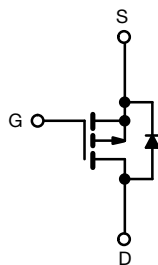
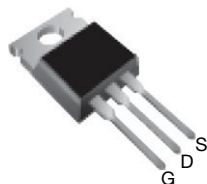


# Power MOSFET

**TO-220AB**


P-Channel MOSFET

## FEATURES

- Dynamic dV/dt rating
- Repetitive avalanche rated
- P-channel
- 175 °C operating temperature
- Fast switching
- Ease of paralleling
- Simple drive requirements
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS\***  
Available

## Note

\* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

## DESCRIPTION

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

## PRODUCT SUMMARY

V <sub>DS</sub> (V)	-60	
R <sub>DS(on)</sub> (Ω)	V <sub>GS</sub> = -10 V	0.28
Q <sub>g</sub> max. (nC)	19	
Q <sub>gs</sub> (nC)	5.4	
Q <sub>gd</sub> (nC)	11	
Configuration	Single	

## ORDERING INFORMATION

Package	TO-220AB
Lead (Pb)-free	IRF9Z24PbF
Lead (Pb)-free and halogen-free	IRF9Z24PbF-BE3

## ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25 °C, unless otherwise noted)

PARAMETER	SYMBOL	LIMIT	UNIT
Drain-source voltage	V <sub>DS</sub>	-60	V
Gate-source voltage	V <sub>GS</sub>	± 20	
Continuous drain current	V <sub>GS</sub> at 10 V	T <sub>C</sub> = 25 °C	A
		T <sub>C</sub> = 100 °C	
Pulsed drain current <sup>a</sup>	I <sub>DM</sub>	-44	
Linear derating factor		0.40	W/°C
Single pulse avalanche energy <sup>b</sup>	E <sub>AS</sub>	240	mJ
Repetitive avalanche current <sup>a</sup>	I <sub>AR</sub>	-11	A
Repetitive avalanche energy <sup>a</sup>	E <sub>AR</sub>	6.0	mJ
Maximum power dissipation	P <sub>D</sub>	60	W
Peak diode recovery dV/dt <sup>c</sup>	dV/dt	-4.5	V/ns
Operating junction and storage temperature range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +175	°C
Soldering recommendations (peak temperature) <sup>d</sup>	For 10 s	300	
Mounting torque	6-32 or M3 screw	10	lbf · in
		1.1	N · m

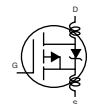

## Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- V<sub>DD</sub> = -25 V, starting T<sub>J</sub> = 25 °C, L = 2.3 mH, R<sub>g</sub> = 25 Ω, I<sub>AS</sub> = -11 A (see fig. 12)
- I<sub>SD</sub> ≤ -11 A, di/dt ≤ 140 A/μs, V<sub>DD</sub> ≤ V<sub>DS</sub>, T<sub>J</sub> ≤ 175 °C
- 1.6 mm from case

