

650 V, 9.6 A, 380 mΩ

## Description

The 650V E series has excellent low on-resistance and gate charge by utilizing charge balance technology.

This technology combines the benefits of an excellent switching performance with ease of usage and robustness. Consequently, the 650V E series is suitable for application requiring superior efficiency and extra safety margin for design with higher voltage.

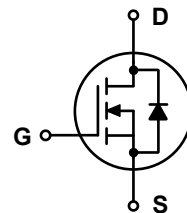
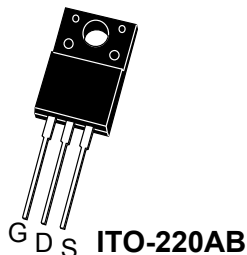
## Applications

- PFC, Hard & Soft Switching Topologies
- Industrial & Consumer Power Supplies

## Features

$BV_{DSS} @ T_{J,max}$	$I_D$	$R_{DS(on),max}$	$Q_{g,typ}$
700 V	9.6 A	380 mΩ	16.5 nC

- Reduced Switching & Conduction Losses
- Lower Switching Noise
- 100% Avalanche Tested
- Pb-free and RoHS Compliant
- Compliance with EU REACH



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

Symbol	Parameter		Value	Unit
$V_{DSS}$	Drain to Source Voltage		650	V
$V_{GSS}$	Gate to Source Voltage		$\pm 30$	V
$I_D$	Drain Current	Continuous ( $T_C = 25^\circ\text{C}$ )	9.6*	A
		Continuous ( $T_C = 100^\circ\text{C}$ )	6.1*	
$I_{DM}$	Drain Current	Pulsed (Note1)	28.8*	A
$E_{AS}$	Single Pulsed Avalanche Energy (Note2)		40	mJ
$I_{AS}$	Avalanche Current (Note2)		2.5	A
$E_{AR}$	Repetitive Avalanche Energy (Note1)		0.87	mJ
dv/dt	MOSFET dv/dt		100	V/ns
	Peak Diode Recovery dv/dt (Note3)		20	
$P_D$	Power Dissipation	( $T_C = 25^\circ\text{C}$ )	28	W
		Derate Above $25^\circ\text{C}$	0.22	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, 1/8" from Case for 10 Seconds		260	$^\circ\text{C}$

\*Drain current limited by maximum junction temperature

## Thermal Characteristics

Symbol	Parameter	Value	Unit
$R_{\theta JC}$	Thermal Resistance, Junction to Case, Max.	4.5	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient, Max.	62.5	



## Package Marking and Ordering Information

Part Number	Top Marking	Package	Packing Method	Quantity
HXMH65M380EF	H65M380EF	ITO-220AB	Tube	50 units

## Electrical Characteristics (T<sub>C</sub> = 25°C unless otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
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### Off Characteristics

BV <sub>DSS</sub>	Drain to Source Breakdown Voltage	V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA	650			V
		V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 150°C	700			
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	V <sub>DS</sub> = 650 V, V <sub>GS</sub> = 0 V			1	μA
		V <sub>DS</sub> = 520 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125°C		2		
I <sub>GSS</sub>	Gate-Source Leakage Current	V <sub>GS</sub> = ±30 V, V <sub>DS</sub> = 0 V			±100	nA

### On Characteristics

V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 0.8 mA	2.5		4.5	V
R <sub>DS(on)</sub>	Static Drain to Source On Resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 4 A		318	380	mΩ

### Dynamic Characteristics

C <sub>iss</sub>	Input Capacitance	V <sub>DS</sub> = 400 V, V <sub>GS</sub> = 0 V, f = 250 kHz		624		pF
C <sub>oss</sub>	Output Capacitance			17		pF
C <sub>o(tr)</sub>	Time Related Output Capacitance	V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V		224		pF
C <sub>o(er)</sub>	Energy Related Output Capacitance			28		pF
Q <sub>g(tot)</sub>	Total Gate Charge at 10 V	V <sub>DS</sub> = 400 V, I <sub>D</sub> = 4 A, V <sub>GS</sub> = 10 V		16.5		nC
Q <sub>gs</sub>	Gate to Source Charge			3.4		nC
Q <sub>gd</sub>	Gate to Drain "Miller" Charge			8.2		nC
R <sub>G</sub>	Gate Resistance	f = 1 MHz		6.9		Ω

