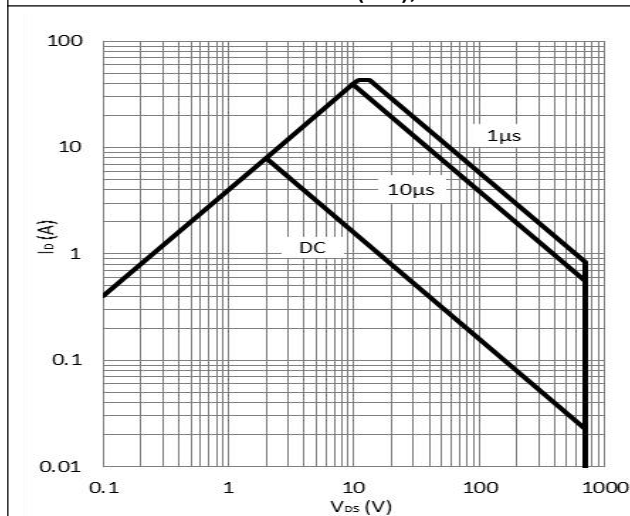


Figure 11. Safe Operating Area $T_c = 80^\circ\text{C}$
(calculated based on thermal limit)

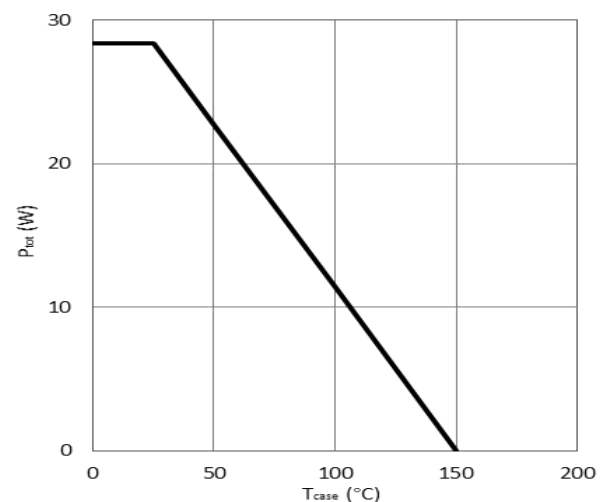


Figure 12. Power Dissipation

Typical Characteristics ($T_C = 25^\circ\text{C}$ unless otherwise noted)