**THERMAL RESISTANCE RATINGS**

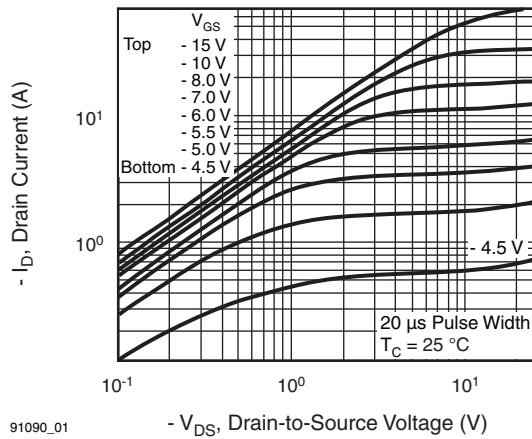
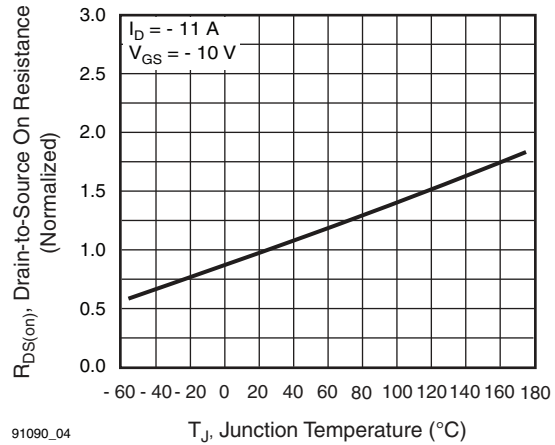
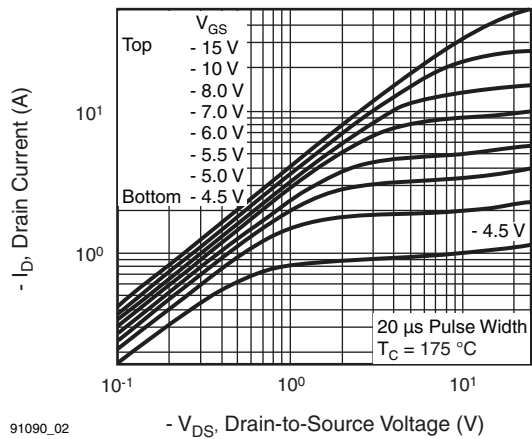
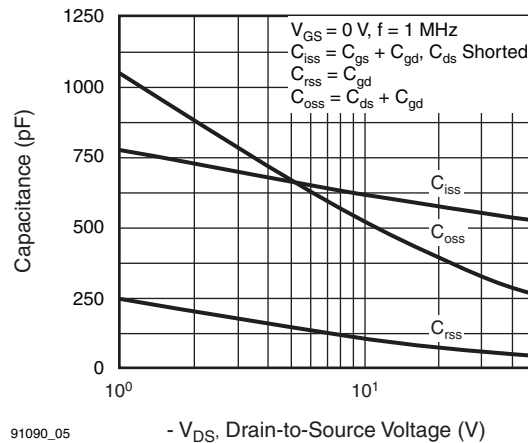
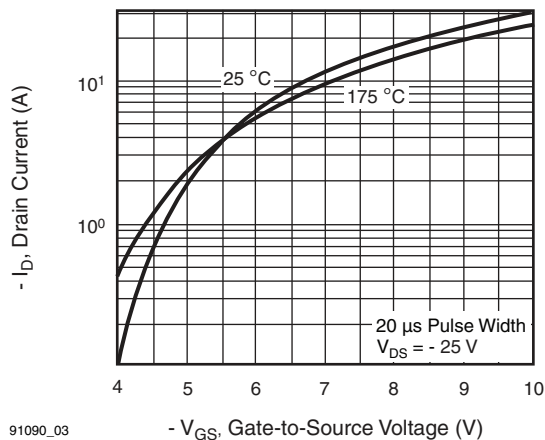
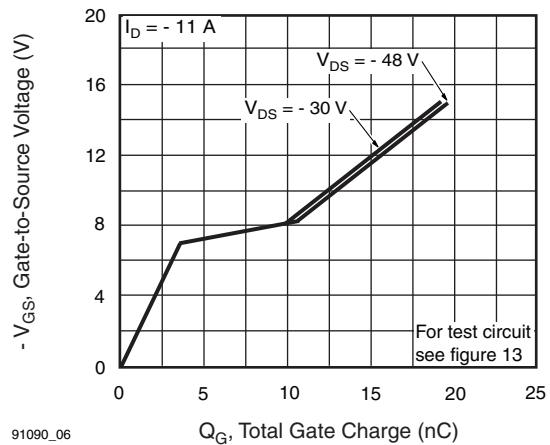
PARAMETER	SYMBOL	TYP.	MAX.	UNIT
Maximum junction-to-ambient	$R_{thJA}$	-	62	°C/W
Case-to-sink, flat, greased surface	$R_{thCS}$	0.50	-	
Maximum junction-to-case (drain)	$R_{thJC}$	-	2.5	