### Switching Characteristics

t <sub>d(on)</sub>	Turn-On Delay Time	V <sub>DS</sub> = 400 V, I <sub>D</sub> = 4 A, V <sub>GS</sub> = 10 V, R <sub>G</sub> = 10 Ω See Figure 13		9		ns
t <sub>r</sub>	Turn-On Rise Time			9		ns
t <sub>d(off)</sub>	Turn-Off Delay Time			39		ns
t <sub>f</sub>	Turn-Off Fall Time			10		ns

### Source-Drain Diode Characteristics

I <sub>S</sub>	Maximum Continuous Diode Forward Current			9.6	A
I <sub>SM</sub>	Maximum Pulsed Diode Forward Current			28.8	A
V <sub>SD</sub>	Diode Forward Voltage	V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 4 A		1.2	V
t <sub>rr</sub>	Reverse Recovery Time	V <sub>DD</sub> = 400 V, I <sub>SD</sub> = 4 A, di <sub>F</sub> /dt = 100 A/μs		220	ns
Q <sub>rr</sub>	Reverse Recovery Charge			1.78	μC

### ※Notes:

1. Repetitive rating: pulse-width limited by maximum junction temperature.
2. I<sub>AS</sub> = 2.5 A, R<sub>G</sub> = 25 Ω, starting T<sub>J</sub> = 25°C.
3. I<sub>SD</sub> ≤ 4 A, di/dt ≤ 100 A/μs, V<sub>DD</sub> ≤ 400 V, starting T<sub>J</sub> = 25°C.



#### Typical Performance Characteristics

Figure 1. On-Region Characteristics

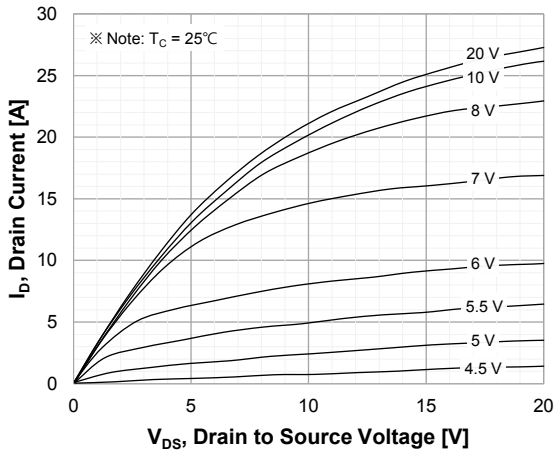


Figure 2. Transfer Characteristics

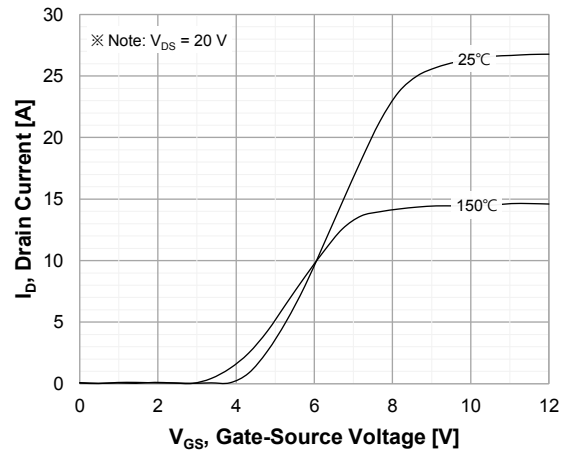


Figure 3. On-Resistance Characteristics vs. Drain Current and Gate Voltage

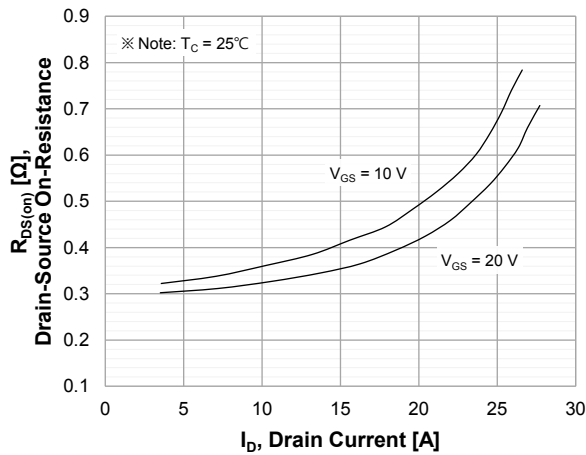


Figure 4. Diode Forward Voltage Characteristics vs. Source-Drain Current and Temperature