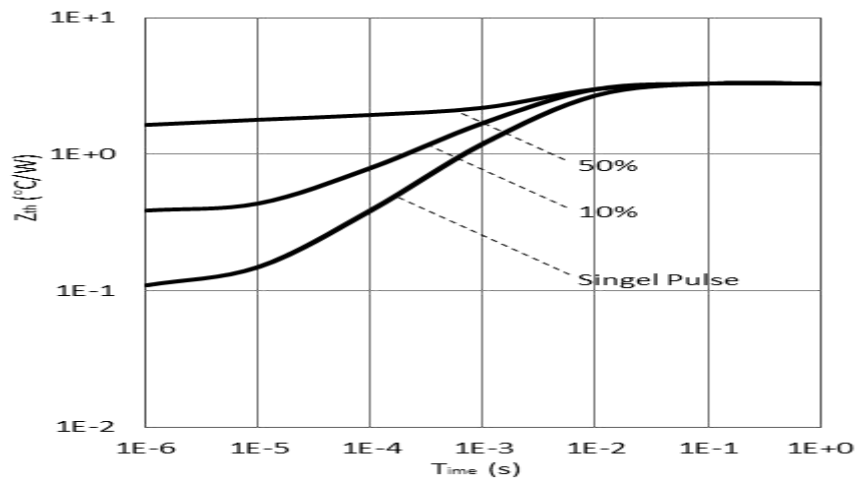


Figure 13. Transient Thermal Resistance

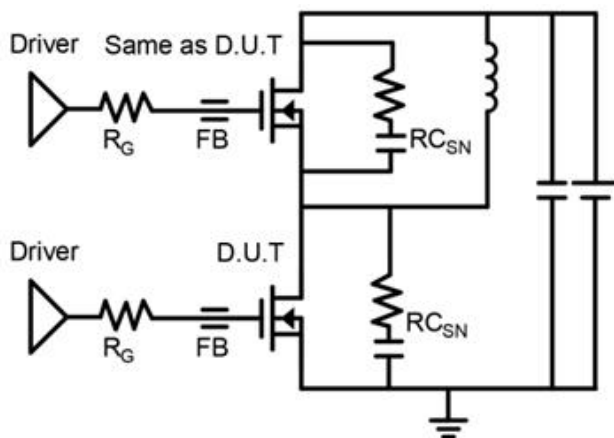


Figure 14. Switching Time Test Circuit

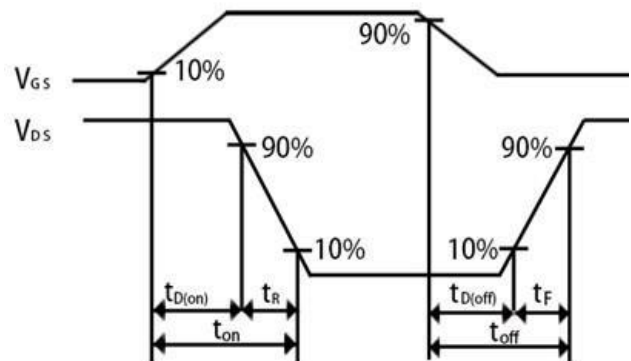


Figure 15. Switching Time Waveform

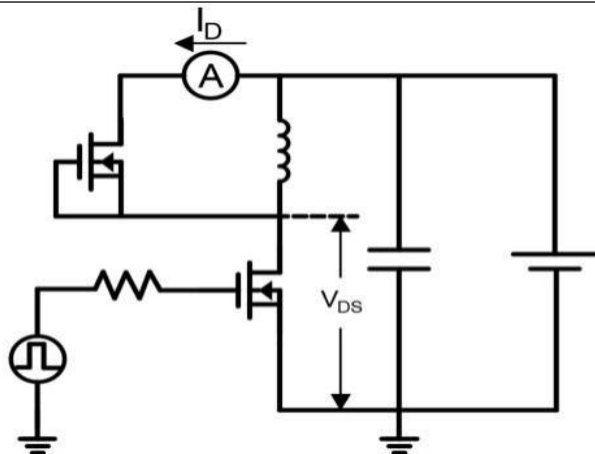


Figure 16. Diode Characteristics Test Circuit

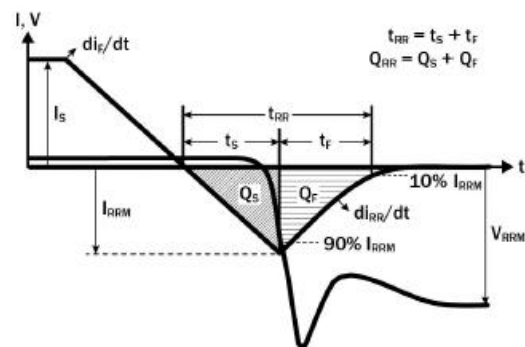
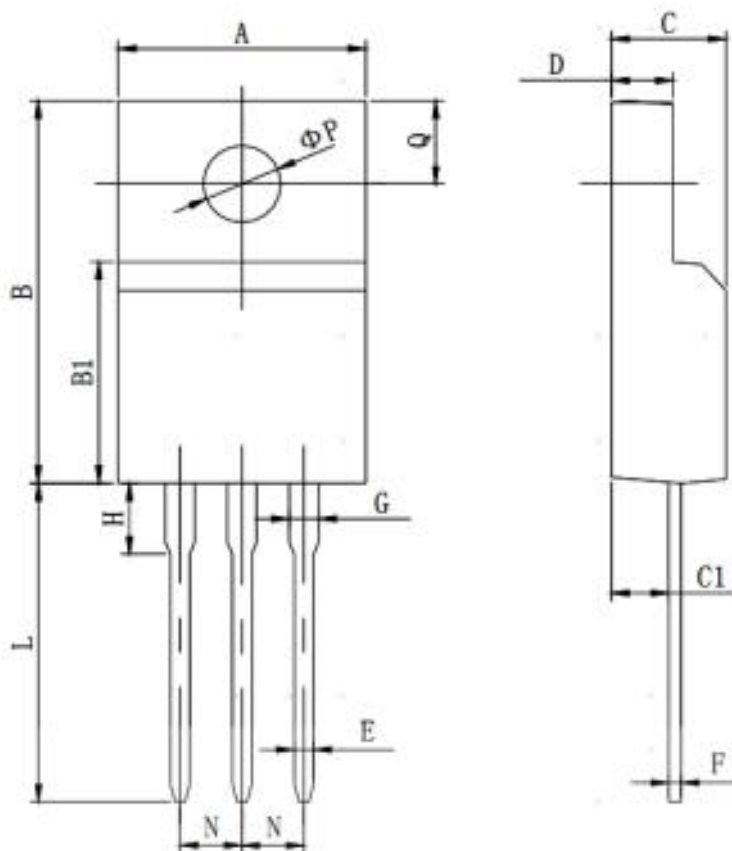


Figure 17. Diode Recovery Waveform

■ TO-220F Package Information



SYMBOL	Millimeter		
	Min	Nom	Max
A	9.60	10.00	10.40
B	15.40	15.80	16.20
B1	8.90	9.20	9.50
C	4.30	4.60	4.90
C1	2.10	2.50	3.00
D	2.40	2.70	3.00
E	0.60	0.80	1.00
F	0.30	0.45	0.60
G	1.12	1.30	1.42
H	3.40	3.60	3.80
L	12.00	13.00	14.00
N	2.34	2.54	2.74
Q	3.15	3.35	3.55
P	2.90	3.10	3.30



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■ Revision History

Version	Date	Subjects (major changes since last revision)
0.1	2023-05-07	Preliminary Version
1.0	2024-10-10	Datasheet Complete