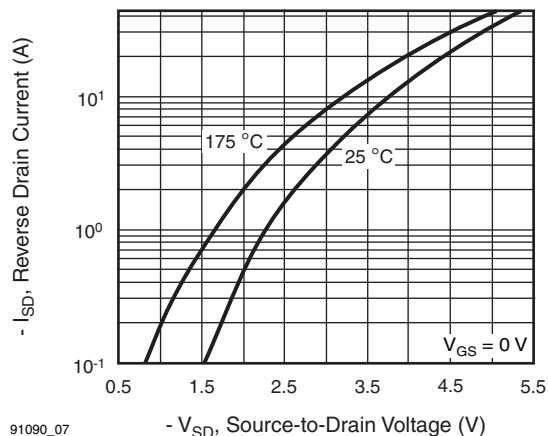
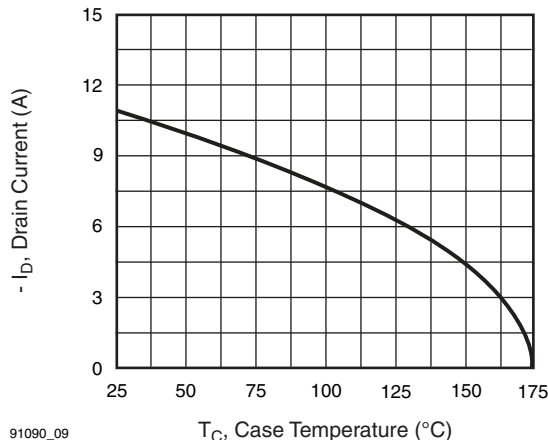
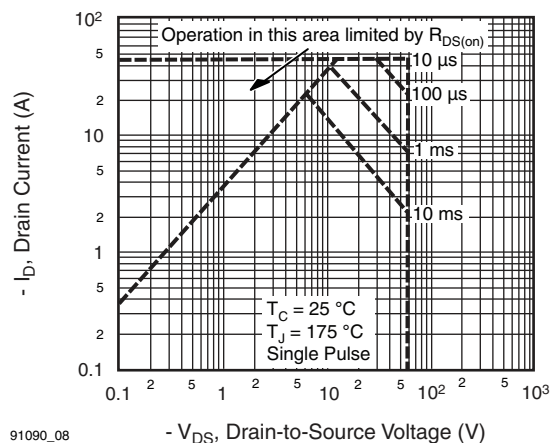
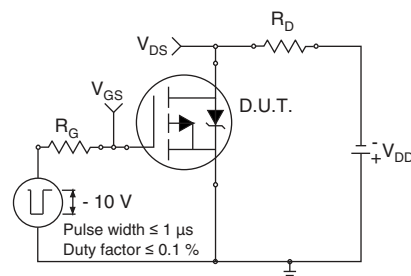
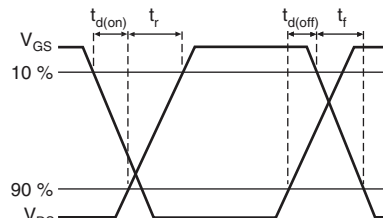
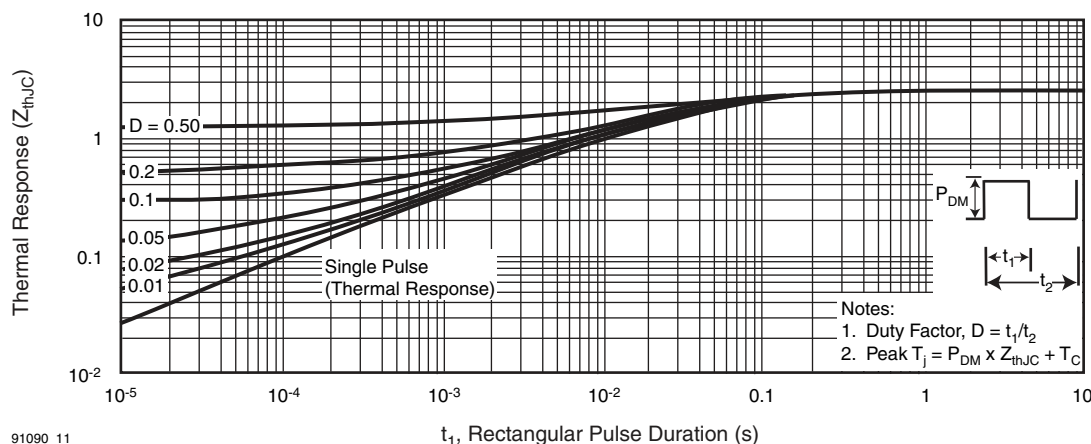
**SPECIFICATIONS** ( $T_J = 25\text{ °C}$ , unless otherwise noted)