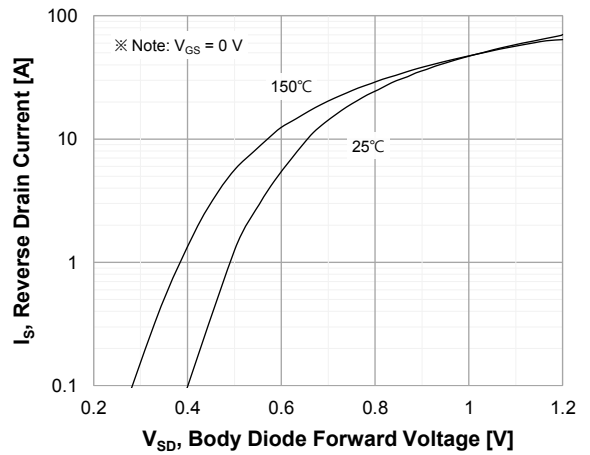


Figure 5. Capacitance Characteristics

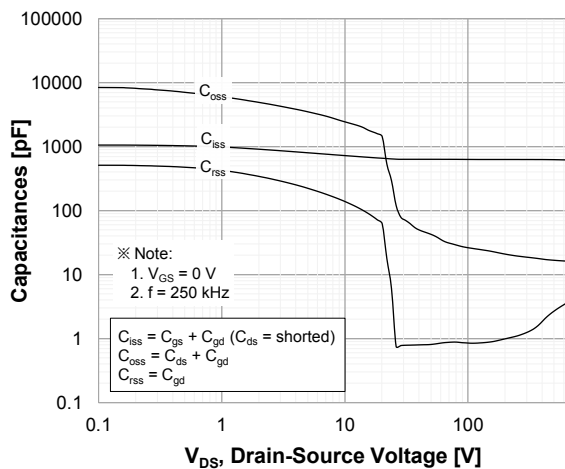
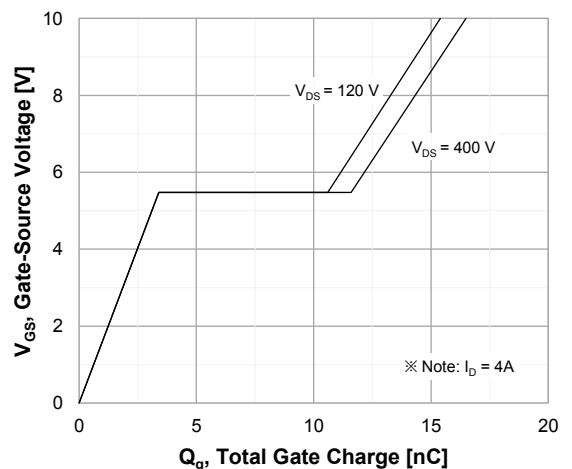
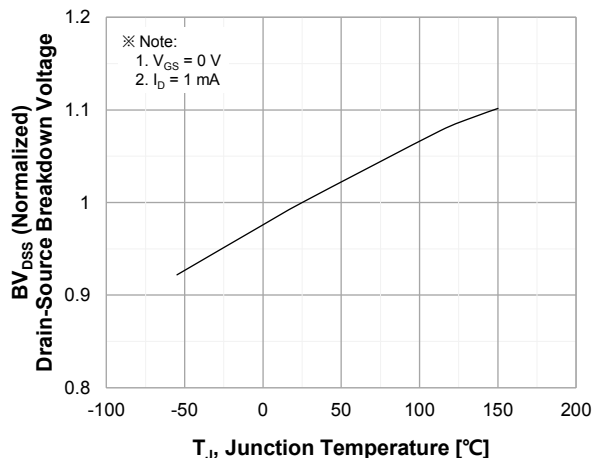


Figure 6. Gate Charge Characteristics

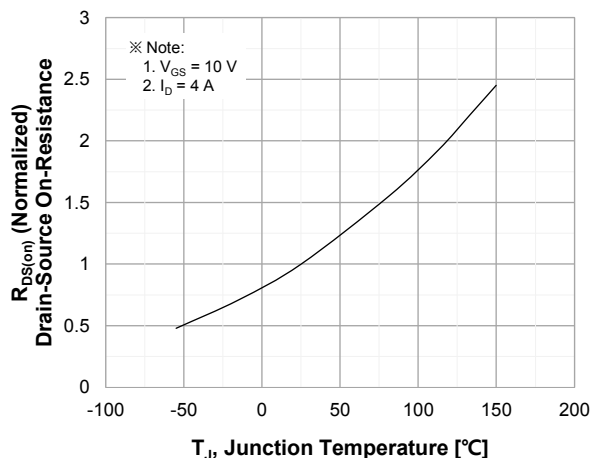


### Typical Performance Characteristics

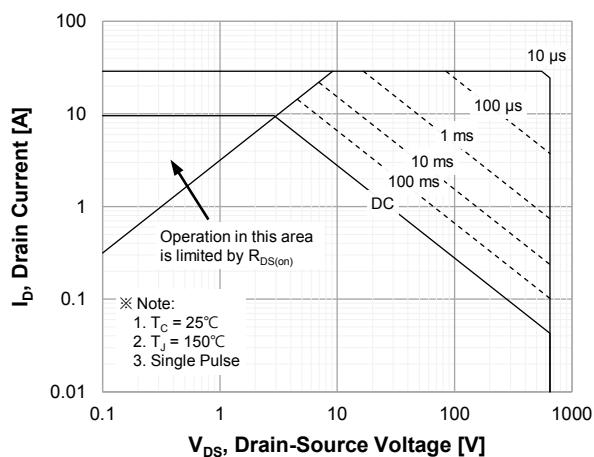
**Figure 7. Breakdown Voltage Characteristics vs. Temperature**



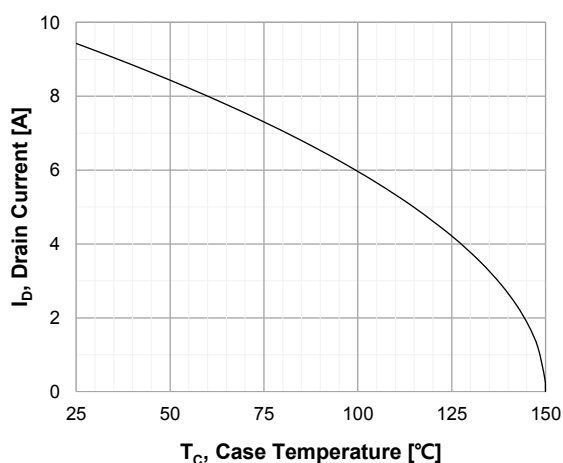
**Figure 8. On-Resistance Characteristics vs. Temperature**



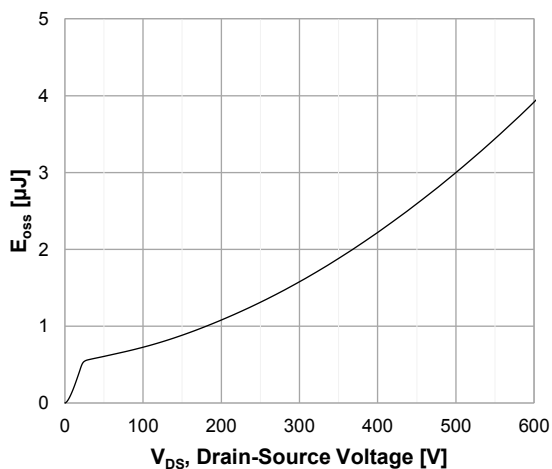
**Figure 9. Maximum Safe Operating Area**