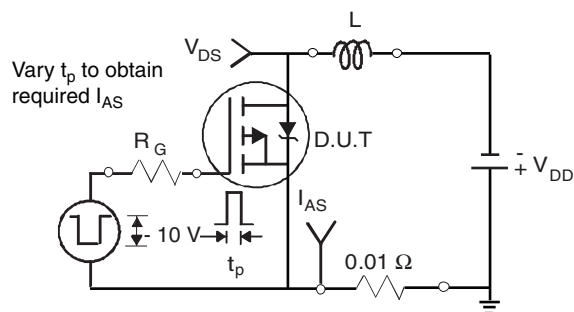
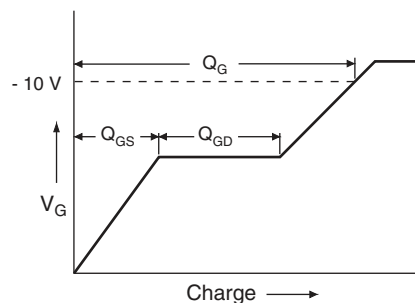
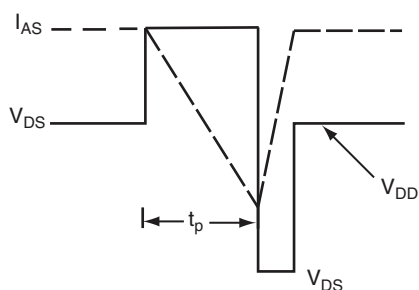
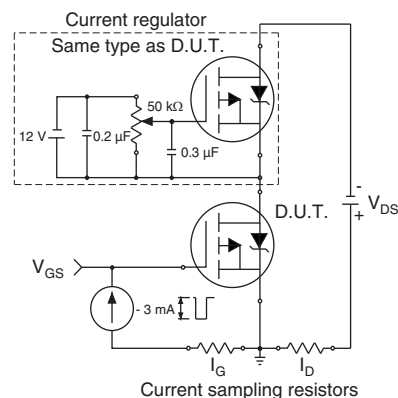
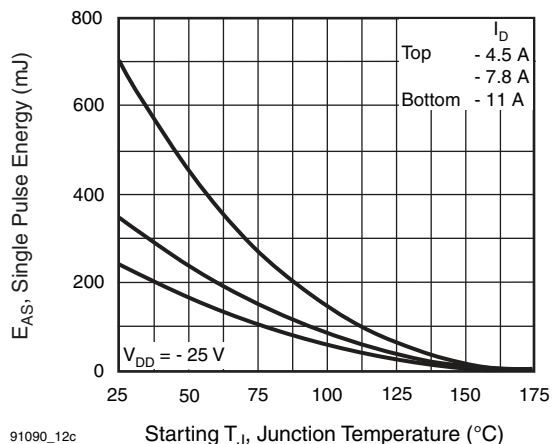
PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Static							
Drain-source breakdown voltage	V <sub>DS</sub>	V <sub>GS</sub> = 0 V, I <sub>D</sub> = -250 μA		-60	-	-	V
V <sub>DS</sub> temperature coefficient	ΔV <sub>DS</sub> /T <sub>J</sub>	Reference to 25 °C, I <sub>D</sub> = -1 mA		-	-0.056	-	V/°C
Gate-source threshold voltage	V <sub>GS(th)</sub>	V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = -250 μA		-2.0	-	-4.0	V
Gate-source leakage	I <sub>GSS</sub>	V <sub>GS</sub> = ± 20 V		-	-	± 100	nA
Zero gate voltage drain current	I <sub>DSS</sub>	V <sub>DS</sub> = -60 V, V <sub>GS</sub> = 0 V		-	-	-100	μA
		V <sub>DS</sub> = -48 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 150 °C		-	-	-500	
Drain-source on-state resistance	R <sub>DS(on)</sub>	V <sub>GS</sub> = -10 V	I <sub>D</sub> = -6.6 A <sup>b</sup>	-	-	0.28	Ω
Forward transconductance	g <sub>fs</sub>	V <sub>DS</sub> = -25 V, I <sub>D</sub> = -6.6 A <sup>b</sup>		1.4	-	-	S
Dynamic							
Input capacitance	C <sub>iss</sub>	V <sub>GS</sub> = 0 V, V <sub>DS</sub> = -25 V, f = 1.0 MHz, see fig. 5		-	570	-	pF
Output capacitance	C <sub>oss</sub>			-	360	-	
Reverse transfer capacitance	C <sub>rss</sub>			-	65	-	
Total gate charge	Q <sub>g</sub>	V <sub>GS</sub> = -10 V	I <sub>D</sub> = -11 A, V <sub>DS</sub> = -48 V, see fig. 6 and 13 <sup>b</sup>	-	-	19	nC
Gate-source charge	Q <sub>gs</sub>			-	-	5.4	
Gate-drain charge	Q <sub>gd</sub>			-	-	11	
Turn-on delay time	t <sub>d(on)</sub>	V <sub>DD</sub> = -30 V, I <sub>D</sub> = -11 A, R <sub>g</sub> = 18 Ω, R <sub>D</sub> = 2.5 Ω, see fig. 10 <sup>b</sup>		-	13	-	ns
Rise time	t <sub>r</sub>			-	68	-	
Turn-off delay time	t <sub>d(off)</sub>			-	15	-	
Fall time	t <sub>f</sub>			-	29	-	
Gate input resistance	R <sub>g</sub>	f = 1 MHz, open drain		0.5	-	3.5	Ω
Internal drain inductance	L <sub>D</sub>	Between lead, 6 mm (0.25") from package and center of die contact 		-	4.5	-	nH
Internal source inductance	L <sub>S</sub>			-	7.5	-	
Drain-Source Body Diode Characteristics							
Continuous source-drain diode current	I <sub>S</sub>	MOSFET symbol showing the integral reverse p - n junction diode 		-	-	-11	A
Pulsed diode forward current <sup>a</sup>	I <sub>SM</sub>			-	-	-44	
Body diode voltage	V <sub>SD</sub>	T <sub>J</sub> = 25 °C, I <sub>S</sub> = -11 A, V <sub>GS</sub> = 0 V <sup>b</sup>		-	-	-6.3	V
Body diode reverse recovery time	t <sub>rr</sub>	T <sub>J</sub> = 25 °C, I <sub>F</sub> = -11 A, dI/dt = 100 A/μs <sup>b</sup>		-	100	200	ns
Body diode reverse recovery charge	Q <sub>rr</sub>			-	0.32	0.64	μC
Forward turn-on time	t <sub>on</sub>	Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> and L <sub>D</sub> )					