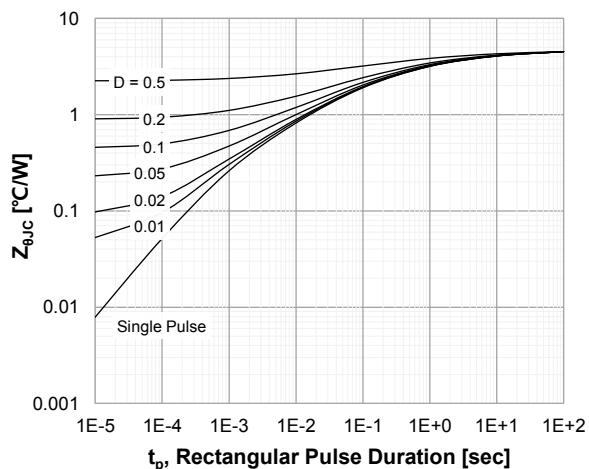
**Figure 10. Maximum Drain Current vs. Case Temperature**



**Figure 11.  $E_{oss}$  vs. Drain to Source Voltage**



**Figure 12. Transient Thermal Response Curve**



### Test Circuits

Figure 13. Inductive Load Switching Test Circuit and Waveforms

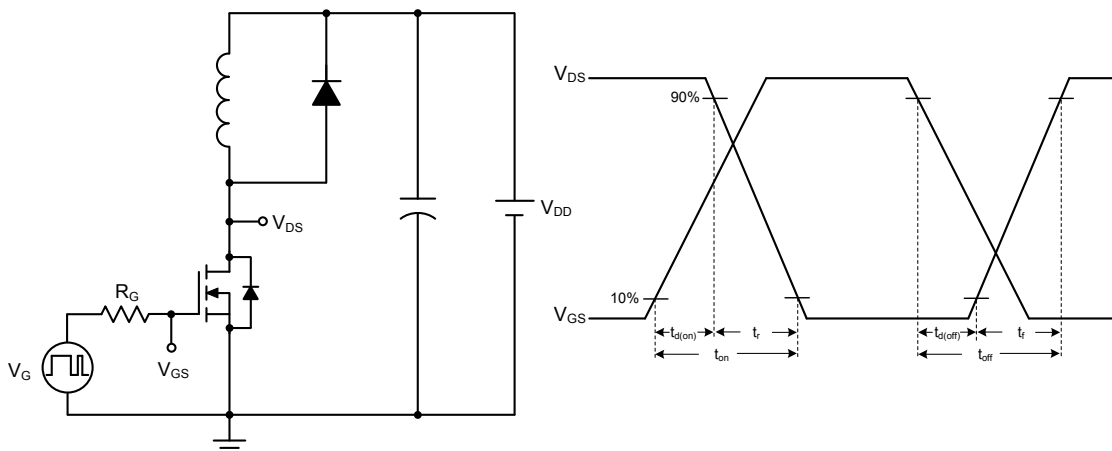


Figure 14. Unclamped Inductive Switching Test Circuit and Waveforms

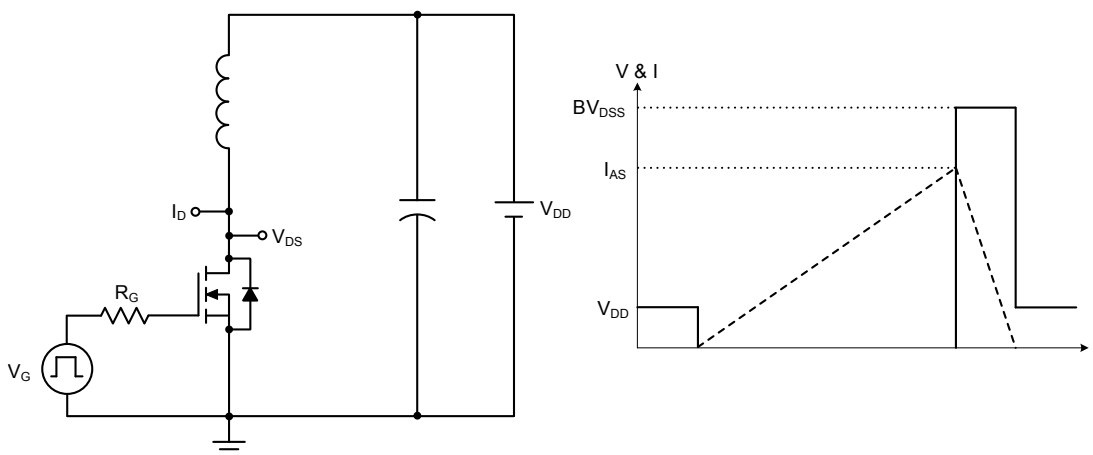
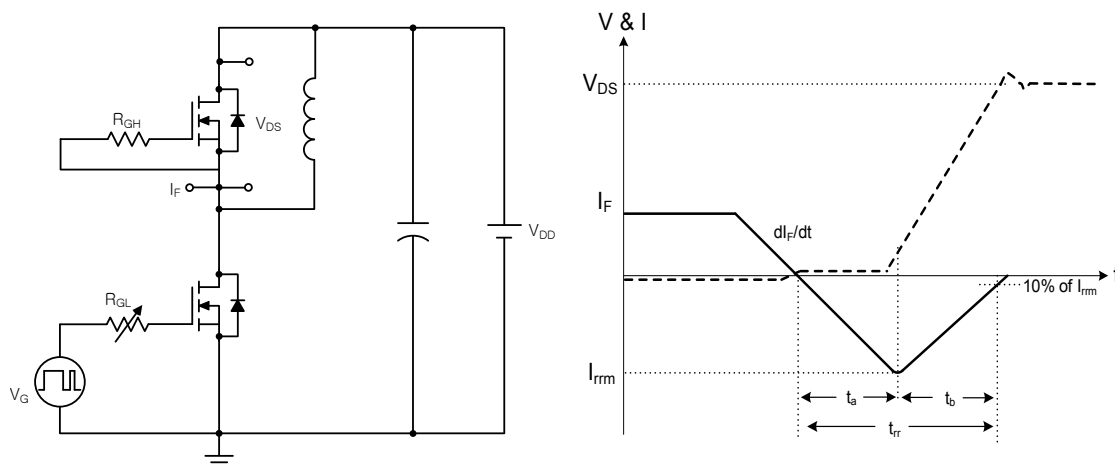
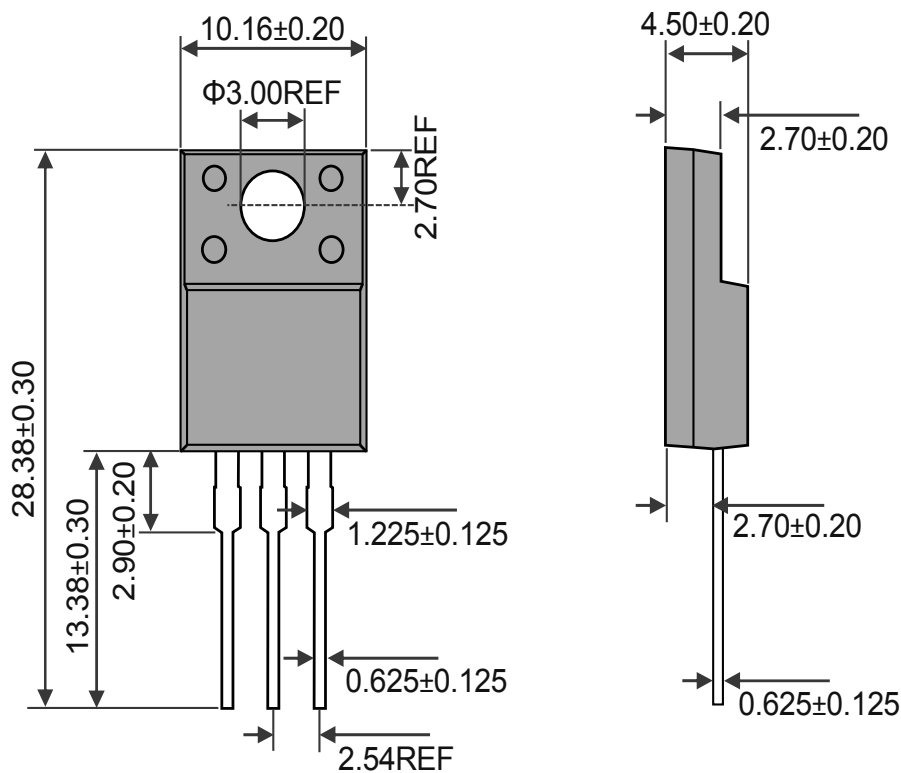


Figure 15. Peak Diode Recovery dv/dt Test Circuit and Waveforms



Package Outlines

**ITO-220AB**



ITO-220AB  
Unit:mm



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