**Notes**

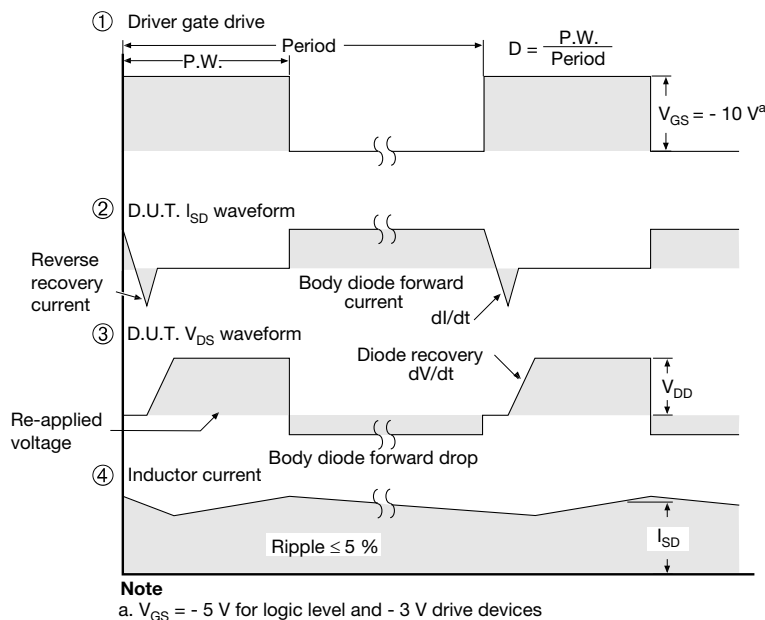
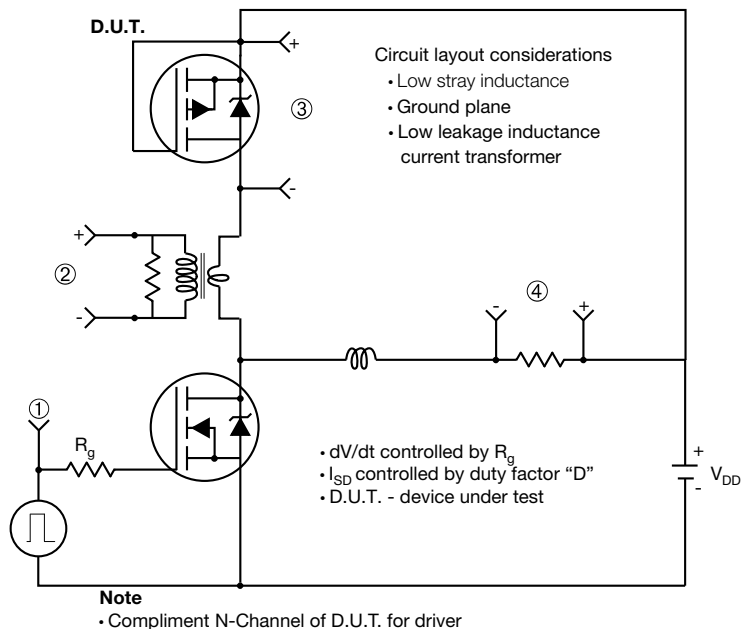
- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)  
b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$** 

**Fig. 4 - Normalized On-Resistance vs. Temperature**

**Fig. 2 - Typical Output Characteristics,  $T_C = 175^\circ\text{C}$** 

**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

**Fig. 3 - Typical Transfer Characteristics**

**Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage**


**Fig. 7 - Typical Source-Drain Diode Forward Voltage**

**Fig. 9 - Maximum Drain Current vs. Case Temperature**

**Fig. 8 - Maximum Safe Operating Area**

**Fig. 10a - Switching Time Test Circuit**

**Fig. 10b - Switching Time Waveforms**

**Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**


**Fig. 12a - Unclamped Inductive Test Circuit**

**Fig. 13a - Basic Gate Charge Waveform**

**Fig. 12b - Unclamped Inductive Waveforms**

**Fig 13b - Gate Charge Test Circuit**

**Fig. 12c - Maximum Avalanche Energy vs. Drain Current**

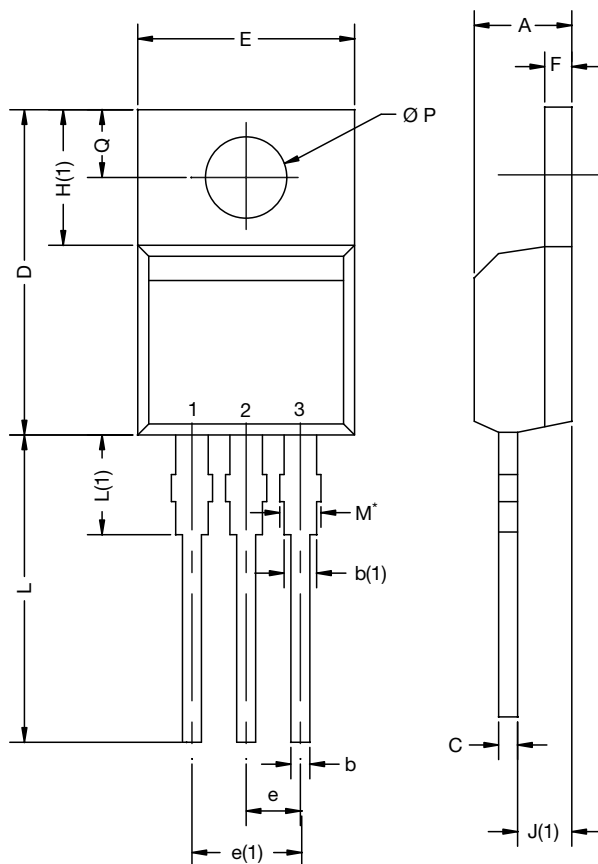
### Peak Diode Recovery dV/dt Test Circuit



**Fig. 14 - For P-Channel**

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## TO-220-1



DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	4.24	4.65	0.167	0.183
b	0.69	1.02	0.027	0.040
b(1)	1.14	1.78	0.045	0.070
c	0.36	0.61	0.014	0.024
D	14.33	15.85	0.564	0.624
E	9.96	10.52	0.392	0.414
e	2.41	2.67	0.095	0.105
e(1)	4.88	5.28	0.192	0.208
F	1.14	1.40	0.045	0.055
H(1)	6.10	6.71	0.240	0.264
J(1)	2.41	2.92	0.095	0.115
L	13.36	14.40	0.526	0.567
L(1)	3.33	4.04	0.131	0.159
$\varnothing P$	3.53	3.94	0.139	0.155
Q	2.54	3.00	0.100	0.118

ECN: E21-0621-Rev. D, 04-Nov-2021  
DWG: 6031

### Note

- $M^*$  = 0.052 inches to 0.064 inches (dimension including protrusion), heatsink hole for HVM



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